

study results, and increases the soundness of the conclusions reached in the study. Accordingly, patients with background disease sufficiently severe to overwhelm or confound an expected treatment effect are systematically identified and excluded quite independently from considerations of anticipated safety or efficacy of the test article in this particular patient group.

19. For example, patients with malignancy are often excluded from non-oncologic clinical trials, not because the test agents are unsafe, pose any specific risk in this population, or will not work, but rather because the clinical results will be confounded by the wholly unrelated effects of the underlying malignancy, thereby reducing the power of the clinical trial to answer a specific hypothesis regarding the test treatment. As a specific example, exclusion of patients with malignancy or advanced heart failure from cholesterol lowering trials does not imply that statins are unsafe or ineffective in these patients, but rather that their inclusion would confound the potential effects of statins on overall mortality or cardiovascular events.

20. In the specific case of Kinsella et al., it is clear that one of ordinary skill in the art would understand that the patients having fatal congenital anomalies or congenital heart disease were excluded not because of a suspected safety risk of treating these patients with inhaled NO (e.g., a risk of pulmonary edema), but rather solely because the inclusion of such patients would have made it much more difficult – if not impossible - for Kinsella et al. to interpret the target outcomes of the study (i.e., would have “confounded” the results).

21. On page 9 of the Office Action, the Examiner states:

*Loh et al. teach that inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure (Title and Abstract). Loh et al. clearly teaches that patients with pulmonary artery wedge pressure, which is synonymous with the instantly claimed pulmonary capillary wedge pressure, of greater than or equal to 18mm Hg had a greater effect of inhaled NO due to the greater degree of reactive pulmonary hypertension present in such patients (p. 2784, left column). Loh et al. state: “Since the degree of reactive pulmonary hypertension is generally related to the severity of hemodynamic compromise in patients with LV failure, it might be*

*anticipated that patients with more severe heart failure will have a more marked hemodynamic response to inhaled NO." Loh et al. examined this prediction further and verified it (p. 2784, left column).*

The Examiner apparently neglects to consider that the acute hemodynamic effect of inhaled NO was studied by Loh et al. only in **adult** patients with New York Heart Association Class III or IV congestive failure due to coronary artery disease or dilated cardiomyopathy, not in term or near-term neonates who were not dependent upon right-to-left shunting. Thus, their observations do not teach, or even suggest, the risk of inhaled NO in neonates or children with pulmonary hypertension and left ventricular dysfunction who are not dependent on right-to-left shunting of blood, the population that is addressed in the present claims.

22. The underlying etiologies and hemodynamic characteristics of both the primary heart disease and the increased pulmonary vascular resistance are drastically different from adults, as compared to non-adults, such that one cannot readily assume or anticipate clinical results within adults to translate into neonates or children. In particular, left ventricular dysfunction in neonates with congenital heart disease is primarily due to developmental structural disease of the heart, inborn errors of metabolism that impair energy generation in the heart muscle, or viral infection. Class III or class IV congestive heart failure in adults (in contrast to congenital heart disease in neonates or children) is due to ischemic or dilated cardiomyopathy, mostly secondary to coronary artery disease and/or chronic systemic hypertension. Pulmonary hypertension associated with neonatal congenital heart disease is secondary to chronic hypoxemia, developmental abnormalities of the pulmonary blood vessels and/or pulmonary vascular damage from abnormally high blood flow and/or pressure through the pulmonary vasculature, resulting in evident disease of the lung vasculature. In contrast, increased pulmonary vascular resistance in adult Class III or IV congestive heart failure is due to reactive pulmonary vasoconstriction secondary to increased sympathetic tone or circulating vasoactive molecules (Loh et al., p. 2780, left column) in otherwise structurally normal blood vessels. Therefore, the hemodynamic responses to pulmonary vasodilation by inhaled NO in children or neonates, without right-to-left shunting of blood, but with significant pulmonary hypertension and left ventricular dysfunction cannot be reasonably predicted from the hemodynamic responses to pulmonary vasodilation by inhaled NO of adults with advanced

atherosclerotic congestive heart failure and reactive neuro-humoral pulmonary vascular constriction (with or without pulmonary hypertension) as described by Loh et al.

23. On page 10 of the Office Action, the Examiner states:

*“It would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to perform the method of Atz et al. and identify patients with a second condition/risk factor and administer iNO to patients that do not have the first or second condition/risk factors of instant claims 20-27 and inform the medical provider that patients with a pulmonary capillary wedge pressure greater than 20 mm Hg that may increase pulmonary edema, as suggested by Loh et al., and Kinsella et al., and produce the instant invention.”*

24. Atz & Wessel do not recommend exercising “caution” when treating term or near-term neonates who are not dependent upon right-to-left shunting, but rather refer to two other patient populations, namely (i) neonatal patients whose systemic circulation is dependent upon right-to-left shunting of blood and who therefore might suffer from systemic circulatory collapse if given inhaled NO (a well-known contraindication for inhaled NO) and (ii) adult patients with New York Heart Association Class III-IV heart failure due to ischemic or dilated cardiomyopathy and increased neuro-humorally-mediated pulmonary vascular resistance might be hemodynamically at risk for pulmonary edema if given inhaled NO (the same population discussed by Loh et al.).

25. On page 10 of the Office Action, the Examiner states:

*“One of ordinary skill in the art would have been motivated to do this because: 1) it is common sense that if the neonate is healthy then iNO therapy can be performed safely; 2) if the neonate is not healthy and has left ventricular dysfunction (LVD), then Atz et al. clearly teach using extreme caution or not using NO at all in the treatment of patients with LVD which would also render obvious all conditions/risk factors associated with LVD; and 3) the art of Kinsella et al. establishes excluding certain patients (premature neonates) from inhaled nitric oxide treatment if they have fatal congenital anomalies or congenital heart disease.”*

The conclusion presented by the Examiner is not clinically accurate, nor does it accurately reflect the expectations or motivations of a clinician of ordinary skill in the art at the time of the invention. Their expectation would have been quite the opposite. It is by no means “1) ... common sense that if the neonate is healthy then iNO therapy can be performed safely; 2) if the neonate is not healthy and has left ventricular dysfunction (LVD), then Atz et al. clearly teach using extreme caution or not using NO at all in the treatment of patients with LVD.” Firstly, inhaled NO would have no utility in healthy neonates, and is safely used in very severely ill neonates on a routine basis. Secondly, Atz & Wessel teach “using extreme caution or not using NO at all” only in neonates dependent upon right-to-left shunting of blood in order to avoid systemic circulatory collapse, and makes no statement regarding neonates with left ventricular dysfunction **who are not dependent upon right-to-left shunting**. Kinsella et al. do not teach about the safe or unsafe use of inhaled NO in neonates or children, let alone term or near-term neonates not dependent upon right-to-left shunting, but merely noted that they had excluded premature babies with fatal malformations or congenital heart disease from a clinical trial of inhaled NO in premature babies suffering from the respiratory distress of prematurity. Loh et al. teach about the effect of inhaled NO on hemodynamic measurements in adults with advanced heart failure and secondary neuro-humorally-mediated increased pulmonary vascular resistance, and speculate that these adults may be at increased risk for pulmonary edema, but do not teach anything about the use of inhaled NO in term or near-term neonates not dependent upon right-to-left shunting.

26. On page 11 of the Office Action, the Examiner states:

*“Furthermore, it is already known through the teachings of Loh et al. that a pulmonary capillary wedge pressure (PCWP) of greater than 18 mm Hg serves as a guidepost for alerting the artisan to adverse events from inhaled NO. Thus, it is not inventive to exclude patients with a PCWP of greater than 20 mm Hg when the art already suggests the risk of trouble of treating patients with a PCWP of 18 mm Hg because inhaled NO increases the wedge pressure as taught by Loh et al. (see entire document). In summary, it remains the position of the Examiner, which is in alignment with the written opinion of the international search authority, that it is simply not inventive to 'inform' a medical provider that a neonate with LVD is at risk of adverse/serious adverse*

*events from iNO therapy when the art already has established that fact and the ordinary artisan is alerted to this fact. If the patient has LVD then they are at risk of adverse and/or serious adverse events from iNO therapy and it is not inventive to further identify other secondary conditions/risk factors associated with LVD and provide further warnings for secondary conditions/risk factors that are separate and independent from the first condition/risk factor but nevertheless associated with LVD to the medical provider. Screening for conditions that predispose the patient to adverse/serious adverse effects from medical treatment is obvious given the teachings above.* (emphasis in original)

It is inaccurate to represent Loh et al as “*servicing as a guidepost for alerting the artisan to adverse events from inhaled NO,*” as Loh et al. reported no adverse events during administration of inhaled NO for 10 minutes to 19 stable patients with advanced heart failure. Rather, Loh et al. speculated that a finding of an elevation in PCWP in a subgroup of such patients could pose an increased risk of pulmonary edema in adults with congestive heart failure due to ischemic or dilated cardiomyopathy. As discussed above, extrapolation of that theoretical risk to neonates and children with different forms of heart disease, different cardiovascular hemodynamics, and different pulmonary vasculature physiology, pathophysiology and pathology was not obvious, as evidenced by the fact that the members of the INOT22 Screening Committee (including Dr. Wessel) who designed the INOT22 study protocol, the approximately 18 Institutional Review Boards and/or Independent Ethics Committee, and 5 National Health Authorities (FDA and national Health Authority for United Kingdom, France, Netherlands and Spain) who reviewed and approved the INOT22 study protocol prior to its initiation, all failed to predict that any untoward effects would be caused by the administration of inhaled NO within a pediatric patient population having left ventricular dysfunction who are not dependent on right-to-left shunting of blood.. Only after being informed of the present invention did the FDA mandate a change to the drug labeling for inhaled NO to include a new warning (separate and distinct from the pre-existing contraindication pertaining to neonates dependent on right-to-left shunting of blood) concerning the use of inhaled NO in patients with pre-existing left ventricular dysfunction.

27. On page 12 of the Office Action the Examiner states:

*Respectfully, the instantly claimed method steps are in the realm of common sense and not in the realm of invention because it is already known in the art that patients with pre-existing LVD are at risk of adverse effects from iNO. It is obvious to the ordinary artisan that if the neonate has LVD with or without any number of conditions/risk factors, then in order to avoid the risk of adverse or serious adverse events associated with iNO, to then exclude the neonate from iNO therapy. In other words, given the art as a whole, determination of further conditions/risk factors that would exclude the neonate from iNO therapy is obvious given the teachings in the art as discussed above which direct the artisan to screen neonates about to undergo treatment with NO by inhalation and to exclude those with LVD from such treatment. In light of the forgoing discussion, the Examiner concludes that the subject matter defined by the instant claims would have been obvious within the meaning of 35 USC 103(a). From the teachings of the references, it is apparent that one of ordinary skill in the art would have had a reasonable expectation of success in producing the claimed invention. Therefore, the invention as a whole was prima facie obvious to one of ordinary skill in the art at the time the invention was made, as evidenced by the references, especially in the absence of evidence to the contrary."*

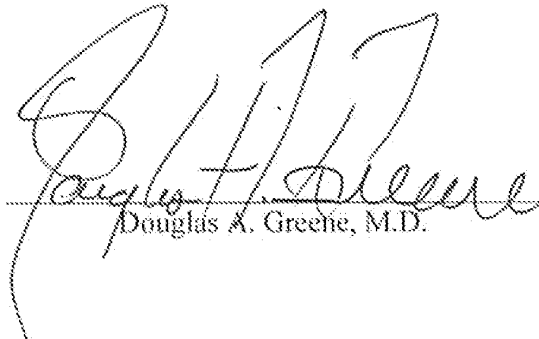
The arguments by which this conclusion is supported are both medically and scientifically unsound. To summarize, the teaching of Atz & Wessel is inaccurately portrayed by the Examiner due to his confusion of the known risk of systemic vascular collapse if inhaled NO is administered to neonates dependent upon right-to-left shunting of blood, and the opposite case of adults where inhaled NO may be less effective than in children. The Examiner misconstrues Kinsella et al.'s clinical trial inclusion/exclusion criteria as a teaching of risk associated with inhaled NO administration, rather than as a routine practical measure in the design of clinical trials to minimize confounding factors and heterogeneity in the study population. Lastly, the Examiner grossly over-interprets the hemodynamic findings of Loh et al. in adults with ischemic or dilated cardiomyopathy and congestive heart failure (a disease process differing in etiology, physiology, pathophysiology and pathology from childhood congenital heart disease) as "a guidepost to the artisan" regarding the use of inhaled NO in children and neonates with pulmonary hypertension and left ventricular dysfunction, but not dependent on right-to-left shunting of blood. These inaccurate and erroneous interpretations of all three supporting publications cited by the Examiner lead the Examiner to draw incorrect conclusions regarding what is or is not taught or suggested by the prior art.

28. On June 28, 2011, I met with Dr. David L. Wessel, the chair of the INOT22 Steering Committee and the senior author of *Atz & Wessel (Seminars in Perinatology 1997, 21(5), pp 441-455*. During our discussion, I informed Dr. Wessel of the 12/820,866 and 12/820,980 patent applications, and the fact that in both pending patent applications, the Examiner was citing Atz & Wessel to allege that it would have been obvious to predict the adverse events and outcomes of the INOT22 study that lead to the inventions claimed in 12/820,866 and 12/820,980.

29. Dr. Wessel disagreed with the Examiner's allegation and found it ironic that his own publication would be cited to suggest the obviousness of the unexpected outcomes of the INOT22 study, when Dr. Wessel himself, the senior author of Atz & Wessel, failed to predict that neonatal and child patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood would be at increased risk of adverse events when administered inhaled NO. A copy of a June 29, 2011 letter from Dr. Wessel to me stating this opinion is attached hereto as Exhibit 2.

30. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the '359 patent.

Dated: 7/7/11

  
Douglas A. Greene, M.D.

Applicant : Baldassarre et al  
Serial No. : 12/820,866  
Filed : 22JUN10  
Page : 15 of 15

Attorney's Docket No.: I001-0002USC1

# EXHIBIT 1

(curriculum vitae)



## CURRICULUM VITAE

### PERSONAL DATA

Name: Douglas Alan Greene, M.D.

### EDUCATION

High School Columbia High School, South Orange, NJ, 1962  
Undergraduate Princeton University, Princeton, NJ, BA Biology(cum laude), 1962-1966  
Graduate/Professional Johns Hopkins School of Medicine, Baltimore, MD, M.D., 1966-1970

### POSTDOCTORAL TRAINING

Medical Internship: Department of Medicine, Johns Hopkins, Baltimore, MD, 1970-1971  
Medical Residency: Department of Medicine, Johns Hopkins, Baltimore, MD, 1971-1972  
Fellowship: Medical Fellowship, Department of Medicine, Johns Hopkins University, School of Medicine, Baltimore, MD, 1970-1972

Post-doctoral Research Fellow, Diabetes, George S. Cox Medical Research Institute; Hospital of the University of Pennsylvania, Philadelphia, PA (Dr. Albert I. Winegrad, preceptor), 1972-1975

Medical Fellowship, Department of Medicine, University of Pennsylvania, School of Medicine, Philadelphia, PA, 1972-1975

### NON-ACADEMIC EMPLOYMENT

2000-2003 Executive Vice President, Clinical Sciences and Product Development (CSPD), Merck Research Laboratories, Rahway, New Jersey, and Corporate Officer, Merck, Inc. Supervised and directly managed all clinical research, regulatory affairs, clinical and non-clinical quality assurance and pharmaco-vigilance at Merck Research Laboratories.

2003-2006 Vice President, Head Corporate Regulatory Development, Sanofi-Aventis, Bridgewater, NJ. Overseeing all aspects of corporate regulatory development of all pre-clinical and clinical development projects/life-cycle products in Research & Development.

2006-2009 Senior Vice President, Chief Medical Officer, Sanofi-Aventis, Bridgewater, NJ. Overseeing medical, regulatory, pharmacovigilance, risk management, education and medical communications for US region, Member US Executive Committee, Member Committee Operational de Development, International Clinical Development.

2009-present Senior Vice President, Senior Scientific Advisor, Sanofi-Aventis, Bridgewater, New Jersey. Member Corporate Portfolio Valuation Process and Drug Development Committees. The position at the interface between the Research and Development and Pharmaceutical Operations is responsible for providing key scientific and medical guidance for sanofi-aventis' scientific strategy within U.S. and global contexts to enhance the quality and effectiveness of the company's research and product portfolio, including assessment and guidance of internal R&D product pipeline and franchise portfolio and external commercial and academic innovation opportunities.

#### **ACADEMIC APPOINTMENTS**

1975-1980	Assistant Professor of Medicine, University of Pennsylvania, School of Medicine, Philadelphia, Pennsylvania
1980-1986	Associate Professor of Medicine, Director, General Clinical Research Center and Diabetes Research Laboratories, University of Pittsburgh, School of Medicine
1986-2000	Professor of Internal Medicine, Director, Michigan Diabetes Research and Training Center, University of Michigan School of Medicine
1991-2000	Chief, Division of Endocrinology & Metabolism, University of Michigan School of Medicine
2000-Present	Adjunct Professor, Internal Medicine, Division of Endocrinology & Metabolism, University of Michigan, School of Medicine

#### **SELECTED SCIENTIFIC ACTIVITIES**

1988-1994	Chairman, Endocrinologic and Metabolic Drug Advisory Board, Food and Drug Administration, Washington D.C (Chair, 1990-1994)
1994-2000	Chairman, Merck Scientific Board of Advisors

#### **SELECTED SCIENTIFIC PRIZES AND AWARDS**

1986	First Annual Raymond A. and Robert L. Kroc Lecturer, Eisenhower Medical Center, Palm Springs, California
1987	Moore Award, The American Association of Neuropathologists, Seattle, Washington
1987	Carol Sinicki Manuscript Award (The Diabetes Educator), American Association of Diabetes Educators, Chicago, Illinois
1988	Kellion Lecture, International Diabetes Federation, Sydney, Australia
1989	Banting and Best Lecture, Toronto General Hospital, Toronto, Canada
1994	Charles H. Best Lecturer, Toronto Diabetes Association, Toronto, Canada
1996	Invited Speaker, Seventy-fifth Anniversary Celebrating the Discovery of Insulin, Toronto, Canada
1996	First Alan Robinson Lecturer, University of Pittsburgh
1998	Outstanding Foreign Investigator Award, Japan Society of Diabetic Complications

## SELECTED BIBLIOGRAPHY

### *Peer-Reviewed Publications (Selected from over 170 peer-reviewed articles):*

1. Greene DA, DeJesus PV, Winegrad AI: Effect of insulin and dietary Myo-Inositol on impaired peripheral motor nerve conduction velocity in acute streptozotocin diabetes. *J. Clin. Invest.* 55:1326-1336, 1975.
2. Winegrad AI, Greene DA: Diabetic polyneuropathy: The importance of insulin deficiency, hyperglycemia and alterations in myoinositol metabolism in its pathogenesis. *N. Engl. J. Med.* 295:1416-1420, 1976.
3. Greene DA, Lattimer SA: Sodium- and energy dependent uptake of myo-inositol by rabbit peripheral nerve. Competitive inhibition by glucose and lack of an insulin effect. *J. Clin. Invest.* 70:1009-1018, 1982.
4. Greene DA, Lattimer SA: Impaired rat sciatic nerve sodium-potassium ATPase in acute streptozotocin diabetes and its correlation by dietary myo-inositol supplementation. *J. Clin. Invest.* 72:1058-1063, 1983.
5. Greene DA, Lattimer SA: Impaired energy utilization and Na-K-ATPase in diabetic peripheral nerve. *Am. J. Physiol.* 246:E311-E318, 1984.
6. Greene DA, Yagihashi S, Lattimer SA, Sima AAF: Nerve Na<sup>+</sup>+K<sup>+</sup>-ATPase, conduction and myo-inositol in the insulin deficient BB rat. *Am J Physiol* 247:E534-E539, 1984.
7. Greene DA, Lattimer SA: Protein kinase C agonists acutely normalize decreased ouabain-inhibitable respiration in diabetic rabbit nerve: Implications for [Na,K]-ATPase regulation and diabetic complications. *Diabetes* 35:242-245, 1986.
8. Sima AAF, Lattimer SA, Yagihashi S, Greene DA: 'Axo-glial dysjunction' a novel structural lesion that accounts for poorly-reversible slowing of nerve conduction in the spontaneously diabetic BB-rat. *J. Clin. Invest.* 77:474-484, 1986.
9. Greene DA: A sodium-pump defect in diabetic peripheral nerve corrected by sorbinil administration: Relationship to myo-inositol metabolism and nerve conduction slowing. *Metabolism* 35:60-66, 1986.
10. Greene DA, Mackway AM: Decreased myo-inositol content and Na<sup>+</sup>-K<sup>+</sup>-ATPase activity in superior cervical ganglion of STZ-diabetic rat and prevention by aldose reductase inhibition. *Diabetes* 35:1106-1108, 1986.
11. Carroll PB, Thornton BM, Greene DA: Glutathione redox state is not the link between polyol pathway activity and diminished (Na,K)-ATPase activity in experimental diabetic neuropathy. *Diabetes* 35:1282-1285, 1986.
12. Greene DA, Lattimer SA, Sima AAF: Sorbitol, phosphoinositides and the sodium-potassium ATPase in the pathogenesis of diabetic complications. *N. Engl. J. Med.* 316:599-606, 1987.
13. Greene DA, Chakrabarti S, Lattimer SA, Sima AAF: Role of sorbitol accumulation and myo-inositol depletion in paranodal swelling of large myelinated nerve fibers in the insulin-deficient spontaneously diabetic bio-breeding rat: Reversal by insulin replacement, an aldose reductase inhibitor, and myo-inositol. *J. Clin. Invest.* 79:1479-1485, 1987.

14. Sima AAF, Nathaniel V, Bril V, McEwen TAJ, Greene DA: Histopathological heterogeneity of neuropathy in insulin-dependent and non-insulin-dependent diabetes, and demonstration of axo-glial dysjunction in human diabetic neuropathy. *J. Clin. Invest.* 81:349-364, 1988.
15. Greene DA, Lattimer SA, Sima AAF: Perspectives in diabetes: Are disturbances of sorbitol, phosphoinositide, and Na<sup>+</sup>-K<sup>+</sup>-ATPase regulation involved in pathogenesis of diabetic neuropathy? *Diabetes* 37:688-693, 1988.
16. Greene DA, Lattimer SA, Sima AA: Pathogenesis and prevention of diabetic neuropathy. *Diabetes Metab Rev* 4:201-221, 1988.
17. Lattimer SA, Sima AAF, Greene DA: In Vitro correction of impaired Na<sup>+</sup>-K<sup>+</sup>-ATPase in diabetic nerve by protein kinase C agonists. *Am. J. Physiol.* 256 (Endocrinol. Metab. 19):E264-E269, 1989.
18. Greene DA, Lattimer SA, Sima AAF: Pathogenesis of diabetic neuropathy: Role of altered phosphoinositide metabolism. *CRC Critical Reviews in Neurobiology* (J. Nelson, ed., CRC Press, Inc.), pp. 143-219, 1989.
19. Greene DA, Lattimer SA, Carroll PB, Fernstrom JD, Finegold DN: A defect in sodium-dependent amino acid uptake in diabetic rabbit peripheral nerve: Correction by an aldose reductase inhibitor or myo-inositol administration. *J. Clin. Invest.* 85:1657-1665, 1990.
20. Greene DA, Sima AF, Pfeifer MA, Albers JW. Diabetic Neuropathy. *Annu Rev Med* 41:303-317, 1990.
21. Sima AAF, Prashar A, Zhang W-X, Chakrabarti S, Greene DA: Preventive effect of long-term aldose reductase inhibition (Ponalrestat) on nerve conduction and sural nerve structure in the spontaneously diabetic bio-breeding rat. *J. Clin. Invest.* 85:1410-1420, 1990.
22. Kim J, Kyriazi H, Greene DA: Normalization of (Na,K)-ATPase activity in an isolated membrane fraction from sciatic nerves of streptozotocin-diabetic rats by dietary myo-inositol supplementation in vivo or protein kinase C agonists in vitro. *Diabetes* 40:558-567, 1991.
23. Stevens MJ, Lattimer SA, Kumijo M, Van Huysen C, Sima AAF, Greene DA: Osmotically induced nerve taurine depletion in experimental diabetes: An hypothetical mediator of painful neuropathy. *Diabetologia* 36:608-614, 1993.
24. Henry DN, Del Monte M, Greene DA, Killen PD: Altered aldose reductase gene regulation in cultured human retinal pigment epithelial cells. *J. Clin. Invest.* 92:617-623, 1993.
25. The DCCT Research Group: The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N. Eng. J. Med.* 329:977-986, 1993.
26. Thomas TP, Feldman BL, Nakamura J, Kato K, Lien M, Stevens MJ, Greene DA: Ambient glucose and aldose reductase-induced myo-inositol depletion modulate basal and carbachol-stimulated inositol phospholipid metabolism and diacylglycerol accumulation in human retinal pigment epithelial cells in culture. *Proc. Natl. Acad. Sci. USA* 90:9712-9716, 1993.
27. Thomas TP, Porcellati F, Kato K, Stevens MJ, Sherman WR, Greene DA: Effects of glucose on sorbitol pathway activation, cellular redox, and metabolism of myo-inositol, phosphoinositide and

- diacylglycerol in cultured human retinal pigment epithelial cells. *J. Clin. Invest.* 93:2718-2724, 1994.
28. Stevens MJ, Dananberg J, Feldman EL, Lattimer SA, Kamijo M, Thomas TP, Shindo H, Sima AAF, Greene DA: The linked roles of nitric oxide, aldose reductase and (Na<sup>+</sup>,K<sup>+</sup>)-ATPase in the slowing of nerve conduction in the streptozotocin diabetic rat. *J. Clin. Invest.* 94:853-859, 1994.
  29. Feldman EL, Stevens MJ, Thomas PK, Brown MB, Canal N, Greene DA: A practical two-step quantitative clinical and electrophysiological assessment for the diagnosis and staging of diabetic neuropathy. *Diabetes Care* 17:1281-1289, 1994.
  30. The DCCT Research Group: The effect of intensive treatment of diabetes on nerve conduction measures in the DCCT. *Annals of Neuro.* 38:869-880, 1995.
  31. Stevens MJ, Feldman EL, Greene DA: The aetiology of diabetic neuropathy: The combined roles of metabolic and vascular defects. *Diabetic Medicine* 12:566-579, 1995.
  32. Shindo H, Thomas TP, Larkin DD, Karihaloo AK, Inada H, Onaya T, Stevens MJ, Greene DA: Modulation of basal nitric oxide-dependent cyclic-GMP production by ambient glucose, myo-inositol, and protein kinase C in SH-SY5Y human neuroblastoma cells. *J Clin Invest* 97:736-745, 1996.
  33. Sima AAF, Ristic H, Merry A, Kamijo M, Lattimer SA, Stevens MJ, Greene DA: Primary preventive and secondary interventional effects of acetyl-L-carnitine on diabetic neuropathy in the bio-breeding Worcester rat. *J Clin Invest* 97:1900-1907, 1996.
  34. Karihaloo A, Kato K, Greene DA, Thomas TP: Protein kinase and cytosolic calcium modulation of myo-inositol transport in cultured retinal pigment epithelial cells. *Am J Physiol* 273:C671-678, 1997.
  35. The DCCT Research Group: Effect of intensive therapy on residual  $\beta$ -cell function in patients with Type I diabetes in the DCCT: A randomized, controlled trial. *Ann Int Med* 128:517-523, 1998.
  36. The DCCT Research Group: The effect of intensive diabetes therapy on measures of autonomic nervous system function in the DCCT. *Diabetologia* 41:416-423, 1998.
  37. Porcellati F, Hlaing T, Togawa M, Stevens MJ, Larkin DD, Hosaka Y, Glover TW, Henry DN, Greene DA, Killen PD: Human Na<sup>+</sup>-myo-inositol cotransporter gene: alternate splicing generates diverse transcripts. *Am J Physiol.* 274: C1215-C1225, 1998.
  38. Porcellati F, Hosaka Y, Hlaing T, Togawa M, Larkin DD, Karihaloo A, Stevens MJ, Killen PD, Greene DA: alternate splicing in human Na<sup>+</sup>-MI cotransporter gene yields differentially regulated transport isoforms. *Am J Physiol* 276:1325-1337, 1999.
  39. Greene DA, Stevens MJ, Obrosova I, Feldman EL. Glucose-induced oxidative stress and programmed cell death in diabetic neuropathy. *European Journal of Pharmacology* 375:217-223, 1999.
  40. Greene DA, Arezzo JC, Brown MB: Effect of aldose reductase inhibition on nerve conduction and morphometry in diabetic neuropathy. *Neurology* 53:580-591, 1999.

41. Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group: Retinopathy and nephropathy in patients with type 1 diabetes four years after a trial of intensive therapy. *N Engl J Med* 342:381-389, 2000.
42. Sundkvist G, Dahlin LB, Nilsson H, Eriksson KF, Lingarde F, Rosen I, Lattimer SA, Sima AAF, Sullivan KA, Greene DA: Sorbitol and myo-inositol levels and morphology of sural nerve in relation to peripheral nerve function and clinical neuropathy in men with diabetic, impaired, and normal glucose tolerance. *Diabetic Medicine* 17:259-268, 2000.
43. Stevens MJ, Obrosova I, Cao X, Van Huysen C, Greene DA: Effects of DL-alpha-lipoic acid on peripheral nerve conduction, blood flow, energy metabolism and oxidative stress in experimental diabetic neuropathy. *Diabetes* 49:1006-1015, 2000.
44. Obrosova IG, Fathallah L, Greene DA: Early changes in lipid peroxidation and antioxidative defense in diabetic rat retina: effect of DL-alpha-lipoic acid. *Eur J Pharmacol* 398:139-146, 2000.
45. White NH, Cleary PA, Dahms W, Goldstein D, Malone J, Tamborlane WV; Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) Research Group: Beneficial effects of intensive therapy of diabetes during adolescence: outcomes after the conclusion of the Diabetes Control and Complications Trial (DCCT). *J Pediatr* 139:804-812, 2001.
46. Perkins BA, Greene DA, Bril V: Glycemic control is related to the morphological severity of diabetic sensorimotor polyneuropathy. *Diabetes Care* 24: 748-752, 2001.
47. Moller DE, Greene DA: Peroxisome proliferators-activated receptor (PPAR) gamma agonists for diabetes. *Adv Protein Chem* 56:181-212, 2001.
48. Obrosova IG, Van Huysen C, Fathallah L, Cao XC, Greene DA, Stevens MJ: An aldose reductase inhibitor reverses early diabetes-induced changes in peripheral nerve function, metabolism, and antioxidative defense. *FASEB J* 16:123-125, 2002.
49. Pop-Busui R, Marinescu V, Van Huysen C, Li F, Sullivan K, Greene DA, Larkin D, Stevens MJ: Dissection of metabolic, vascular, and nerve conduction interrelationships in experimental diabetic neuropathy by cyclooxygenase inhibition and acetyl-L-carnitine administration. *Diabetes* 51: 2619-2628, 2002.
50. Viberti G, Kahn SE, Greene DA, Herman WH, Zinman B, Holman RR, Haffner SM, Levy D, Lachin JM, Berry RA, Heise MA, Jones NP, Freed MI: A diabetes outcome progression trial (ADOPT): an international multicenter study of the comparative efficacy of rosiglitazone, glyburide, and metformin in recently diagnosed type 2 diabetes. *Diabetes* 25:1737-1743, 2002.
51. The Writing Team for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group: Effect of intensive therapy on the microvascular complications of type 1 diabetes mellitus. *JAMA* 287:2563-2569, 2002.

Applicant : Baldassarre et al  
Serial No. : 12/820,866  
Filed : 22JUN10  
Page : 16 of 15

Attorney's Docket No.: 1001-0002USC1

## EXHIBIT 2

(June 29, 2011, letter from Dr. David Wessel to Dr. Douglas Greene)

8191933.2

Ex. 2007-0865



**Children's National**  
Medical Center

David L. Wessel, MD

Senior Vice President

Center for Hospital-Based Specialties

*Barrie® Distinguished Professor of*

*Critical Care Medicine*

June 29, 2011

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Ikaria, Inc.  
Perryville III Corporate Park  
53 Frontage Road, 3<sup>rd</sup> Floor  
PO Box 9001  
Hampton, NJ 08827-9001

RE: **USSN 12/820,866 and 12/820,980**  
***Atz et al., Seminars in Perinatology 1997,21(5), pp 441-455***

Dear Doug:

In 2005, I chaired the Steering Committee of the Sponsor, INO Therapeutics LLC (INOT), to establish, design and oversee the INOT22 Study. Presently, I am Chief, Division of Critical Care Medicine and Senior Vice President, Children's National Medical Center, Washington, D.C.<sup>1</sup>

In addition to being the Chair of the INOT22 Steering Committee, I also am the senior author of *Atz et al., Seminars in Perinatology 1997,21(5), pp 441-455* (Atz et al.).

At the time of the design of the INOT22 Study protocol, neither myself, the other Steering Committee members, nor the study Sponsor appreciated or anticipated that a child with left ventricular dysfunction who is not dependent on right-to-left shunting of blood would be at additional risk when treated with inhaled nitric oxide (iNO). This is the reason such children were not originally excluded from the INOT22 Study entry criteria.

Neither the Atz et al. article that I co-authored, nor the medical literature or medical experience of which I was aware at the time, predict this risk. Instead, Atz et al describes two distinct, independent precautions with respect to the use of iNO. First, with respect to adults, Atz et al. stated that iNO may be more effective in newborns than in older patients, and noted that it

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<sup>1</sup> In the interest of full disclosure, I formerly served as a consult for INO Therapeutics LLC. I currently serve without remuneration as a member of the Ikaria Scientific Board of Advisors. In 2010 I was appointed by my institution as the Ikaria Distinguished Professor of Critical Care Medicine.





should be used with caution in adults with ischemic cardiomyopathy in whom a risk of pulmonary edema is a consideration (see page 452, left column). Second, with respect to neonates, we stated the well-known contraindication (currently found in the INOMAX<sup>®</sup> prescribing information) that iNO should not be used in newborns dependent upon right-to-left shunting of blood across a patent ductus arteriosus to avoid circulatory collapse. What we did not disclose or predict was that neonatal patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood would be at greater risk of adverse events.

It is ironic that my own publication would be cited to suggest that it would have been obvious to predict the adverse events and outcomes of the INOT22 Study when I, the senior author of Atz et al., failed to anticipate or predict these unexpected outcomes at the time I participated in drafting the original INOT22 Study protocol. If so, I would have been acting either negligently or intentionally to harm babies, and I most certainly was not. Furthermore, to my knowledge, none of the other members of the INOT22 Steering Committee who assisted me in designing the study, nor the approximately 18 Institutional Review Boards and 2 National Health Authorities who reviewed and approved the study prior to its initiation, predicted the adverse events in children with left ventricular dysfunction who are not dependent on right-to-left shunting of blood.

In summary, although it was known that neonates whose systemic circulation was dependent on right-to-left shunt should not receive iNO, and it had been reported that adults with pre-existing left ventricular dysfunction (from coronary artery disease) may be at risk when provided iNO, it was unanticipated and surprising that children with left ventricular dysfunction who are not dependent on right-to-left shunting would be at increased risk of adverse events when administered iNO.

Sincerely,

A handwritten signature in black ink, appearing to read "David L. Wessel", written in a cursive style.

David L. Wessel, M.D.

Applicant : James S. Baldassarre et al.  
Serial No. : 12/820,866  
Filed : June 22, 2010  
Page : 26 of 23

Attorney's Docket No.: I001-0002USC1

## APPENDIX C

(Declaration of James S. Baldassarre)

UNITED STATES PATENT AND TRADEMARK OFFICE	
Application Serial Number	12/820,866
Confirmation Number	2913
Filing Date	22-JUN-2010
Title of Application	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
First Named Inventor	JAMES S. BALDASSARRE
Assignee	IKARIA, INC.
Group Art Unit	1616
Examiner	ARNOLD, ERNST V.
Attorney Docket Number	I001-0002USC1

Mail Stop Amendment  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

DECLARATION OF JAMES S. BALDASSARRRE, M.D.  
UNDER 37 C.F.R. § 1.132

I, James S. Baldassarre, do hereby declare the following:

1. I currently hold the position of Vice President of Clinical Research at INO Therapeutics LLC (“INO”), which is a wholly-owned subsidiary of Ikaria, Inc. A copy of my *curriculum vitae* is attached as **Exhibit 1**.
2. I have over 20 years of experience as a physician and over fifteen years of experience directing clinical research in the pharmaceutical industry.
3. In 2004, I was the Medical Monitor responsible for the design and execution of the INOT22 study.
4. The INOT22 study, entitled “Comparison of Supplemental Oxygen and Nitric Oxide for Inhalation Plus Oxygen in the Evaluation of the Reactivity of the Pulmonary Vasculature During Acute Pulmonary Vasodilatory Testing”, was a randomized, multi-center study having an expected

enrollment of 150 patients, aged four weeks to 18 years, in approximately 18 study sites over approximately 2 years.

5. The INOT22 study was established and designed by the study sponsor, INO Therapeutics LLC and a Steering Committee comprising international recognized experts in the field of pediatric heart and lung disease, whose members would assist INO to develop the INOT22 protocol, monitor the progress of the trial, and provide recommendations to INO on changes in the procedures and conduct of the trial

6. The Steering Committee consisted of:

- a. David L. Wessel, MD, presently Senior Vice President, The Center for Hospital based Specialties, and Division Chief, Pediatric Critical Care Medicine at Children's National Medical Center, Washington, DC;
- b. Robyn J. Barst, MD, presently Professor Emeritus of Pediatrics and Medicine, Columbia University College of Physicians and Surgeons, New York; and
- c. Duncan J. Macrae, MD, presently Director, Pediatric Intensive Care, Royal Brompton Hospital, London, UK.

7. The original INOT22 study protocol designed by INO and the Steering Committee did not exclude study patients with pre-existing left ventricular dysfunction who were not dependent on right-to-left shunting of blood.

8. After the INOT22 study protocol design, but prior to study initiation and enrollment, the original INOT22 study protocol was reviewed by an Institutional Review Board (IRB) and/or Independent Ethics Committee (IEC) at each of the 18 participating study institutions, including review by the principal investigator within each study institution. In addition, prior to study initiation and enrollment, the original INOT22 study protocol was reviewed by the US Food and

Drug Administration (FDA) and separately reviewed by each national Health Authority (European equivalent to FDA) within the four European countries participating in the INOT22 trial (United Kingdom, France, Netherlands and Spain). In addition, INO regularly requested input and scientific guidance on clinical trials from its own Scientific Advisory Board. At no time did any member of the Steering Committee, INOT, an IRB, IEC, individual principal investigator, Advisory Board member, FDA or European Health Authority appreciate, recognize or otherwise suggest that subjects with pre-existing left ventricular dysfunction who are not dependent on right-to-left shunt should be excluded from the INOT22 study or that such subjects would be anticipated or predicted to have an increased risk of adverse events or serious adverse events arising from the administration to them of inhaled nitric oxide.

9. Under FDA regulations, an IRB is an appropriately constituted group that has been formally designated to review and monitor biomedical research involving human subjects. In accordance with FDA regulations, an IRB has the authority to approve, require modifications in (to secure approval), or disapprove research. This group review serves an important role in the protection of the rights and welfare of human research subjects. The purpose of IRB review is to assure, both in advance and by periodic review, that appropriate steps are taken to protect the rights and welfare of humans participating as subjects in the research. To accomplish this purpose, IRBs use a group process to review research protocols to ensure protection of the rights and welfare of human subjects of research. An IRB must have at least five members and each member must have enough experience, expertise and diversity to make an informed decision on whether the research is ethical, informed consent is sufficient and the appropriate safeguards have been put in place (see 21 CFR Part 56).

10. In Europe, an Ethics Committee is an independent body in a Member State consisting of healthcare professionals and non-medical members whose responsibility is to protect the rights, safety and well being of human subjects involved in a clinical trial and to provide public assurance of that protection by expressing an opinion on a proposed clinical trial protocol, the suitability of the investigators and adequacy of facilities involved in a trial (see Directive 2001/20/EC).

11. In total, at least 115 individuals experienced in, and responsible for, the review of clinical trial protocols for patient safety, in addition to the FDA and four European Health Authorities reviewed the original INOT22 protocol prior to initiating the INOT22 study. Again, not a single individual or authority suggested, predicted or raised a concern about an increased risk associated with the use of inhaled nitric oxide in study subjects with pre-existing left ventricular dysfunction who are not dependent on right-to-left shunt.

12. On the contrary, it was only after unexpected serious adverse events (including at least one death) occurred during the course of the INOT22 study that the study protocol was amended to exclude study subjects with pre-existing left ventricular dysfunction who are not dependent on right-to-left shunt. In particular, the exclusion criteria of the INOT22 study was amended to exclude subjects having an elevated pulmonary capillary wedge pressure greater than 20 mm Hg.

13. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the '359 patent.

Dated: \_\_\_\_\_

7 July 2011

  
\_\_\_\_\_  
James S. Baldassarre, M.D.

Applicant : Baldassarre et al  
Serial No. : 12/820,866  
Filed : 22JUN10  
Page : 5 of 5

Attorney's Docket No.: I001-0002USC1

# EXHIBIT 1

*(curriculum vitae)*

## CURRICULUM VITAE

James S. Baldassarre, MD

**HOME ADDRESS:** 145 Pebble Woods Dr  
Doylestown, Pa  
18901 **PHONE:** 215-348-2835

**PERSONAL:** Married (Susan Cohen-Baldassarre)  
Children Alyssa (18), Julia (16) and Andrew (10)  
Citizenship: USA

**BUSINESS ADDRESS:** Ikaria/ INO Therapeutics  
6 Route 1173  
Clinton, NJ 08809 **PHONE:** 908-238-6363

**EDUCATION:** S.U.N.Y. Downstate Medical Center  
Brooklyn, NY  
1986 - M.D.

S.U.N.Y., Binghamton, NY  
1982 - Biology, B.S.

### EMPLOYMENT:

2007- present **Ikaria (INO Therapeutics)**  
VP, Clinical Research  
Project Team Leader: IK 5001  
2009-present Project Team Leader: INOmax®  
2008-2010

2003- 2007 **INO Therapeutics**  
Senior Director, Clinical Research

2003 **Johnson & Johnson Pharmaceutical Research and Development LLC**  
Compound Development Team Leader/Clinical Leader-REGRANEX®

2001-2003 **Johnson & Johnson Pharmaceutical Research and Development LLC**  
Senior Director, Operations Team Management

1999-2001 **Janssen Research Foundation**  
Director of Clinical Research Italy/Greece

1997 -1999 **Janssen-Cilag Limited, UK**  
Head of Clinical Research and Senior Medical Advisor

1993 - 1997 **R.W. Johnson Pharmaceutical Research Institute**  
Spring House, PA  
1995-1997 Associate Director, Clinical Research  
1993-1995 Assistant Director, Clinical Research

1992 - 1993 **Presbyterian Medical Center**  
Philadelphia, PA  
Attending Physician, Division of Infectious Diseases

1986 - 1993 **Medical College of Pennsylvania**  
Philadelphia, PA  
1990-1993 Fellow, Division of Infectious Diseases  
1989-1990 Medical Director (half time)



1986-1989 Internship/Residency Internal Medicine

1989 - 1990                    **Philadelphia Department of Health**  
Philadelphia, PA  
Medical Director, Sexually Transmitted Diseases Clinic (half time)

**ACADEMIC APPOINTMENT :**

**John Radcliffe Hospital, Oxford, UK**

1999-2000                    Honorary SHO, Dept of Clinical Pharmacology

**Medical College of Pennsylvania, Philadelphia, USA**

1994 -                        Clinical Assistant Professor, Department of Medicine

1991 - 1993                Instructor in Medicine

**CERTIFICATION:**

Diplomat, A.B.I.M.  
Internal Medicine, 1989  
Infectious Diseases, 1992  
Limited GMC registration, 1999

**EMPLOYMENT-RELATED ACTIVITIES/COMMITTEES:**

RWJ-PRI Continuous Process Improvement Committee	1995-1996
Johnson & Johnson Signature of Quality submission	1997 and 1999
JJ PRD New Product Development Committee Implementation Team	2002-2003
Ikaria Opportunity Review Team	2007-present

**PUBLICATIONS:**

1. Levison M E and Baldassarre J S: Intra-Abdominal Infections. *Current Practice of Medicine* 1993.
2. Baldassarre J S and Abrutyn E: Antibiotic-Resistant Streptococcus pneumoniae. *Infectious Disease Practice* 1993; 17 (9).
3. Baldassarre J S and Abrutyn E: Genital Ulcer Disease. *Infectious Disease Practice* 1992; 16 (9); 1-7.
4. Levison M E and Baldassarre J S: Community Acquired Pneumonia: Time to Reassess Treatment Strategies. *Modern Med* 1992; 60:12 86-91.
5. Levison M E and Baldassarre J S: Community Acquired Pneumonia: Keys to Making the Diagnosis. *Modern Med* 1992; 60: 11 42-58.
6. Baldassarre J S, Ingerman M J, Nansteel J, and Santoro J: Development of Listeria Meningitis during Vancomycin Therapy: A Case Report. *J Infect Dis* 1991; 164: 221-222.
7. Baldassarre J S, Update on the Management of Sexually Transmitted Diseases. *Phila Med* 1991; 87-5 230-233.
8. Baldassarre J S and Kaye D: Special Problems in Urinary Tract Infection in the Elderly. *Med Clin North Am* 1991; 75:2 375-390.
9. Baldassarre J S, Johnson CC and Levison M E: Peritonitis: Update on Pathophysiology, Clinical Manifestations and Management. *Clinical Infectious Diseases* 1997; 24(6); 1035-47.

10. Baldassarre JS and Levison ME: Intra-abdominal Infections *Current Practice of Medicine* 1999, vol 2 (4):591-605
11. Baldassarre JS and Pledger GW Clinical Trial Design for New Antiepileptic Drugs: Determination of Dose and Titration Schedules *Rev Contemp Pharmacother* 1999: 10
12. E. Potapov, D. Meyer, M. Swaminathan, M. Ramsay, A. El Banayosy, C. Diehl et al. Use of Inhaled Nitric Oxide After Left Ventricular Assist Device Placement: Results of a Prospective, Randomized, Double-Blind, Multicenter, Placebo-Controlled Trial *J Heart Lung Transplant* 2010 accepted
13. Mercier JC, Hummler H, Durrmeyer X, Sanchez-Luna M, Carnielli V, Field D, Greenough A, Van Overmeire B, Jonsson B, Hallman M, Baldassarre J; EUNO Study Group. Inhaled nitric oxide for prevention of bronchopulmonary dysplasia in premature babies (EUNO): a randomised controlled trial. *Lancet*. 2010 Jul 31;376(9738):346-54.
14. Barst RJ, Agnoletti G, Fraisse A, Baldassarre J, Wessel DL; NO Diagnostic Study Group. Vasodilator testing with nitric oxide and/or oxygen in pediatric pulmonary hypertension *Pediatr Cardiol*. 2010 Jul;31(5):598-606.

#### Book Chapters

Baldassarre J S and Kaye D: Principles and Overview of Antibiotic Use in Infective Endocarditis. In: Kaye D (ed) *Infective Endocarditis* 2nd ed. New York: Raven Press, 1992; 169-190.

#### Abstracts

1. Baldassarre J S and Stull T L: Cytosol-Mediated Ulcerogenesis in *Haemophilus ducreyi*. 1993 Annual Meeting of the Infectious Diseases Society of America, Abst #19, Oct. 16 and 17, 1993.
2. Sutherland J and Baldassarre JS : Mediastinal Adenopathy in a Patient with AIDS. American College of Physicians Regional Scientific Meetings, October 2, 1992.
3. Baldassarre J S and Stull T L: Characterization of Aminopeptidase (AP) Activity in *Haemophilus ducreyi*. American College of Physicians Regional Scientific Meetings, October 3, 1992.
4. Fontinella E, Dorfman M, Baldassarre J, Kaye D and Murasko D: Immune Response to Influenza Immunization in an Elderly Community Dwelling Africa American Population. *FASEB J* 1991 5: A1373 Abst 5814.
5. Doose DR, Walker SA, Baldassarre J. The effect of food on the oral bioavailability of topiramate from an investigational paediatric sprinkle formulation. *Epilepsia* 1997; 38(suppl 3):147.
6. Glauser TA, Olberding L, Clark P, Reife R, Baldassarre J, Conover D. Topiramate monotherapy substitution in children with partial epilepsy. *Epilepsia* 1996; 37(suppl 4):98.
7. JC Mercier, H. Hummler, X Durrmeyer, M. Sanchez-Luna, V Carnielli, D Field, A. Greenough, B. Van Overmeire, B Jonsson, M Hallman, J Baldassarre, for the EUNO Study Group. The effects of inhaled nitric oxide on the development of bronchopulmonary dysplasia (BPD) in preterm infants: the 'EUNO' multicentre randomised clinical trial. European Academy of Pediatrics; Nice, France October 2008
8. RJ Barst, G Agnoletti, A Fraisse, J Baldassarre, DL Wessel. Nitric Oxide in Combination with Oxygen Versus Either Oxygen Alone or Nitric Oxide Alone for Acute Vasodilator Testing in Children with Pulmonary Hypertension: A Multicenter, Randomized Study. Pediatric Academic Societies Scientific Meeting, Baltimore Md; May 2009 [3861.195]
9. EV Potapov; D Meyer; M Swaminathan; M Ramsay; A El Banayosy; C Diehl; B Veynovich; ID Gregoric; J Baldassarre; M J Zucker; R Hetzer Use of Inhaled Nitric Oxide After Left Ventricular

**Assist Device Placement: Results of a Prospective, Randomized, Double-Blind, Multicenter, Placebo-Controlled Trial. American Heart Association Scientific Sessions Orlando, FL; Nov 2009 [3663]**

<b>UNITED STATES PATENT &amp; TRADEMARK OFFICE</b>	
<b>Application Serial Number</b>	12/820,866
<b>Confirmation Number</b>	2913
<b>Filing Date</b>	June 22, 2010
<b>Title of Application</b>	Methods of Treating Term and Near-Term Neonates Having Hypoxic Respiratory Failure Associated with Clinical or Echocardiographic Evidence of Pulmonary Hypertension
<b>First Named Inventor</b>	James S. Baldassarre
<b>Assignee</b>	Ikaria, Inc.
<b>Group Art Unit</b>	1616
<b>Examiner</b>	Arnold, Ernst V.
<b>Attorney Docket Number</b>	I001-0002USC1

Mail Stop Amendment  
 Commissioner for Patents  
 P.O. Box 1450  
 Alexandria, VA 22313-1450

**STATEMENT UNDER 37 CFR 1.57(f)**

This communication is responsive to the Non-Final Office Action mailed June 8, 2011, setting a shortened statutory period for reply of 1 month.

Applicant respectfully requests entry of this Statement, reconsideration of the pending rejections, and allowance of the application.

**Amendments to the Specification**

Please amend paragraph [0020] as follows:

[0020] INOmax® (nitric oxide) for inhalation was approved for sale in the United States by the U.S. Food and Drug Administration (“FDA”) in 1999. Nitric oxide, the active substance in INOmax®, is a selective pulmonary vasodilator that increases the partial pressure of arterial oxygen (PaO<sub>2</sub>) by dilating pulmonary vessels in better ventilated areas of the lung, redistributing pulmonary blood flow away from the lung regions with low ventilation/perfusion (V/Q) ratios toward regions with normal ratios. INOmax® significantly improves oxygenation, reduces the need for extracorporeal oxygenation and is indicated to be used in conjunction with ventilatory support and other appropriate agents. The current FDA-approved prescribing information for INOmax® is incorporated herein by reference in its entirety. Section 4 of the prescribing information, Contraindications, states that INOmax® is contraindicated in the treatment of neonates known to be dependent on right-to-left shunting of blood.

**Statement under 37 CFR 1.57**

In the specification, paragraph [0020] was amended to include language from the INOMAX® prescribing information, which was expressly incorporated by reference within paragraph [0020] of the original specification. In particular, paragraph [0020] was amended as follows:

[0020] INOmax® (nitric oxide) for inhalation was approved for sale in the United States by the U.S. Food and Drug Administration (“FDA”) in 1999. Nitric oxide, the active substance in INOmax®, is a selective pulmonary vasodilator that increases the partial pressure of arterial oxygen (PaO<sub>2</sub>) by dilating pulmonary vessels in better ventilated areas of the lung, redistributing pulmonary blood flow away from the lung regions with low ventilation/perfusion (V/Q) ratios toward regions with normal ratios. INOmax® significantly improves oxygenation, reduces the need for extracorporeal oxygenation and is indicated to be used in conjunction with ventilatory support and other appropriate agents. The current FDA-approved prescribing information for INOmax® is incorporated herein by reference in its entirety. Section 4 of the prescribing information, Contraindications, states that INOmax® is contraindicated in the treatment of neonates known to be dependent on right-to-left shunting of blood.

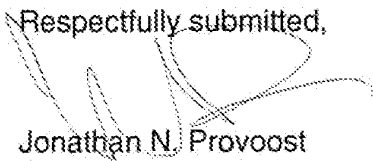
The amendment above is appropriately made within the time period set by the Office for responding the current and prior rejection in accordingly to the requirements of 37 CFR 1.57(b), (c) or (d) and the language incorporated into independent claims 20, 21 and 25 contains the exact language added to paragraph [0020].

In accordance with 37 CFR 1.57(f), applicant states herein that the amendment to paragraph [0020] includes matter that was previously incorporated by reference in

paragraph [0020] of the original specification and therefore, the present amendment to paragraph [0020] contains no new matter.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the '359 patent.

Respectfully submitted,



Jonathan N. Provoost  
Attorney for Applicant and Assignee  
Associate General Counsel  
Icaria  
6 Route 173  
Clinton, NJ 08809  
Direct phone: (908) 238-6392  
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jonathan.provoost@icaria.com

Dated: July 7, 2011

# EXHIBIT 1

(INOMax® prescribing information -- 2009)

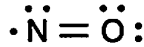


# INOMax<sup>®</sup> (nitric oxide) for inhalation 100 and 800 ppm (parts per million)

## DESCRIPTION

INOMax (nitric oxide gas) is a drug administered by inhalation. Nitric oxide, the active substance in INOMax, is a pulmonary vasodilator. INOMax is a gaseous blend of nitric oxide and nitrogen (0.08% and 99.92%, respectively for 800 ppm; 0.01% and 99.99%, respectively for 100 ppm). INOMax is supplied in aluminum cylinders as a compressed gas under high pressure (2000 pounds per square inch gauge [psig]).

The structural formula of nitric oxide (NO) is shown below:



## CLINICAL PHARMACOLOGY

Nitric oxide is a compound produced by many cells of the body. It relaxes vascular smooth muscle by binding to the heme moiety of cytosolic guanylate cyclase, activating guanylate cyclase and increasing intracellular levels of cyclic guanosine 3',5'-monophosphate, which then leads to vasodilation. When inhaled, nitric oxide produces pulmonary vasodilation.

INOMax appears to increase the partial pressure of arterial oxygen (PaO<sub>2</sub>) by dilating pulmonary vessels in better ventilated areas of the lung, redistributing pulmonary blood flow away from lung regions with low ventilation/perfusion (V/Q) ratios toward regions with normal ratios.

### Effects on Pulmonary Vascular Tone in PPHN

Persistent pulmonary hypertension of the newborn (PPHN) occurs as a primary developmental defect or as a condition secondary to other diseases such as meconium aspiration syndrome (MAS), pneumonia, sepsis, hyaline membrane disease, congenital diaphragmatic hernia (CDH), and pulmonary hypoplasia. In these states, pulmonary vascular resistance (PVR) is high, which results in hypoxemia secondary to right-to-left shunting of blood through the patent ductus arteriosus and foramen ovale. In neonates with PPHN, INOMax improves oxygenation (as indicated by significant increases in PaO<sub>2</sub>).

## PHARMACOKINETICS

The pharmacokinetics of nitric oxide has been studied in adults.

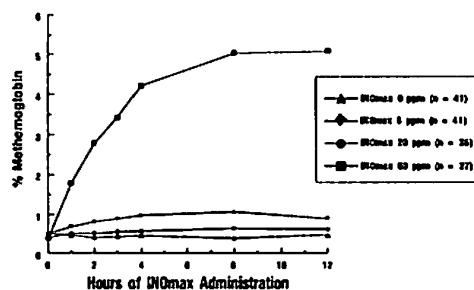
### Uptake and Distribution

Nitric oxide is absorbed systemically after inhalation. Most of it traverses the pulmonary capillary bed where it combines with hemoglobin that is 60% to 100% oxygen-saturated. At this level of oxygen saturation, nitric oxide combines predominantly with oxyhemoglobin to produce methemoglobin and nitrate. At low oxygen saturation, nitric oxide can combine with deoxyhemoglobin to transiently form nitrosylhemoglobin, which is converted to nitrogen oxides and methemoglobin upon exposure to oxygen. Within the pulmonary system, nitric oxide can combine with oxygen and water to produce nitrogen dioxide and nitrite, respectively, which interact with oxyhemoglobin to produce methemoglobin and nitrate. Thus, the end products of nitric oxide that enter the systemic circulation are predominantly methemoglobin and nitrate.

### Metabolism

Methemoglobin disposition has been investigated as a function of time and nitric oxide exposure concentration in neonates with respiratory failure. The methemoglobin (MetHb) concentration-time profiles during the first 12 hours of exposure to 0, 5, 20, and 80 ppm INOMax are shown in Figure 1.

Figure 1  
Methemoglobin Concentration - Time Profiles  
Neonates Inhaling 0, 5, 20 or 80 ppm INOMax



Methemoglobin concentrations increased during the first 8 hours of nitric oxide exposure. The mean methemoglobin level remained below 1% in the placebo group and in the 5 ppm and 20 ppm INOMax groups, but reached approximately 5% in the 80 ppm INOMax group. Methemoglobin levels >7% were attained only in patients receiving 80 ppm, where they comprised 35% of the group. The average time to reach peak methemoglobin was 10 ± 9 (SD) hours (median, 8 hours) in these 13 patients; but one patient did not exceed 7% until 40 hours.

### Elimination

Nitrate has been identified as the predominant nitric oxide metabolite excreted in the urine, accounting for >70% of the nitric oxide dose inhaled. Nitrate is cleared from the plasma by the kidney at rates approaching the rate of glomerular filtration.

## CLINICAL TRIALS

The efficacy of INOMax has been investigated in term and near-term newborns with hypoxic respiratory failure resulting from a variety of etiologies. Inhalation of INOMax reduces the oxygenation index (OI= mean airway pressure in cm H<sub>2</sub>O x fraction of inspired oxygen concentration [FIO<sub>2</sub>] x 100 divided by systemic arterial concentration in mm Hg [PaO<sub>2</sub>]) and increases PaO<sub>2</sub> (See CLINICAL PHARMACOLOGY).

## NINOS study

The Neonatal Inhaled Nitric Oxide Study (NINOS) group conducted a double-blind, randomized, placebo-controlled, multicenter trial in 235 neonates with hypoxic respiratory failure. The objective of the study was to determine whether inhaled nitric oxide would reduce the occurrence of death and/or initiation of extracorporeal membrane oxygenation (ECMO) in a prospectively defined cohort of term or near-term neonates with hypoxic respiratory failure unresponsive to conventional therapy. Hypoxic respiratory failure was caused by meconium aspiration syndrome (MAS; 49%), pneumonia/sepsis (21%), idiopathic primary pulmonary hypertension of the newborn (PPHN; 17%), or respiratory distress syndrome (RDS; 11%). Infants ≤14 days of age (mean, 1.7 days) with a mean PaO<sub>2</sub> of 46 mm Hg and a mean oxygenation index (OI) of 43 cm H<sub>2</sub>O / mm Hg were initially randomized to receive 100% O<sub>2</sub> with (n=114) or without (n=121) 20 ppm nitric oxide for up to 14 days. Response to study drug was defined as a change from baseline in PaO<sub>2</sub> 30 minutes after starting treatment (full response = >20 mm Hg, partial = 10–20 mm Hg, no response = <10 mm Hg). Neonates with a less than full response were evaluated for a response to 80 ppm nitric oxide or control gas. The primary results from the NINOS study are presented in Table 1.

Table 1  
Summary of Clinical Results from NINOS Study

	Control (n=121)	NO (n=114)	P value
Death or ECMO <sup>†</sup>	77 (64%)	52 (46%)	0.006
Death	20 (17%)	16 (14%)	0.60
ECMO	66 (55%)	44 (39%)	0.014

<sup>†</sup> Extracorporeal membrane oxygenation

<sup>‡</sup> Death or need for ECMO was the study's primary end point

Although the incidence of death by 120 days of age was similar in both groups (NO, 14%; control, 17%), significantly fewer infants in the nitric oxide group required ECMO compared with controls (39% vs. 55%, p = 0.014). The combined incidence of death and/or initiation of ECMO showed a significant advantage for the nitric oxide treated group (46% vs. 64%, p = 0.006). The nitric oxide group also had significantly greater increases in PaO<sub>2</sub> and greater decreases in the OI and the alveolar-arterial oxygen gradient than the control group (p<0.001 for all parameters). Significantly more patients had at least a partial response to the initial administration of study drug in the nitric oxide group (66%) than the control group (26%, p<0.001). Of the 125 infants who did not respond to 20 ppm nitric oxide or control, similar percentages of NO-treated (18%) and control (20%) patients had at least a partial response to 80 ppm nitric oxide for inhalation or control drug, suggesting a lack of additional benefit for the higher dose of nitric oxide. No infant had study drug discontinued for toxicity. Inhaled nitric oxide had no detectable effect on mortality. The adverse events collected in the NINOS trial occurred at similar incidence rates in both treatment groups (See ADVERSE REACTIONS). Follow-up exams were performed at 18–24 months for the infants enrolled in this trial. In the infants with available follow-up, the two treatment groups were similar with respect to their mental, motor, audiological, or neurologic evaluations.

## CINRGI study

This study was a double-blind, randomized, placebo-controlled, multicenter trial of 186 term and near-term neonates with pulmonary hypertension and hypoxic respiratory failure. The primary objective of the study was to determine whether INOMax would reduce the receipt of ECMO in these patients. Hypoxic respiratory failure was caused by MAS (35%), idiopathic PPHN (30%), pneumonia/sepsis (24%), or RDS (8%). Patients with a mean PaO<sub>2</sub> of 54 mm Hg and a mean OI of 44 cm H<sub>2</sub>O / mm Hg were randomly assigned to receive either 20 ppm INOMax (n=97) or nitrogen gas (placebo; n=89) in addition to their ventilatory support. Patients who exhibited a PaO<sub>2</sub> >60 mm Hg and a pH < 7.55 were weaned to 5 ppm INOMax or placebo. The primary results from the CINRGI study are presented in Table 2.

Table 2  
Summary of Clinical Results from CINRGI Study

	Placebo	INOMax	P value
ECMO <sup>†</sup>	51/89 (57%)	30/97 (31%)	< 0.001
Death	5/89 (6%)	3/97 (3%)	0.46

<sup>†</sup> Extracorporeal membrane oxygenation

<sup>‡</sup> ECMO was the primary end point of this study

Significantly fewer neonates in the INOMax group required ECMO compared to the control group (31% vs. 57%, p<0.001). While the number of deaths were similar in both groups (INOMax, 3%; placebo, 6%), the combined incidence of death and/or receipt of ECMO was decreased in the INOMax group (33% vs. 58%, p<0.001).

In addition, the INOMax group had significantly improved oxygenation as measured by PaO<sub>2</sub>, OI, and alveolar-arterial gradient (p<0.001 for all parameters). Of the 97 patients treated with INOMax, 2 (2%) were withdrawn from study drug due to methemoglobin levels >4%. The frequency and number of adverse events reported were similar in the two study groups (See ADVERSE REACTIONS).

## ARDS study

In a randomized, double-blind, parallel, multicenter study, 385 patients with adult respiratory distress syndrome (ARDS) associated with pneumonia (46%), surgery (33%), multiple trauma (26%), aspiration (23%), pulmonary contusion (18%), and other causes, with PaO<sub>2</sub>/FIO<sub>2</sub> <250 mm Hg despite optimal oxygenation and ventilation, received placebo (n=193) or INOMax (n=192), 5 ppm, for 4 hours to 28 days or until weaned because of improvements in oxygenation. Despite acute improvements in oxygenation, there was no effect of INOMax on the primary endpoint of days alive and off ventilator support. These results were consistent with outcome data from a smaller dose ranging study of nitric oxide (1.25 to 80 ppm). INOMax is not indicated for use in ARDS.

## INDICATIONS

INOmax, in conjunction with ventilatory support and other appropriate agents, is indicated for the treatment of term and near-term (>34 weeks) neonates with hypoxic respiratory failure associated with clinical or echocardiographic evidence of pulmonary hypertension, where it improves oxygenation and reduces the need for extracorporeal membrane oxygenation.

## CONTRAINDICATIONS

INOmax should not be used in the treatment of neonates known to be dependent on right-to-left shunting of blood.

## PRECAUTIONS

### Rebound

Abrupt discontinuation of INOmax may lead to worsening oxygenation and increasing pulmonary artery pressure.

### Methemoglobinemia

Methemoglobinemia increases with the dose of nitric oxide. In the clinical trials, maximum methemoglobin levels usually were reached approximately 8 hours after initiation of inhalation, although methemoglobin levels have peaked as late as 40 hours following initiation of INOmax therapy. In one study, 13 of 37 (35%) of neonates treated with INOmax 80 ppm had methemoglobin levels exceeding 7%. Following discontinuation or reduction of nitric oxide the methemoglobin levels returned to baseline over a period of hours.

### Elevated NO<sub>x</sub> Levels

In one study, NO<sub>x</sub> levels were <0.5 ppm when neonates were treated with placebo, 5 ppm, and 20 ppm nitric oxide over the first 48 hours. The 80 ppm group had a mean peak NO<sub>x</sub> level of 2.6 ppm.

### Drug Interactions

No formal drug-interaction studies have been performed, and a clinically significant interaction with other medications used in the treatment of hypoxic respiratory failure cannot be excluded based on the available data. INOmax has been administered with tolazoline, dopamine, dobutamine, steroids, surfactant, and high-frequency ventilation. Although there are no study data to evaluate the possibility, nitric oxide donor compounds, including sodium nitroprusside and nitroglycerin, may have an additive effect with INOmax on the risk of developing methemoglobinemia. An association between prilocaine and an increased risk of methemoglobinemia, particularly in infants, has specifically been described in a literature case report. This risk is present whether the drugs are administered as oral, parenteral, or topical formulations.

### Carcinogenesis, Mutagenesis, Impairment of Fertility

No evidence of a carcinogenic effect was apparent, at inhalation exposures up to the recommended dose (20 ppm), in rats for 20 hr/day for up to two years. Higher exposures have not been investigated.

Nitric oxide has demonstrated genotoxicity in Salmonella (Ames Test), human lymphocytes, and after *in vivo* exposure in rats. There are no animal or human studies to evaluate nitric oxide for effects on fertility.

### Pregnancy: Category C

Animal reproduction studies have not been conducted with INOmax. It is not known if INOmax can cause fetal harm when administered to a pregnant woman or can affect reproductive capacity. INOmax is not intended for adults.

### Nursing Mothers

Nitric oxide is not indicated for use in the adult population, including nursing mothers. It is not known whether nitric oxide is excreted in human milk.

### Pediatric Use

Nitric oxide for inhalation has been studied in a neonatal population (up to 14 days of age). No information about its effectiveness in other age populations is available.

## ADVERSE REACTIONS

Controlled studies have included 325 patients on INOmax doses of 5 to 80 ppm and 251 patients on placebo. Total mortality in the pooled trials was 11% on placebo and 9% on INOmax, a result adequate to exclude INOmax mortality being more than 40% worse than placebo.

In both the NINOS and CINRGI studies, the duration of hospitalization was similar in INOmax and placebo-treated groups.

From all controlled studies, at least 6 months of follow-up is available for 278 patients who received INOmax and 212 patients who received placebo. Among these patients, there was no evidence of an adverse effect of treatment on the need for rehospitalization, special medical services, pulmonary disease, or neurological sequelae.

In the NINOS study, treatment groups were similar with respect to the incidence and severity of intracranial hemorrhage, Grade IV hemorrhage, periventricular leukomalacia, cerebral infarction, seizures requiring anticonvulsant therapy, pulmonary hemorrhage, or gastrointestinal hemorrhage.

The table below shows adverse events with an incidence of at least 5% on INOmax in the CINRGI study, and that were more common on INOmax than on placebo.

ADVERSE EVENTS IN THE CINRGI TRIAL

Adverse Event	Placebo (n=89)	Inhaled NO (n=97)
Hypotension	9 (10%)	13 (13%)
Withdrawal	9 (10%)	12 (12%)
Atelectasis	8 (9%)	9 (9%)
Hematuria	5 (6%)	8 (8%)
Hyperglycemia	6 (7%)	8 (8%)
Sepsis	2 (2%)	7 (7%)
Infection	3 (3%)	6 (6%)
Stridor	3 (3%)	5 (5%)
Cellulitis	0 (0%)	5 (5%)

## OVERDOSAGE

Overdosage with INOmax will be manifest by elevations in methemoglobin and NO<sub>x</sub>. Elevated NO<sub>x</sub> may cause acute lung injury. Elevations in methemoglobinemia reduce the oxygen delivery capacity of the circulation. In clinical studies, NO<sub>x</sub> levels >3 ppm or methemoglobin levels >7% were treated by reducing the dose of, or discontinuing, INOmax.

Methemoglobinemia that does not resolve after reduction or discontinuation of therapy can be treated with intravenous vitamin C, intravenous methylene blue, or blood transfusion, based upon the clinical situation.

## POST-MARKETING EXPERIENCE

The following adverse events have been reported as part of the post-marketing surveillance. These events have not been reported above. Given the nature of spontaneously reported post-marketing surveillance data, it is impossible to determine the actual incidence of the events or definitively establish their causal relationship to the drug. The listing is alphabetical: dose errors associated with the delivery system; headaches associated with environmental exposure of INOmax in hospital staff; hypotension associated with acute withdrawal of the drug; hypoxemia associated with acute withdrawal of the drug; pulmonary edema in patients with CREST syndrome.

## DOSAGE AND ADMINISTRATION

### Dosage

The recommended dose of INOmax is 20 ppm. Treatment should be maintained up to 14 days or until the underlying oxygen desaturation has resolved and the neonate is ready to be weaned from INOmax therapy.

An initial dose of 20 ppm was used in the NINOS and CINRGI trials. In CINRGI, patients whose oxygenation improved with 20 ppm were dose-reduced to 5 ppm as tolerated at the end of 4 hours of treatment. In the NINOS trial, patients whose oxygenation failed to improve on 20 ppm could be increased to 80 ppm, but those patients did not then improve on the higher dose. As the risk of methemoglobinemia and elevated NO<sub>x</sub> levels increases significantly when INOmax is administered at doses >20 ppm, doses above this level ordinarily should not be used.

### Administration

Additional therapies should be used to maximize oxygen delivery. In patients with collapsed alveoli, additional therapies might include surfactant and high-frequency oscillatory ventilation.

The safety and effectiveness of inhaled nitric oxide have been established in a population receiving other therapies for hypoxic respiratory failure, including vasodilators, intravenous fluids, bicarbonate therapy, and mechanical ventilation. Different dose regimens for nitric oxide were used in the clinical studies (see CLINICAL TRIALS).

INOmax should be administered with monitoring for PaO<sub>2</sub>, methemoglobin, and NO<sub>x</sub>.

The nitric oxide delivery systems used in the clinical trials provided operator-determined concentrations of nitric oxide in the breathing gas, and the concentration was constant throughout the respiratory cycle. INOmax must be delivered through a system with these characteristics and which does not cause generation of excessive inhaled nitrogen dioxide. The INOvent® system and other systems meeting these criteria were used in the clinical trials. In the ventilated neonate, precise monitoring of inspired nitric oxide and NO<sub>x</sub> should be instituted, using a properly calibrated analysis device with alarms. The system should be calibrated using a precisely defined calibration mixture of nitric oxide and nitrogen dioxide, such as INOCAL®. Sample gas for analysis should be drawn before the Y-piece, proximal to the patient. Oxygen levels should also be measured.

In the event of a system failure or a wall-outlet power failure, a backup battery power supply and reserve nitric oxide delivery system should be available.

The INOmax dose should not be discontinued abruptly as it may result in an increase in pulmonary artery pressure (PAP) and/or worsening of blood oxygenation (PaO<sub>2</sub>). Deterioration in oxygenation and elevation in PAP may also occur in children with no apparent response to INOmax. Discontinue/wean cautiously.

## HOW SUPPLIED

INOmax (nitric oxide) is available in the following sizes:

Size D Portable aluminum cylinders containing 353 liters at STP of nitric oxide gas in 800 ppm concentration in nitrogen (delivered volume 344 liters) (NDC 64693-002-01)

Size D Portable aluminum cylinders containing 353 liters at STP of nitric oxide gas in 100 ppm concentration in nitrogen (delivered volume 344 liters) (NDC 64693-001-01)

Size 88 Aluminum cylinders containing 1963 liters at STP of nitric oxide gas in 800 ppm concentration in nitrogen (delivered volume 1918 liters) (NDC 64693-002-02)

Size 88 Aluminum cylinders containing 1963 liters at STP of nitric oxide gas in 100 ppm concentration in nitrogen (delivered volume 1918 liters) (NDC 64693-001-02)

Store at 25°C (77°F) with excursions permitted between 15–30°C (59–86°F) [see USP Controlled Room Temperature].

## Occupational Exposure

The exposure limit set by the Occupational Safety and Health Administration (OSHA) for nitric oxide is 25 ppm, and for NO<sub>2</sub> the limit is 5 ppm.

## CAUTION

Federal law prohibits dispensing without a prescription.

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SPC-0303 V:3.0

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b> ( Not for submission under 37 CFR 1.99)	Application Number	12820866
	Filing Date	2010-06-22
	First Named Inventor	James S. Baldassarre
	Art Unit	1613
	Examiner Name	Ernst V. Arnold
	Attorney Docket Number	I001-0002USC1

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	Attorney Docket Number	I001-0002USC1

1	Barst, et al. "Vasodilator Testing with Nitric Oxide and/or Oxygen in Pediatric Pulmonary Hypertension" Received: 14 September 2009 / Accepted: 19 January 2010 Springer Science+Business Media, LLC 2010, 9 pages	<input type="checkbox"/>
2	Bates, Inhaled Nitric Oxide: A Selective Pulmonary Vasodilator, 2004, 9 pages	<input type="checkbox"/>
3	Beggs, et al., "Cardiac Failure in Children" 17th Expert Committee on the Selection and Use of Essential Medicines, Geneva, March 2009, 31 pages	<input type="checkbox"/>
4	Copy of the Canadian Office Action mailed May 31, 2011 for Canadian patent application No. 2671029, a counterpart foreign application of US patent application No. 12/494,598	<input type="checkbox"/>
5	Douwes, et al. "The Maze of Vasodilator Response Criteria" Published online: 26 November 2010, <i>Pediatr Cardiol</i> (2011) 32: pp. 245-246	<input type="checkbox"/>
6	Fraisse, et al., "Acute pulmonary hypertension in infants and children: cGMP-related drugs" <i>Pediatric Crit Care Med</i> 2010, Vol 11, No. 2 (Suppl.), 4 pages	<input type="checkbox"/>
7	INOmax (nitric oxide) for inhalation 100 and 800 ppm (parts per million), drug label insert, 2007, 2 pages	<input type="checkbox"/>
8	Kay, et al. "Congestive heart failure in pediatric patients," From the Department of Pediatrics, Duke University Medical Center, 2001 by Mosby, Inc., 6 pages	<input type="checkbox"/>
9	Definition of Contraindication on Medicine.net.com; <a href="http://www.medterms.com/script/main/art.asp?articlekey=17824">http://www.medterms.com/script/main/art.asp?articlekey=17824</a> ; retrieved 3/14/2011; 2 pages	<input type="checkbox"/>
10	Murray, Angiotensin Converting Enzyme Inhibitory Peptides Derived from Food Proteins: Biochemistry, Bioactivity and Production; <i>Current Pharmaceutical Design</i> , 2007, 773-791	<input type="checkbox"/>
11	Non-Final Office Action for US Patent Application 12/820,980, mailed on June 10, 2011, James Baldassarre, "METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION"	<input type="checkbox"/>

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12	UCI General Clinical Research Center, Federal Regulations 21 CFR Part 312, <<http://www.gcrc.uci.edu/rsa/aer.cfm>>, retrieved 9/13/2010, 2 pages	<input type="checkbox"/>
13	NIH CC: Critical Care Services, http://www.cc.nih.gov/ccmd/clinical_services.html; retrieved 3/10/2011, 3 pages	<input type="checkbox"/>
14	Guidelines for Industry: Clinical Safety Data Management <<www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidance/ucm073087.pdf>>, March 1995, 17 pages	<input type="checkbox"/>
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### CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

None

### SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/David A. Divine, Reg. No. 51,275/	Date (YYYY-MM-DD)	2011-07-08
Name/Print	David D. Divine	Registration Number	51,275

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## Electronic Patent Application Fee Transmittal

<b>Application Number:</b>	12820866			
<b>Filing Date:</b>	22-Jun-2010			
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION			
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre			
<b>Filer:</b>	Lewis Carl Lee/Anna Goforth			
<b>Attorney Docket Number:</b>	I001-0002USC1			
Filed as Small Entity				
<b>Utility under 35 USC 111(a) Filing Fees</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent-Appeals-and-Interference:</b>				
<b>Post-Allowance-and-Post-Issuance:</b>				
<b>Extension-of-Time:</b>				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
<b>Miscellaneous:</b>				
Submission- Information Disclosure Stmt	1806	1	180	180
<b>Total in USD (\$)</b>				<b>180</b>



## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	10482888
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	49584
<b>Filer:</b>	Lewis Carl Lee/Anna Goforth
<b>Filer Authorized By:</b>	Lewis Carl Lee
<b>Attorney Docket Number:</b>	I001-0002USC1
<b>Receipt Date:</b>	08-JUL-2011
<b>Filing Date:</b>	22-JUN-2010
<b>Time Stamp:</b>	17:58:25
<b>Application Type:</b>	Utility under 35 USC 111(a)

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1		R92108.PDF	5355142 2049b98f3386e79beaf9cf9f41968610a953e671	yes	98
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		Amendment/Req. Reconsideration-After Non-Final Reject	1	1	
		Specification	2	2	
		Claims	3	5	
		Applicant Arguments/Remarks Made in an Amendment	6	98	
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14	Non Patent Literature	R78484.PDF	271991 351664f10f6d755169cea82f2dd40bdbbd078dd6	no	9
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<b>Information:</b>					
<b>Total Files Size (in bytes):</b>				10322733	
<p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>  <b>If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</b></p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>  <b>If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</b></p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>  <b>If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</b></p>					

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

<b>PATENT APPLICATION FEE DETERMINATION RECORD</b> Substitute for Form PTO-875				Application or Docket Number <b>12/820,866</b>		Filing Date <b>06/22/2010</b>		<input type="checkbox"/> To be Mailed			
<b>APPLICATION AS FILED – PART I</b>						<b>OTHER THAN</b>					
(Column 1)		(Column 2)		SMALL ENTITY <input checked="" type="checkbox"/>		OR		SMALL ENTITY			
FOR	NUMBER FILED	NUMBER EXTRA	RATE (\$)	FEE (\$)	OR	RATE (\$)	FEE (\$)				
<input type="checkbox"/> BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A					
<input type="checkbox"/> SEARCH FEE (37 CFR 1.16(k), (j), or (m))	N/A	N/A	N/A			N/A					
<input type="checkbox"/> EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A					
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X \$ =		OR	X \$ =					
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X \$ =			X \$ =					
<input type="checkbox"/> APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$250 (\$125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).										
<input type="checkbox"/> MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))											
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL					
<b>APPLICATION AS AMENDED – PART II</b>						<b>OTHER THAN</b>					
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OR		SMALL ENTITY	
AMENDMENT	07/08/2011	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	OR	RATE (\$)	ADDITIONAL FEE (\$)		
	Total (37 CFR 1.16(i))	* 15	Minus ** 20	= 0	X \$26 =	0	OR	X \$ =			
	Independent (37 CFR 1.16(h))	* 3	Minus *** 3	= 0	X \$110 =	0	OR	X \$ =			
	<input type="checkbox"/> Application Size Fee (37 CFR 1.16(s))										
	<input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						OR				
					TOTAL ADD'L FEE	0	OR	TOTAL ADD'L FEE			
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OR		SMALL ENTITY	
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	OR	RATE (\$)	ADDITIONAL FEE (\$)		
	Total (37 CFR 1.16(i))	*	Minus **	=	X \$ =		OR	X \$ =			
	Independent (37 CFR 1.16(h))	*	Minus ***	=	X \$ =		OR	X \$ =			
	<input type="checkbox"/> Application Size Fee (37 CFR 1.16(s))										
	<input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						OR				
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE			
<p>* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.                  ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".                  *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".                  The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.</p>											

Legal Instrument Examiner:  
/NINA RATANAVONG/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

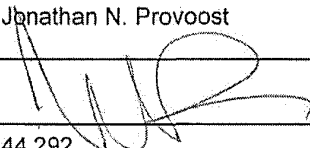
**AUTHORIZATION TO ACT IN A REPRESENTATIVE CAPACITY**

In re Application of: James S. Baldassarre et al.	
Application No: 12/820,866	
Filed: 6/22/2010	
Title: Methods for Treating Term and Near-Term Neonates Having Hypoxic Respiratory Failure Associated with Clinical or Echocardiographic Evidence of Pulmonary Hypertension	
Attorney Docket No. 1001-0002USC1	Art Unit: 1613

The Practitioner named below is authorized to conduct interviews and has the authority to bind the principal concerned. Furthermore, the practitioner is authorized to file correspondence in the above-identified application pursuant to 37 CFR 1.34.

Name	Registration Number
<i>Janis K. Fraser, Ph.D., J.D.</i>	<i>34,819</i>

**This is not a Power of Attorney to the above-named practitioner.** Accordingly, the practitioner named above does not have authority to sign a request to change correspondence address, a request for an express abandonment, a disclaimer, a power of attorney, or other document requiring the signature of the applicant, assignee of the entire interest or an attorney of record. If appropriate, a separate Power of Attorney to the above-named practitioner should be executed and filed in the United States Patent and Trademark Office.

SIGNATURE of Practitioner of Record			
Name	Jonathan N. Provoost		
Signature		Date	<i>13 JUL 11</i>
Registration Number	44,292	Telephone	(908) 238-6392

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	10518274
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	49584
<b>Filer:</b>	Janis K. Fraser/Mary Florczak
<b>Filer Authorized By:</b>	Janis K. Fraser
<b>Attorney Docket Number:</b>	I001-0002USC1
<b>Receipt Date:</b>	14-JUL-2011
<b>Filing Date:</b>	22-JUN-2010
<b>Time Stamp:</b>	12:48:24
<b>Application Type:</b>	Utility under 35 USC 111(a)

### Payment information:

Submitted with Payment	no
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### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	260470003004Authorization.pdf	68552 e047281d278f7873212bbd5b408221645e42c42a	no	1

### Warnings:

### Information:

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**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : James S. Baldassarre et al.                      Art Unit : 1613  
Serial No. : 12/820,866    Examiner : Ernst V. Arnold  
Filed : June 22, 2010  
Title : METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING  
HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR  
ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

REVOCATION AND NEW POWER OF ATTORNEY

Under 37 CFR §3.73(b), Ikaria Holdings, Inc., a corporation, certifies that it is the assignee of the entire right, title, and interest in the patent application identified above, by virtue of an assignment from the inventors of the patent application identified above, which assignment was recorded in the Patent and Trademark Office at Reel 026606, Frame 0197 on July 18, 2011.

The undersigned has reviewed all the documents in the chain of title of the patent application identified above and, to the best of undersigned's knowledge and belief, title is in the assignee identified above.

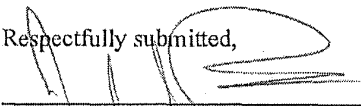
The undersigned, whose title is supplied below, is empowered to act on behalf of the assignee.

The undersigned, acting on behalf of the assignee, hereby revokes all powers of attorney previously granted in the application and appoints the attorneys and agents associated with the Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith, said appointment to be to the exclusion of the inventors and their attorney(s) and/or agent(s) in accordance with the provisions of 37 CFR §3.71, et seq. of the Patent Office Rules of Practice.

**PTO Customer Number: 94169**

The undersigned also directs all correspondence be addressed to that Customer Number.

Date: July 21, 2011

Respectfully submitted,  
  
\_\_\_\_\_  
JONATHAN N. PRQVOOST  
Associate General Counsel  
Ikaria, Inc.

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	10570232
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	49584
<b>Filer:</b>	Janis K. Fraser/Nancy Bechet
<b>Filer Authorized By:</b>	Janis K. Fraser
<b>Attorney Docket Number:</b>	I001-0002USC1
<b>Receipt Date:</b>	21-JUL-2011
<b>Filing Date:</b>	22-JUN-2010
<b>Time Stamp:</b>	15:30:06
<b>Application Type:</b>	Utility under 35 USC 111(a)

### Payment information:

Submitted with Payment	no
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### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	revpower26047_003004.pdf	55576 a6d84c11903bbc6d898bcf2eb017a15e5610f1b	no	1

### Warnings:

### Information:

Total Files Size (in bytes):

55576

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**New Applications Under 35 U.S.C. 111**

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**National Stage of an International Application under 35 U.S.C. 371**

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**New International Application Filed with the USPTO as a Receiving Office**

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : James S. Baldassarre et al.                      Art Unit : 1613  
Serial No. : 12/820,866    Examiner : Ernst V. Arnold  
Filed : June 22, 2010    Conf. No. : 2913

Title : METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING  
HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR  
ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

TRANSMITTAL OF DECLARATION

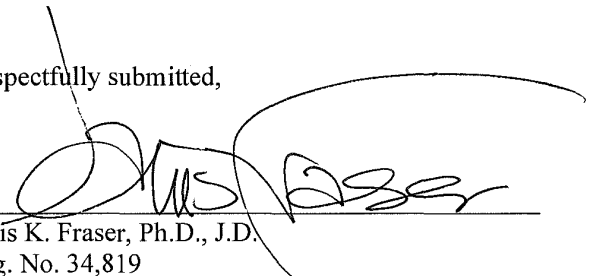
A fully responsive reply to the June 8, 2011, Office action in the above-captioned case was filed on July 8, 2011. That reply included, as an exhibit to the Appendix B Declaration of Douglas A. Greene, M.D. under 37 C.F.R. § 1.132, a letter addressed to Dr. Greene from David L. Wessel, M.D. (the "Letter"). Applicants now submit and ask the Examiner to consider the enclosed **Declaration of David L. Wessel, M.D. under 37 C.F.R. § 1.132**. In the enclosed Declaration, Dr. Wessel repeats the points he made in the previously-submitted Letter, putting them in the form of a formal declaration. The remarks made by applicants in the reply filed July 8, 2011, regarding Dr. Wessel's comments in the Letter apply as well to the corresponding comments in the enclosed Declaration.

Apply any charges or credits to Deposit Account No. 06-1050, referencing Attorney Docket No. 26047-0003002.

Respectfully submitted,

Date:

July 27, 2011

  
\_\_\_\_\_  
Janis K. Fraser, Ph.D., J.D.  
Reg. No. 34,819

Customer Number 94169  
Fish & Richardson P.C.  
Telephone: (617) 542-5070  
Facsimile: (877) 769-7945

22674400.doc

**CERTIFICATE OF MAILING BY EFS-WEB FILING**

I hereby certify that this paper was filed with the Patent and Trademark Office using the EFS-WEB system on this date:

7/27/11

UNITED STATES PATENT AND TRADEMARK OFFICE	
Application Serial Number	12/820,866
Confirmation Number	2913
Filing Date	22-JUN-2010
Title of Application	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
First Named Inventor	JAMES S. BALDASSARRE
Assignee	IKARIA, INC.
Group Art Unit	1616
Examiner	ARNOLD, ERNST V.
Attorney Docket Number	1001-0002USC1

Mail Stop Amendment  
 Commissioner for Patents  
 P.O. Box 1450  
 Alexandria, VA 22313-1450

DECLARATION OF DAVID L. WESSEL, M.D.  
UNDER 37 C.F.R. § 1.132

I, David L. Wessel, do hereby declare the following:

1. I currently hold the position of Senior Vice President, The Center for Hospital-based Specialties, at Children's National Medical Center in Washington, D.C., where I am also the Division Chief of Critical Care Medicine. I am also the Ikaria Distinguished Professor of Critical Care Medicine. A copy of my *curriculum vitae* is attached as **Exhibit 1**.

2. I received a bachelor's degree (B.S.) in physics from the College of William and Mary in 1972, a bachelor's degree (B.A.) in physiology from Oxford University in 1974, a doctoral degree (*cum laude*) in medicine (M.D.) from the Yale University School of Medicine in 1978, and a master's degree (M.A.) in physiology from Oxford University in 1983.

3. Following my graduation from Yale, the majority of my time as a practicing physician was spent in academic medicine, where I focused on pediatric cardiology. From 1978-1981, I performed an internship in pediatrics followed by a clinical fellowship at the Yale University School of Medicine. From 1981-1985, I was a fellow in pediatric anesthesiology at

Harvard Medical School, where I later became an instructor (1985), assistant professor (1987), associate professor (1994), and ultimately professor (2002), all in the area of pediatrics. In 2011, I will become a professor of pediatrics at the George Washington University School of Medicine and Health Sciences in Washington, DC.

4. In addition to my academic experience, I have extensive experience in the pharmaceutical industry as a member of scientific advisory boards, advisory panels or steering committees for companies such as Pfizer, Johnson & Johnson, Eli Lilly, Bristol-Myers Squibb, Sanofi-Aventis, and INO Therapeutics.<sup>1</sup>

5. In 2005, I chaired the Steering Committee of the Sponsor, INO Therapeutics LLC (INOT), to establish, design and oversee the INOT22 Study. In addition to being the Chair of the INOT22 Steering Committee, I also am the senior author of Atz and Wessel, *Seminars in Perinatology* 1997, 21(5), pp. 441-455 (Atz et al.).

6. At the time of the design of the INOT22 Study protocol, neither I, the other Steering Committee members, nor the study Sponsor appreciated or anticipated that a child with left ventricular dysfunction who is not dependent on right-to-left shunting of blood would be at additional risk when treated with inhaled nitric oxide (iNO). This is the reason such children were not originally excluded from the INOT22 Study entry criteria.

7. Neither the Atz et al. article that I co-authored, nor the medical literature or medical experience of which I was aware at the time, predict this risk. Instead, Atz et al. describes two distinct, independent precautions with respect to the use of iNO. First, with respect to adults, Atz et al. stated that iNO may be more effective in newborns than in older patients, and noted that it should be used with caution in adults with ischemic cardiomyopathy in whom a risk of pulmonary edema is a consideration (see page 452, left column). Second, with respect to neonates, we stated the well-known contraindication (currently found in the INOMAX<sup>®</sup>

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<sup>1</sup> In the interest of full disclosure, I formerly served as a consultant for INO Therapeutics LLC. I currently serve without remuneration as a member of the Ikaria Scientific Board of Advisors. In 2010, I was appointed by my institution as the Ikaria Distinguished Professor of Critical Care Medicine.

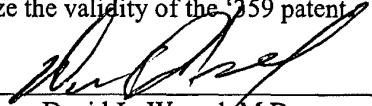
prescribing information) that iNO should not be used in newborns dependent upon right-to-left shunting of blood across a patent ductus arteriosus to avoid circulatory collapse. What we did not disclose or predict was that neonatal patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood would be at greater risk of adverse events.

8. It is ironic that my own publication would be cited to suggest that it would have been obvious to predict the adverse events and outcomes of the INOT22 Study when I, the senior author of Atz et al., failed to anticipate or predict these unexpected outcomes at the time I participated in drafting the original INOT22 Study protocol. If so, I would have been acting either negligently or intentionally to harm babies, and I most certainly was not. Furthermore, to my knowledge, none of the other members of the INOT22 Steering Committee who assisted me in designing the study, nor the approximately 18 Institutional Review Boards and 2 National Health Authorities who reviewed and approved the study prior to its initiation, predicted the adverse events in children with left ventricular dysfunction who are not dependent on right-to-left shunting of blood.

9. In summary, although it was known that neonates dependent on right-to-left shunt should not receive iNO and it had been reported that adults with pre-existing left ventricular dysfunction may be at risk when provided iNO, it was unanticipated and surprising that children with left ventricular dysfunction who are not dependent on right-to-left shunting would be at increased risk of adverse events when administered iNO.

10. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the '359 patent

Dated: July 15 2011

  
\_\_\_\_\_  
David L. Wessel, M.D.

Applicant : James S. Baldassarre et al.  
Serial No. : 12/820,866  
Filed : June 22, 2010

Attorney Docket No. 26047-0003002

# EXHIBIT 1



## CURRICULUM VITAE

### **1) PERSONAL DATA**

Date prepared: April 2011

Name: David Lloyd Wessel

Home address: 3251 Prospect St. NW, Suite 404 Washington, D.C. 20007

Home phone: 202-342-0908

Office Address: Children's National Medical Center  
111 Michigan Ave, NW Suite 3W-100 Washington, DC 20007  
TEL: 202 476 5047 FAX: 202 476-5868

E-Mail Address: dwessel@childrensnational.org

Place of Birth: Newton, Iowa U.S.A.

Citizenship: United States

### **2) EDUCATION:**

1972 B.S. College of William and Mary (Physics), Williamsburg, VA

1974 B.A. Oxford University (Physiology), Oxford, England

1978 M.D. Yale University School of Medicine (Medicine), New Haven, CT

1983 M.A. Oxford University (Physiology), Oxford, England

### **POSTDOCTORAL TRAINING:**

#### *Internship and Residencies:*

1978-79 Intern in Pediatrics, Yale-New Haven Hospital, New Haven, CT

1979-80 Resident in Pediatrics, Yale-New Haven Hospital, New Haven, CT

1981-83 Resident in Anesthesia, Massachusetts General Hospital, Boston, MA

#### *Fellowships:*

1980-81 Fellow in Pediatric Cardiology and Intensive Care, Yale-New Haven Hospital, New Haven, CT

1983-84 Fellow in Pediatric Cardiology, Children's Hospital, Boston, MA

1984-85 Fellow in Anesthesia and Intensive Care, Children's Hospital, Boston, MA

### **3) EMPLOYMENT**

#### **CHILDREN'S HOSPITAL, BOSTON**

1985-87 Assistant in Anesthesia

1985-88 Assistant in Cardiology

1987-00 Associate in Anesthesia

1988-89 Associate in Cardiology

1988-07 Associate in Cardiovascular Surgery

1988-02 Chief, Cardiovascular Intensive Care Unit

1989-07 Senior Associate in Cardiology

1995-02 Division Chief

2000-07 Senior Associate in Anesthesia

2002-03 Honorary Consultant, Royal Brompton Hospital, London, U.K.

**CHILDREN'S NATIONAL MEDICAL CENTER, WASHINGTON, DC**

- 2007- Interim Chief, Division of Critical Care Medicine
- 2007-09 Executive Director, Center for Hospital Based Specialties
- 2009- Senior Vice President, Center for Hospital Based Specialties
- 2010- IKARIA Distinguished Professor of Critical Care Medicine, Children's National Medical Center, Washington, DC

**ACADEMIC APPOINTMENTS:**

- 1980-81 Fellow in Pediatrics (Cardiology), Yale School of Medicine, New Haven, CT
- 1981-83 Clinical Fellow in Anaesthesia, Harvard Medical School, Boston, MA
- 1983-84 Clinical Fellow in Pediatrics, Harvard Medical School, Boston, MA
- 1984-85 Clinical Fellow in Anaesthesia, Harvard Medical School, Boston, MA
- 1985-86 Instructor in Anaesthesia, Harvard Medical School, Boston, MA
- 1987-93 Assistant Professor of Anaesthesia (Pediatrics), Harvard Medical School, Boston,
- 1987-94 Assistant Professor of Pediatrics (Anaesthesia), Harvard Medical School, Boston, MA
- 1994-99 Associate Professor of Pediatrics, Harvard Medical School, Boston, MA
- 1999-02 Associate Professor of Pediatrics (Anaesthesia), Harvard Medical School, Boston, MA
- 2002-03 Visiting Professor Imperial College, University of London, London UK (4/024/03)
- 2002-07 Professor of Pediatrics (Anaesthesia), Harvard Medical School, Boston, MA
- 2011- Professor of Pediatrics, George Washington University School of Medicine and Health Sciences, Washington, DC (pending)

**4) LICENSURE AND CERTIFICATION:**

- 1979 National Board of Medical Examiners
- 1985-07 Massachusetts License Registration
- 1985 American Board of Pediatrics (Permanent)
- 1985 American Board of Pediatrics, Sub-board of Pediatric Cardiology (Permanent)
- 1986 American Board of Anesthesiology (Permanent)
- 1987 American Board of Pediatrics, Sub-board of Critical Care (Re-certified 1996, 2004, 2010)

**5) PROFESSIONAL SOCIETIES & HONORS:**

- 1982- American Society of Anesthesiologists
- 1982-2007 Massachusetts Medical Society
- 1986- American Academy of Pediatrics
- 1987- Society of Critical Care Medicine
- 1987- American Society of Critical Care Anesthesiologists
- 1987- Society of Pediatric Anesthesia
- 1989- American Heart Association (Fellow)
- 1991- Society of Cardiovascular Anesthesiologists
- 1995- Society of Pediatric Research
- 1999- Pediatric Cardiac Intensive Care Society - President 2000-2004; Vice President, Development 2010-

**AWARDS, HONORS AND NAMED LECTURES:**

- 1968 Maytag Scholar (industry sponsored competitive college scholarship)
- 1971 Phi Beta Kappa
- 1971 Omicron Delta Kappa
- 1971 National Physics Honor Society (President)
- 1972 General Honors (William and Mary)
- 1972 Drapers' Scholar (Oxford)
- 1972 Mathematics Honor Society
- 1974 Balliol College Prize (Oxford)
- 1974 First Class Honours (Oxford)
- 1978 Cum Laude (Yale)
- 1978 Alpha Omega Alpha Honor Medical Society
- 1978 Harry S. Greene Prize (Yale)

- 1994 Katkov-Lundeen Memorial Lecture, Minneapolis Children's Hospital, Minneapolis, MN
- 1994 Saul Usher Memorial Lecture, Montreal Children's Hospital, Montreal, Canada
- 1994 Farouk Idriss Memorial Lecture, Children's Memorial Hospital, Chicago, IL
- 1995 A. W. Conn Lecture, Hospital for Sick Children, Toronto, Canada
- 1995 DiCerbo Foundation Lectureship in Pediatric Critical Care, North Shore University Hospital, New York, NY
- 1996 Teaching Award, Pediatric Cardiology, Children's Hospital Boston
- 1997- Listed, *Best Doctors in America*, continuously since inception
- 1999 29<sup>th</sup> Annual Jennifer B. Lalin Lecture, Babies Hospital, Columbia University College of Physicians and Surgeons, New York, NY
- 2000 Tenth Anniversary Lecture, Taiwan Pediatric Association, Critical Care Sub Committee, Kaohsiung Veterans General Hospital, Taipei, Taiwan
- 2001 Recipient, Papas Gift Award for Outstanding Clinical Care (\$25,000 to Children's Hospital Boston)
- 2002 M.A. (Honorary) Harvard University, Cambridge, MA
- 2004 Keynote Address, Opening Ceremony, Annual Meeting of the European Society of Pediatric and Neonatal Intensive Care, London, United Kingdom
- 2004 Leadership & Mentor Award: "In recognition of your contributions toward improving children's heart health," *The Fifth International Symposium on Pediatric Cardiac Intensive Care* co-sponsored by the Pediatric Cardiac Intensive Care Society and the Texas Children's Heart Center
- 2005 Jared Ellsworth Memorial Lecture, Rainbow Babies and Children's Hospital, Cleveland, Ohio
- 2006 Eddie Farrell Memorial Lecture, Massachusetts Society of Respiratory Care
- 2007 Robert A. Boxer, M.D. Memorial Lecture, Schneider Children's Hospital LIJ, North Shore
- 2010 John J. Downes, Jr., M.D. Lecture, Cardiology 2010, Orlando, FL. Sponsored by Children's Hospital Philadelphia.
- 2010 Outstanding Research Award in Pediatric Cardiology (Council on Cardiovascular Disease in the Young), AHA Scientific Sessions, Chicago, IL
- 2010 Anthony Chang Honorary (Inaugural) Lecture. Pediatric Cardiac Intensive Care Society.

## **6) ADMINISTRATIVE DUTIES & UNIVERSITY ACTIVITIES**

### **HOSPITAL AND HEALTH CARE ORGANIZATION SERVICE RESPONSIBILITIES:**

#### CHILDREN'S HOSPITAL, BOSTON

- 1985-91 Attending Physician and Associate Director, Multidisciplinary Intensive Care Unit
- 1985-07 Attending Physician in Cardiology (Intensive Care)
- 1985-07 Attending Physician in Anesthesia (Cardiac)
- 1985-07 Associate in Cardiovascular Surgery (teaching)

#### CHILDREN'S NATIONAL MEDICAL CENTER, WASHINGTON, DC

- 2007- Attending Physician in Critical Care Medicine, Cardiology, Cardiac Anesthesia
- 2007- Member, Children's National Heart Institute

### **MAJOR ADMINISTRATIVE RESPONSIBILITIES:**

#### CHILDREN'S HOSPITAL, BOSTON

- 1988-02 Director, Cardiac Intensive Care Unit
- 1990 Associate Director, Critical Care Pediatrics Training Program
- 1993-02 Treasurer, Board of Directors, Boston Children's Heart Foundation including investigative and forensic accounting responsibilities surrounding departed chairman (1993-96)
- 1997-98 Board of Directors, Children's Hospital Physicians' Organization, Boston, MA
- 1998-03 Physician Leadership Council, Children's Hospital, Boston, MA
- 1999-02 Medical Director, Pharmacy, Children's Hospital, Boston, MA
- 2000-02 Clinical Sponsor, Critical Care Clinical Information System, Children's Hospital, Boston, MA
- 2003-04 Interdisciplinary Peer Review Assignments and Presentation of Critical Events to JCAHO
- 2004-05 Board of Directors, Boston Children's Heart Foundation
- 2004-05 Physician Leadership Council, Children's Hospital, Boston, MA

CHILDREN'S NATIONAL MEDICAL CENTER, WASHINGTON DC

- 2007- Accountable executive for clinical Center of Excellence; \$200M revenue, more than 700 full time employees. Includes divisions and departments of critical care medicine (both cardiac and pediatric ICU neonatology; hospitalist medicine (inpatient general pediatrics); emergency medicine; radiology; respiratory care services (respiratory therapy); infectious disease, hospital infection control and epidemiology; endocrinology and the diabetes care complex; transport medicine, fetal and transitional medicine, ECM
- 2007- Leadership Council
- 2007- Children's Hospital Foundation Board of Directors
- 2007- Critical Care Committee (Co-Chair)
- 2007- Executive Committee of the Medical Staff
- 2007- Executive Directors Council (Senior Vice President Council 2008-)
- 2007- Hospital Based Specialties (HBS) Leadership Committee (Chair)
- 2007- HBS Campaign Council (Chair)
- 2007- Strategic Planning Council
- 2007- Interim Chief, Division of Critical Care Medicine
- 2008- Healthcare Review Committee (risk management financial governance)
- 2009- Steering Committee Strategic Planning Council (2010-15)

**MAJOR COMMITTEE ASSIGNMENTS:**HARVARD MEDICAL SCHOOL

- 1996-98 Futility of Care Task Force, Harvard Medical School
- 1999 Search Committee, Chief of Pediatric Pulmonary Medicine, Children's Hospital, Boston, MA
- 2005-07 Ad Hoc Evaluation Committee for Professorial Promotion

CHILDREN'S HOSPITAL, BOSTON

- 1988-93 Multidisciplinary Intensive Care Committee
- 1989-90 Chairman, Hospital Task Force on Sedation
- 1990-92 Hospital HMO Committee
- 1991-92 Medical Staff Quality Improvement Committee
- 1991-93 Department Quality Improvement Officer
- 1991 Hospital Review Committee for Department of Clinical Laboratories
- 1992 Chairman, Nominating Committee, Medical Staff Association
- 1992-99 Chairman, Special Care Units Committee
- 1992 Hospital Search Committee for Director of Clinical Laboratories
- 1992 Physician Advisory Committee on Computers
- 1992 Operations Improvement Committee
- 1993 Hospital Search Committee for MICU Director
- 1993-01 Cardiovascular Program, Quality Improvement Committee
- 1996-98 Product Standardization Council
- 1998-01 Planning and execution committee for ICU electronic clinical information system
- 1998-01 Clinical Oversight Committee for Transport
- 2000 Nominating Committee, Physicians' Organization
- 2000-02 Chairman, Pharmacy and Therapeutics Committee
- 2000-02 Hospital Task Force on Clinical Building and New Construction
- 2000-06 ICU Committee
- 2004-05 Committee on Pension Investments, Physicians' Organization
- 2004-07 Quality and Outcomes Measurement, Physicians' Organization
- 2005-07 Program for Patient Safety and Quality Implementation Committee
- 2006 Hospital Search Committee for Non-invasive Cardiology Division Chief
- 2006-07 Hospital Peer Review Panel
- 2006-07 Physician Profile Task Force

DEPARTMENT OF CARDIOLOGY, CHILDREN'S HOSPITAL, BOSTON

1988-01 Fellowship Selection Committee  
 1998-02 Audit and Finance Committee  
 1998-02 Computing Committee  
 2004-05 Audit and Finance Committee

CHILDREN'S NATIONAL MEDICAL CENTER, WASHINGTON DC

2007-09 Facilities Leadership Committee  
 2007- Growth Management/ CARE  
 2007- NICU Steering Committee  
 2007- Quality and Clinical Effectiveness Committee  
 2007- Quality and Safety Council  
 2007- Information Technology Oversight Committee  
 2007-09 CTI Clinical Advisory Council (electronic medical record)  
 2007- Task Force on Access/Referral  
 2007-08 Hospital Search Committee for Cardiology Division Chief  
 2007- Safety Transformation Advisory Council  
 2009- Executive Oversight Committee (post graduate education)  
 2009- Physicians Advisory Committee (third party payor contracts)  
 2011- Physician Productivity Committee (Chair)  
 2011- Internal Advisory Board, GWU / CNMC, for NIH funded CTSI Award (Chair)

NATIONAL & INTERNATIONAL

1995 Clinical Trials Review Committee (*Ad hoc* reviewer), National Institutes of Health  
 1995-98 Invited Speaker, Cardio-renal Advisory Panel, U.S. Food and Drug Administration  
 2004-06 Task Force ACC AHA AAP: Requirements for Pediatric Cardiac Critical Care Training  
 2005-06 Multi-Societal Committee (PCICS/EACTS/STS) Complications in Pediatric and Congenital Cardiac Surgery Project  
 2008- National Institute of Allergy and Infectious Disease Transplant Data and Safety Monitoring Board (DSMB) - Member  
 2010 FDA Invited Speaker, Continuing Education Series  
 2010 International Liaison Committee on Resuscitation (ILCOR): 2010 Consensus Statement and Treatment Recommendations.  
 2011 Joint American Heart Association (AHA) – American Thoracic Society Expert Guidelines Statement on Pediatric Pulmonary Hypertension.

INDUSTRY

1994-97 Scientific Advisory Board on Nitric Oxide, Ohmeda Pharmaceuticals  
 1998-02 Curriculum Development Committee, INO Therapeutics  
 1999-01 Steering Committee, Prophylactic use of Primacor® in pediatric patients at high risk of developing low cardiac output syndrome following cardiac surgery. PRIMACORP study Prophylactic intravenous use of milrinone after cardiac operation in pediatrics. Sanofi-Synthelabo Inc.  
 2001-06 Chairman, Advisory Panel INO Therapeutics  
 2001-02 Scientific Advisory Board AGA-Linde  
 2001-03 Protocol Planning Committee (PDE V inhibitors) Pfizer  
 2001-09 Scientific Advisory Board for pulmonary hypertension research development, Pfizer  
 2003 Steering Committee for Multicenter Trial on Diagnostic Use of Inhaled Nitric Oxide  
 2005-07 Steering Committee for Multicenter Trial on Use of Nesiritide in Children, SCIOS (Johnson & Johnson)  
 2005-07 Advisory Committee on Iloprost and Treatment of Pulmonary Hypertension in Children, Cotherix  
 2005-07 Advisory Board, Eli Lilly Vardenafil for Pediatric Pulmonary Hypertension  
 2006- Steering Committee (Chairman) for Multicenter Trial on Use of Clopidogrel in Children (CLARINET), Bristol-Myers Squibb & Sanofi-Aventis  
 2009 Advisory Panel, Nesiritide Use in Pediatric Cardiovascular patients, Johnson & Johnson

**COMMUNITY SERVICE RELATED TO PROFESSIONAL WORK:**

- 1994-97 Lecturer, Human Body Curriculum, Wellesley Public School System, Wellesley, MA
- 1996 Hospital Spokesman, Boston/Filenes' Holiday Festival
- 1996 Campaign for William & Mary, 25<sup>th</sup> Anniversary Committee
- 2000-02 Hospital Spokesman, Capital Campaign and Children's Hospital Boston Fundraising, including keynote speaker, 2000
- 2007- Multiple CNMC Fundraising and Community Benefit Events presentations to Emeritus and Lady Visiting Boards, etc.
- 2008 Speaker, CNMC Corporate Leadership Council "What's Up, Doc?" Breakfast, World Bank, Washington D.C.

**EDITORIAL BOARDS/REVIEW COMMITTEES:**

*Ad Hoc Reviewer:*

Acta Paediatrica

American Journal of Cardiology, American Journal of Physiology

American Review of Respiratory Diseases and Critical Care

Anesthesia & Analgesia, Anesthesiology

Annals of Thoracic Surgery

Archives of Diseases of Childhood

Cardiovascular and Interventional Radiology

Chest

Circulation

Critical Care Medicine

European Heart Journal

Future Cardiology

Journal of Intensive Care Medicine

Journal of Pediatrics

Journal of Thoracic and Cardiovascular Surgery

Mayo Clinic Proceedings

Pediatrics, Pediatric Cardiology, Pediatric Critical Care Medicine, Pediatric Research

Proceedings of the National Academy of Science

Invited consultant, to review and make recommendations to institutional programs for pediatric cardiovascular care (national and international)

Asked by Children's Hospital Boston to chair ad hoc committees reviewing sentinel events, other critical incidents and report the hospital's analysis and action to the Hospital's Board of Trustees, JCAHO, etc.

**7) EDUCATIONAL ACHIEVEMENTS**

**REPORT OF TEACHING**

**1. LOCAL CONTRIBUTIONS**

**a) MEDICAL SCHOOL**

Yale University School of Medicine, New Haven, CT

1975-76 Program leader, Cardiovascular physiology core lectures in Physician's Associate Program  
Designed lecture series for new PA program; 20 hours/year

Harvard Medical School, Boston, MA

1983-98 Instructor, Cardiovascular Physiology Animal Laboratory, Harvard Medical School  
Approximately 60 medical students; one day per year

1985-89 Cardiovascular Pathophysiology, Laboratory section on congenital heart disease  
Approximately 30 medical students; half day per year

1985-89 PGY clerkship in Pediatrics  
 Lecturer in Critical Care (Multidisciplinary ICU)  
 2 medical students each lecture; 12 hours/year

**b) GRADUATE MEDICAL EDUCATION (LOCAL)**

- 1985-89 Didactic seminars on cardiovascular pathophysiology for pediatric critical care fellows and rotating residents  
 Lecture once per week, 1 hour, 6 trainees per lecture
- 1986-93 Developed and taught core curriculum: introduction to anesthesia and critical care for cardiologists  
 Lecture once per week, 1 hour, six weeks, 20 fellows and junior faculty. Preparation, 40 hours per year
- 1985-89 Co-developed tutorials on congenital heart disease and supervised core staff (3 tutors) for instruction of cardiology and cardiac ICU fellows during ICU rotation  
 Lectures three mornings per week, 1/2 hour, 3-4 fellows; preparation, 2 hours per week
- 1985-07 CICU attending rounds  
 3 pediatric residents (1985-1989), 4-8 fellows and senior surgical residents; 18 hours/week, 16-40 weeks/year (varies with year)
- 1990-96 Chiefs' Ward Rounds  
 3 medical students, 3 pediatric residents, 1 cardiology fellow; monthly 12 hours/year
- 1996-07 Didactic lectures to cardiology fellows teaching program  
 20 fellows 3 times per year
- 2002-03 Didactic lectures (monthly) to trainees at Royal Brompton Hospital. London

**c) BOSTON INVITED TEACHING PRESENTATIONS (SELECTED)**

- 1984 Anesthesia Grand Rounds, Children's Hospital, Boston, MA  
 1991 Anesthesia Grand Rounds, Children's Hospital, Boston, MA  
 1992 Surgical Grand Rounds, Children's Hospital, Boston, MA  
 1992 Medical Grand Rounds, Children's Hospital, Boston, MA  
 1994 Anesthesia Grand Rounds, Children's Hospital, Boston, MA  
 1996 Anesthesia Grand Rounds, Massachusetts General Hospital, Boston, MA  
 1996 PICU Teaching Sessions, Massachusetts General Hospital, Boston, MA  
 1997 Surgical Grand Rounds, Children's Hospital, Boston, MA  
 1997 Medical Grand Rounds, Children's Hospital, Boston, MA  
 1998 Anesthesia Grand Rounds, Children's Hospital, Boston, MA  
 2003 Grand Rounds and teaching rounds, Royal Brompton Hospital, London, UK  
 2004 Neonatology Clinical Working Group, Children's Hospital, Boston, MA  
 2004 Department of Respiratory Therapy Clinical Working Group, Children's Hospital, Boston, MA  
 2005 Department of Cardiology, Didactic Series, Children's Hospital Boston, Boston, MA

**d) WASHINGTON DC AREA INVITED TEACHING PRESENTATIONS (SELECTED)**

- Chief Rounds Monthly to ICU & Cardiology fellows and staff (15-20 physicians, 2hrs/month), CNMC, DC
- ICU Attending Rounds, Children's National Medical Center, DC
- Clinical Research Presentation to ICU/Cardiology Fellows 2 times per year, Children's National Medical Center, DC
- Grand Rounds, Children's National Medical Center, DC
- Grand Rounds, Mary Washington Hospital, VA
- Grand Rounds, Anne Arundel Medical Center, MD
- Teaching Rounds, Division of Critical Care Medicine, National Institutes of Health

**e) CONTINUING MEDICAL EDUCATION (LOCAL)**

- 1988 Lecturer  
Harvard Medical School, Continuing Education Course in Pediatric Anesthesia  
"Anesthesia for Congenital Heart Disease"
- 1990 Lecturer  
Harvard Medical School Continuing Education Course in Pediatric Anesthesia  
"Common Congenital Cardiac Lesions"
- 1989 Moderator  
Harvard Medical School, Continuing Education Course in Pediatric Cardiovascular Disease
- 1993 Lecturer  
Symposium on Brain Injury and Cardiac Surgery, Harvard Medical School, Boston, MA  
"Choreoathetosis After Cardiopulmonary Bypass"
- 1996 Lecturer  
Harvard Medical School Continuing Education Course in Pediatric Anesthesia  
"New Vasoactive Drugs"
- 1998 Co-director, First Annual Course: Frontiers in the Diagnosis and Management of Congenital Heart Disease, Children's Hospital, Boston, Harvard Medical School, Boston, MA
- 1999 Co-director, Second Annual Course: Frontiers in the Diagnosis and Management of Congenital Heart Disease, Children's Hospital, Boston, Newport, Rhode Island
- 2001 Co-director, Third Annual Course: Frontiers in the Diagnosis and Management of Congenital Heart Disease, Children's Hospital, Boston, Newport, Rhode Island

**f) ADVISORY AND SUPERVISORY RESPONSIBILITIES (LOCAL)**

- 1987- Responsible for clinical supervision and educational component of critical care for cardiology fellows in a large pediatric cardiology training program (two months each year for each of 18 fellows spread over 2-3 years of training).
- 1990-02 Responsible as mentor for clinical, educational and clinical research activities of 2-3 senior clinical fellows each year.
- 1985- Shared responsibilities for cardiovascular education and clinical supervision of pediatric critical care fellows in the CICU (3-5 months per year for 5-6 fellows spread over 2-3 years of training).
- 1985-02 Shared responsibilities for critical care educational component of pediatric cardiovascular surgical training program (10 surgical residents each year rotating for 6 months each).
- 1987-02 Responsible for medical education and clinical advisory tasks for continuing education seminars for 80 critical care nurses.

**g) LEADERSHIP ROLE (LOCAL)**

- 1998-01 Program Co-Director  
Annual Course, "Frontiers in Diagnosis and Management of Congenital Heart Disease" Shared responsibility for organizing and executing post graduate course attended by 200 pediatric cardiologists cardiovascular surgeons and nurses from the US and abroad.



**h) NAMES OF SELECTED TRAINEES AND/OR FORMER CICU STAFF WHO HAVE CURRENT LEADERSHIP POSITIONS**

- 1985-88 Gil Wernovsky, MD, FACC \*†§  
 Director of Program Development  
 Former Director, Cardiac Intensive Care Unit  
 The Children's Hospital of Philadelphia  
 Professor of Pediatrics  
 University of Pennsylvania School of Medicine  
 Philadelphia, Pennsylvania
- 1988-89 Ling Chen, MD \*  
 Director, Cardiac Intensive Care Unit  
 Shanghai Children's Medical Center  
 Shanghai, China
- 1989-92 Pierre C. Wong, MD \*†  
 Cardiology Medical Director, Transplantation  
 Children's Hospital of Los Angeles  
 Los Angeles, California
- 1989-92 Stephen J. Roth, MD, MPH \*†  
 Director, Cardiac Intensive Care Unit  
 Lucile Packard Children's Hospital  
 Associate Professor of Pediatrics  
 Stanford University School of Medicine  
 Palo Alto, California
- 1989-92 Nancy Bridges, MD  
 Chief, Transplantation Immunology Branch, Division of Allergy, Immunology, and  
 Transplantation  
 National Institute of Allergy and Infectious Disease  
 Bethesda, Maryland
- 1990-92 Howard A. Zucker, MD, FACC\*  
 Deputy Director of the World Health Organization  
 Geneva, Switzerland
- 1990-93 Kevin B. Churchwell, MD  
 Chief Executive Officer (CEO) for Nemours/Alfred I. duPont Hospital for Children  
 Wilmington, DE.
- 1990-93 Anthony C. Chang, MD \*†§  
 Medical Director, CHOC Children's Heart Institute  
 Children's Hospital Orange County  
 Orange, California
- 1991-94 Ian Adatia, MB, ChB, MRCP (UK), FRCP (C) \*†  
 Director, Pediatric Cardiac Critical and Intermediate Care Program,  
 Director, Pediatric Pulmonary Hypertension Clinic,  
 Stollery Children's Hospital,  
 Professor of Pediatrics  
 University of Alberta  
 Edmonton, Alberta, Canada

- 1992-96 Andrew M. Atz, MD \*†§  
Director, Pediatric Cardiac Intensive Care Unit  
The Children's Heart Program  
Associate Professor of Pediatrics  
Medical University of South Carolina  
Charleston, South Carolina
- 1992-96 David P. Nelson, MD, PhD \*  
Director, Cardiac Intensive Care  
Cincinnati Children's Hospital Medical Center  
Professor of Pediatrics  
Cincinnati, Ohio
- 1992-97 Sarah Tabbutt, MD, PhD \*  
Director, Pediatric Cardiac Intensive Care Unit  
UCSF Children's Hospital  
San Francisco, California
- 1994-97 Ricardo A. Muñoz, MD \*†§  
Director, Pediatric Cardiac Intensive Care  
Director, Global Business and Telemedicine  
Children's Hospital Pittsburgh  
Associate Professor of Pediatrics  
University of Pittsburgh  
Pittsburgh, Pennsylvania
- 1994-99 Melvin C. Almodovar, MD \*†§  
Medical Director, Cardiac Intensive Care Unit  
Boston Children's Hospital  
Assistant Professor  
Harvard Medical School  
Boston, Massachusetts
- 1995-96 Brendan O'Hare, MD \*  
Consultant in Anesthesia and Critical Care  
Our Lady's Hospital for Sick Children  
Crumlin, Dublin, Ireland
- 1995-96- Steven Schwartz, MD  
Director of Cardiac Intensive Care  
Hospital for Sick Children  
Assistant Professor of Pediatrics  
University of Toronto  
Toronto, Ontario, Canada
- 1996-97 Alain Fraisse, MD \*†  
Chief, Clinical Pediatric Cardiology  
Hopital D'Enfants de la Timone  
Professor of Pediatrics  
Universitaire de Marseille  
Marseille, France

- 1997-98 Guillermo Palacio, MD  
Director Pediatric Cardiac Intensive Care Unit  
Fundacion Cardio Infantil  
Bogota, Colombia
- 1997-98 Mary B. Taylor, MD \*  
Director, Pediatric Cardiac Critical Care  
Cardiology and Critical Care  
Vanderbilt Children's Hospital  
Associate Professor of Pediatrics  
Vanderbilt University Medical Center  
Nashville, Tennessee
- 1997-99 Rajiv Chaturvedi, MB BChir, MRCP (UK), MD \*  
Pediatric Cardiology  
Hospital for Sick Children  
Assistant Professor  
University of Toronto  
Toronto, Ontario, Canada
- 1998-01 Ravi Thiagarajan, M.D.\* † §  
Director, Cardiac ECMO Program  
Children's Hospital Boston  
Associate Professor of Pediatrics  
Harvard Medical School  
Boston, Massachusetts
- 1998-02 Peter C. Laussen, MBBS §  
Chief, Division of Cardiovascular Intensive Care  
D.D. Hansen Chair in Pediatric Anesthesia  
Senior Associate in Cardiology  
Children's Hospital Boston  
Professor of Anesthesia  
Harvard Medical School  
Boston, Massachusetts
- 1998-99 Mary P. Mullen, MD, PhD \*§  
Director, Pulmonary Hypertension Program  
Assistant in Cardiology  
Children's Hospital Boston  
Assistant Professor in Pediatrics  
Harvard Medical School  
Boston, Massachusetts
- 1999 Janet M. Sinsic, M.D.\*  
Director, Pediatric Cardiac Intensive Care Unit  
Nationwide Children's Hospital  
Columbus, Ohio
- 2000 Erica A. Kirsch, MD\*  
Director of Pediatric ECMO Program  
Associate Professor of Pediatrics  
University of Missouri-Kansas City School of Medicine  
Kansas City, Missouri

2003-05 Margarita Burmester, MBBS\* †  
Consultant in Pediatric Intensive Care  
Royal Brompton Hospital  
Imperial College  
London, United Kingdom

\* Clinical Trainees  
† Research Trainees  
§ Faculty in CICU, Children's Hospital Boston  
during my tenure as Chief

**TEACHING AND EDUCATIONAL LEADERSHIP ROLES (LOCAL AND INTERNATIONAL)**

- 1987 Critical Care Consultant for Project Hope and the Cardiac Intensive Care Unit, Xin Hua, Shanghai, China. Developed teaching program for critical care and supervised clinical training of physicians during 2-6month exchange programs.
- 1996- Abstract and Program Reviewer for many National and International Societies including SPR, AHA, ACC, PCICS, World Congress
- 2000 Invited faculty and cardiovascular program curriculum track convener III International Congress of Pediatric Intensive Care, Montreal, Canada.
- 2002 Scientific Programme, Coordinator  
The Third Special Topics in Paediatric Cardiac Intensive Care, The Failing Myocardium  
Royal Brompton Hospital, Imperial College, London, United Kingdom
- 2003 Invited faculty and cardiovascular program curriculum track convener IV International Congress of Pediatric Intensive Care, Boston, MA
- 2004 Discussant Leader and Co-author (after Tom Kulik) on Critical Care Training Guidelines in Cardiology (SCCM, PCICS, AHA, ACC)
- 2005 Scientific Program Committee Pediatric Cardiac Intensive Care Symposium 2005 (PCICS 2005), Miami, FL
- 2006 Planning Committee, First International Conference on Childhood Pulmonary Vascular Disease, San Francisco, CA 2007
- 2008 Critical Care Consultant, University of Mississippi Medical Center, Jackson, MS

**TEACHING AWARD(S) RECEIVED**

- 1996 Faculty Teaching Award, Dept. Cardiology, Children's Hospital, Harvard Medical School
- 2010 Top rated faculty teacher for division of critical care medicine in trainee survey

**MAJOR CURRICULUM OFFERING, TEACHING CASES OR INNOVATIVE EDUCATIONAL PROGRAMS DEVELOPED**

- 1990-02 Developed a senior clinical fellowship training program for cardiac intensive care with short term training experience available through formal training program relationships with the MICU, Children's Hospital; PICU, Massachusetts General Hospital; Neonatology, Children's Hospital; Neonatology, University of Vermont. Long term (6-36 month) training program applicants accepted (2-3 per year) from candidates in advanced levels of fellowship training from national and international programs.

- 1988-90 In collaboration with the Cardiovascular Nursing Director, developed, reviewed and edited algorithms for care, nursing practice and clinical practice guidelines and quality improvement manuals for the Cardiovascular Program, Children's Hospital, Boston.
- 2004 In collaboration with Pediatric Cardiac Intensive Care Society and the Training Program Directors for Pediatric Cardiology, coauthored (with T. Kulik and others) the report to the Joint Committee on Training Programs (AHA/ACC) on training requirements in critical care for pediatric cardiology trainees.
- 2008 As interim division chief of critical care medicine at Children's National Medical Center, I implemented and supervised a reorganization of the fellowship training program, its leadership and aspects of its curriculum

## **8) CONSULTANT APPOINTMENTS**

### **VISITING PROFESSORSHIP:**

- 1986 Visiting Professor  
"Critical Care of the Child with Congenital Heart Disease"  
Department of Cardiology, Children's National Medical Center, Washington, D.C.
- 1993 Visiting Professor,  
"Perioperative Care of the Neonate with Congenital Heart Disease"  
University of Southern California, Children's Hospital of Los Angeles
- 1993 Visiting Professor  
"Nitric Oxide and ECMO Therapies for Persistent Pulmonary Hypertension of the Newborn"  
Schneider Children's Hospital, Albert Einstein College of Medicine, New York, NY
- 1994 Visiting Professor  
"Perioperative Care of the Critically Ill Neonate with Congenital Heart Disease; Perioperative Management of Low Cardiac Output"  
Medical University of South Carolina, Charleston, SC
- 1994 Visiting Professor  
"Inhaled Nitric Oxide in the Treatment of Children with Congenital Heart Disease"  
Dennison Young Memorial Symposium, Montefiore Medical Center, New York, NY
- 1994 Visiting Professor  
"Care of the Critically Ill Neonate"  
Minneapolis Children's Hospital, Minneapolis, MN
- 1994 Visiting Professor  
"Therapeutic Applications of Inhaled Nitric Oxide"  
Children's Memorial Hospital, Chicago, IL
- 1994 Visiting Professor  
Grand Rounds: "Treatment of Pulmonary Hypertension"  
Montreal Children's Hospital, Montreal, Canada
- 1995 Visiting Professor  
"Multidisciplinary Management of Complex Congenital Heart Disease"  
Anesthesia and Critical Care Grand Rounds, Hospital for Sick Children  
University of Toronto, Toronto, Canada

- 1995 Visiting Professor  
"Controversy in Critical Care: New Views of Simple Gases (O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub> and NO)"  
Anesthesia Grand Rounds, Children's Hospital of Philadelphia, Philadelphia, PA
- 1995 Visiting Professor  
"Nitric Oxide: Magic and Medicine"  
Medical College of Georgia, Augusta, GA
- 1995 Visiting Professor  
"Controversy in Critical Care: New Views of Simple Gases"  
Children's Hospital of Pittsburgh, Dept of Surgery, University of Pittsburgh, Pittsburgh, PA
- 1995 Visiting Professor  
"Perioperative Care of the Newborn with Congenital Heart Disease"  
Division of Pediatric Cardiology, Yale University School of Medicine, New Haven, CT
- 1997 Visiting Professor  
"Perioperative Care in the Child with Congenital Heart Disease"  
Pediatric Grand Rounds, Vanderbilt Children's Hospital, Nashville, TN
- 2000 Visiting Professor  
"Newborns with Heart Disease: Extending the Limits of Intervention"  
Columbia-Presbyterian Medical Center, Babies Hospital, New York, NY
- 2003 Visiting Professor  
"Treatment of Low Cardiac Output"  
Cardiovascular Rounds, Hospital for Sick Children, Great Ormand Street,  
London, United Kingdom
- 2005 Visiting Professor  
Multiple lectures. University of Pittsburgh, Department of Critical Care Medicine, University of  
Pittsburgh Medical  
Center and the Children's Hospital of Pittsburgh
- 2005 Visiting Professor  
"Progress and problems in the treatment of critical heart disease"  
Ellsworth Memorial Lecture, Pediatric Grand Rounds, Rainbow Babies & Children's Hospital,  
Cleveland, OH
- 2006 Visiting Professor  
"Navigating a career in Medicine". Health Careers Club, College of William & Mary,  
Williamsburg, VA
- 2009 Visiting Professor  
"The Challenges of Postoperative Care of the Child with CHD"  
Pediatric Grand Rounds, Vanderbilt Children's Hospital, Nashville, TN

## 9) PRESENTATIONS

### NATIONAL

- 1990 Seminar Moderator  
"Cardiovascular Disease"  
Fourth Pediatric Critical Care Colloquium, Waterville, NH

- 1991 Invited Lecture  
"Perioperative Management of Congenital Heart Disease"  
Annual Meeting, Society of Pediatric Anesthesia, San Francisco, CA
- 1992 Workshop Faculty  
"Anesthesia for Congenital Heart Disease"  
Annual Meeting of the Society of Cardiovascular Anesthesiologists, Boston, MA
- 1992 Invited Lectures  
"Perioperative Management & Decision making in the Neonate with Congenital Heart Disease"  
Critical Care Pediatrics Symposium, Arnold Palmer Hospital, Orlando, FL
- 1992 Invited Lectures  
Multiple topics on Critical Care of Children with Heart Disease and  
"Treatment of Pulmonary Hypertension with Inhaled Nitric Oxide"  
First World Congress of Pediatric Critical Care, Baltimore, MD
- 1992 Anesthesia Grand Rounds  
"Postoperative Care of the Child with Congenital Heart Disease"  
Maine Medical Center, Portland, ME
- 1992 Invited Faculty  
"Postoperative Management of the Open Heart Surgery Patient"  
Society of Critical Care Medicine, Pediatric Critical Care Clinical Review Series,  
San Antonio, TX
- 1993 NIH Invited Lecture  
"Nitric Oxide in Congenital Heart Disease"  
National Institutes of Health Workshop: The effects of Nitric Oxide on the Lung, Bethesda, MD
- 1993 NIH Invited Lecture  
"Indications for NO in the Newborn with Heart Disease"  
National Institutes of Health Workshop on Nitric Oxide and the Perinatal Period, Bethesda, MD
- 1993 Symposium  
"Nitric Oxide Gas in the Evaluation and Management of Pulmonary Hypertension"  
Annual Meeting of the American College of Cardiology, Anaheim, CA
- 1993 Invited Lecture  
"New Strategies for Treating Pulmonary Hypertension"  
Annual Meeting, American Academy of Pediatrics, Washington, DC
- 1993 Invited Lecture  
"Use of Inhaled Nitric Oxide for the Acute Treatment of Pulmonary Hypertension in Patients  
with Congenital Heart Disease" Annual Meeting, American Heart Association, Atlanta, GA
- 1993 NIH Workshop Lecture  
"Nitric Oxide in the Perinatal Period" National Institutes of Health, Bethesda, MD
- 1993 Invited Lecture  
"Inhaled Nitric Oxide for the Treatment of Persistent Pulmonary Hypertension of the Newborn"  
Fourth Annual New England ECMO Symposium, Children's Hospital, Boston, MA

- 1993 Symposium  
"Vasodilator Therapy and Inhaled Nitric Oxide in Children" Infant Hearts and Lungs  
Transplantation and Alternative Strategies.  
Children's Hospital of Los Angeles, Long Beach, CA
- 1994 Symposium  
"Update on Nitric Oxide"  
Annual Meeting, Society of Critical Care Medicine, Orlando, FL
- 1994 Symposium  
"Nitric Oxide Gas in the Evaluation and Management of Pulmonary Hypertension"  
Annual Meeting of the American College of Cardiology, Atlanta, GA
- 1994 Invited Lecture  
"Nitric Oxide for Pulmonary Hypertension"  
Post Graduate Course on Congenital Heart Disease  
American Association of Thoracic Surgery, New York, NY
- 1994 Plenary Session  
"Inhaled Nitric Oxide for the Treatment of Pulmonary Hypertension in Children"  
International Conference on Biochemistry and Molecular Biology of Nitric Oxide, University of  
California, Los Angeles, CA
- 1994 Guest Faculty  
"Nitric Oxide in the Treatment of Pulmonary Hypertension in Congenital Heart Disease"  
Pediatric Cardiology-The Failing Heart Conference, Given Biomedical Institute, University of  
Colorado, Aspen, CO
- 1994 Invited Lecture  
"Perioperative Use of Inhaled Nitric Oxide"  
Annual Meeting of the American Academy of Pediatrics, Dallas, TX
- 1994 Invited Faculty  
"Serious Heart Disease of the Neonate: Management"  
American Academy of Pediatrics Neoprep Course, St. Louis, MO
- 1994 Invited Faculty  
"Perioperative Care of the Critically Ill Child with Congenital Heart Disease"  
Society of Critical Care Medicine, Pediatric Critical Care Clinical Review Series, San  
Francisco, CA
- 1995 Invited Lecture  
"Pulmonary Hypertension and Nitric Oxide"  
Annual Meeting, American College of Cardiology, New Orleans, LA
- 1995 Invited Lecture  
"Current Therapeutic Applications of Inhaled Nitric Oxide"  
International Business Communications, Nitric Oxide Conference, Philadelphia, PA
- 1995 Invited Lecture  
"Choreoathetosis After Cardiopulmonary Bypass"  
Annual Meeting, American Society of Extra-Corporeal Technology, Boston, MA
- 1995 Invited Lecture  
"Nitric Oxide for Perioperative Management of Congenital Heart Disease"  
Annual Meeting of the American College of Surgeons, New Orleans, LA



- 1995 Invited Lecture  
Controversy in Critical Care: New Views of Simple Gases  
DiCerbo Foundation Lectureship in Pediatric Critical Care, North Shore University Hospital,  
New York, NY
- 1995 Dinner Speaker  
"Diagnostic and Therapeutic Applications of Inhaled Nitric Oxide"  
Annual Dinner Meeting, New York Society of Pediatric Critical Care Medicine, New York, NY
- 1995 Pediatric Grand Rounds  
"Controversy in Critical Care: New Views of Simple Gases"  
Cornell University Medical Center, New York, NY
- 1995 FDA Invited Lecture  
"Inhaled Nitric Oxide for the Treatment of Persistent Pulmonary Hypertension of the Newborn"  
Open Meeting, Cardiovascular and Renal Drugs Advisory Committee, United States Food &  
Drug Administration, Bethesda, MD
- 1995 FDA Invited Discussant  
"Use of Inhaled Nitric Oxide in Pediatrics"  
Division of Cardiorenal Drug Products, U.S. Food & Drug Administration Rockville, MD
- 1996 Invited Lecture  
"Persistent Pulmonary Hypertension and Alveolar/Capillary Dysplasia"  
Pediatric Grand Rounds, Elliot Hospital, Manchester, NH
- 1996 Invited Lecture  
"Clinical Use of Inhaled Nitric Oxide"  
International Business Communications Nitric Oxide Conference, Philadelphia, PA
- 1996 Seminar Speaker  
"Postoperative Management of Pulmonary Hypertension in Pediatric Patients with Congenital  
or Acquired Heart Disease" Annual Meeting, American College of Cardiology, Orlando, FL
- 1996 Invited Lecture  
"Inhaled Nitric Oxide-Clinical Experience"  
First International Meeting on Pediatric Cardiac Intensive Care, Miami, FL
- 1996 Invited Lecture  
"Pre and Postoperative Manipulation of the Vascular Resistance"  
Annual Meeting, American Heart Association, New Orleans, LA
- 1996 Invited Lecture  
"Current Concepts in Neonatology"  
Section on Perinatology, American Academy of Pediatrics and the Joint Program in  
Neonatology, Harvard Medical School, Boston, MA
- 1997 Seminar  
"Medical Management of Perioperative Pulmonary Hypertension"  
Annual Meeting, Society of Critical Care Medicine, San Diego, CA
- 1997 Invited Lecture  
"Nitric Oxide and the Treatment of Postoperative Pulmonary Hypertension"  
Second World Congress of Pediatric Cardiology and Cardiac Surgery, Honolulu, Hawaii

- 1997 Invited Lecture  
"Inhaled Nitric Oxide for the Treatment of Persistent Pulmonary Hypertension of the Newborn"  
Open Meeting, Division of Cardioresenal Drugs, United States Food & Drug Administration,  
Bethesda, MD
- 1997 Invited Lecture  
"Perioperative Care of the Child with Congenital Heart Disease: New Treatment  
Strategies for Pulmonary Hypertension"  
Cardiothoracic Anesthesia Meeting, Washington University, St. Louis, MO
- 1997 Plenary Session  
"Advances and Controversies in Cardiac Management"  
Tenth Annual Pediatric Critical Care Colloquium, Hot Springs, AR
- 1997 Invited Faculty  
"Critical Care of the Child with Congenital Heart Disease" (moderator lecturer, judge)  
Second International Symposium on Pediatric Cardiac Intensive Care, Palm Beach, FL
- 1997 Invited Speaker  
"Nitric Oxide in Neonatal Care"  
Topics in Neonatal and Respiratory Care, Brigham & Women's Hospital, Boston, MA
- 1998 Invited Lectures  
"Cardiac Surgery in Neonates: Morbidity and Mortality"  
Charleston Symposium on Congenital Heart Disease, Medical University of South Carolina,  
Charleston, SC
- 1998 Symposium  
"Advances in ICU Management for Congenital Heart Disease"  
Annual Meeting, American College of Cardiology, Atlanta, GA
- 1998 Invited Lecture  
"Intensive Care After Neonatal Cardiac Surgery: State-of-the-Art"  
First Annual Course on Frontiers in Diagnosis and Management of Congenital Heart Disease,  
Boston, MA
- 1999 Invited Faculty  
"Myocardial Support for Low Cardiac Output"  
Society of Critical Care Medicine  
Current Concepts in Pediatric Critical Care Course, San Francisco, CA
- 1999 Invited Lecture  
"Nitric Oxide and the Treatment of Pulmonary Hypertension"  
Oral Presentation Moderator, Walk Rounds with the Professor  
28<sup>th</sup> Scientific Symposium, Society of Critical Care Medicine, San Francisco, CA
- 1999 Symposium  
"The Airway, Mechanical Ventilation and Cardiopulmonary Interaction"  
Annual Meeting, American Heart Association, Atlanta, GA
- 1999 Invited Speaker  
"Nitric Oxide and New Therapies"  
Third International Symposium on Pediatric Cardiac Intensive Care, Miami, FL

- 2000      Invited Faculty  
             "Nitric Oxide in the Perioperative Management of CHD"  
             Cardiology Y2K, Annual Update on Pediatric Cardiovascular Disease, Orlando, FL
  
- 2000      Symposium  
             "Intensive Care Unit Management After Surgery for Single Ventricle HLHS Syndrome"  
             Annual Meeting, American College of Cardiology, Anaheim, CA
  
- 2000      Invited Lecture  
             "Perioperative Care of the Premature Newborn with Congenital Heart Disease"  
             Castañeda Society Meeting, Boston, MA
  
- 2000      Invited Faculty  
             "Perioperative Care of the Premature Newborn with Congenital Heart Disease"  
             Tenth Charleston Symposium on Congenital Heart Disease, Charleston, SC
  
- 2001      Invited Faculty  
             "Clinical Research"  
             The Changing Face of Pediatric Cardiology 1950-2000: A Tribute to Alexander S. Nadas, M.D.  
             The Cardiovascular Program at Children's Hospital, Boston, MA
  
- 2001      Invited Faculty  
             "Cardiopulmonary Support in the Pediatric Cardiac Intensive Care Unit"  
             Third Course on Frontiers in Diagnosis and Management of Congenital Heart Disease,  
             Newport, RI
  
- 2001      Invited Faculty  
             Diverse Topics  
             Fourth International Symposium on Pediatric Cardiac Intensive Care, Palm Beach, FL
  
- 2002      Invited Speaker  
             "Sildenafil for Treatment of Pulmonary Hypertension"  
             ECMO Meeting, Children's National Medical Center, Keystone, Colorado
  
- 2002      Invited Speaker  
             "Novel Pediatric Applications of Commonly Used Adult Drugs"  
             Back to our Future: Establishing Safety and Evidence in Pediatric Research  
             Duke University, FDA & Industry, Washington, DC
  
- 2002      Invited Lecturer  
             "The Future of Inhaled Nitric Oxide for Children with Congenital Heart Disease"  
             CME Course in Hematology, Northwestern University Medical School  
             Chicago, Illinois
  
- 2002      Invited Faculty  
             "Manipulating Vascular Resistance in the Newborn: Is it Feasible?"  
             3<sup>rd</sup> International Pediatric Cardiovascular Symposium, Atlanta, Georgia
  
- 2002      Invited Speaker  
             "Viagra for Pulmonary Hypertension"  
             Hot Topics in Neonatology, Washington, DC

- 2003 Plenary Speaker  
"Changes in Worldwide Activity and Mortality in Cardiac Intensive Care"  
Debate: "Cardiac Patients Need Their Own ICU"  
Symposium Chairman: "New Strategies in Treatment of Pulmonary Hypertension"  
4<sup>th</sup> World Congress of Pediatric Intensive Care. Boston, Massachusetts
- 2004 Invited Faculty  
"Pharmacologic Management of Low Cardiac Output Syndrome After Congenital Heart Surgery" Current Concepts in Pediatric Critical Care Medicine Course  
Society for Critical Care Medicine, Orlando, Florida
- 2004 Invited Faculty  
"Structure of a Training Program in Pediatric Cardiac Intensive Care"  
33<sup>rd</sup> Annual Meeting of the Society for Critical Care Medicine, Orlando, Florida
- 2004 Invited Faculty  
"Reconciling FDA, Academic, and Industry Objectives in Pediatric Clinical Trials"  
Cardiology 2004, Orlando, Florida (Children's Hospital of Philadelphia)
- 2004 Invited Speaker  
"Cardiac and Central Nervous System Interactions"  
15<sup>th</sup> Annual Pediatric Critical Care Colloquium, New York City, New York
- 2004 Invited Faculty  
"Advances in the Management of Pulmonary Hypertension"  
"Physician Perspective on Electronic Billing:  
Congenital Cardiovascular Surgery Symposium, San Diego, California
- 2004 Invited Participant in "How To" Session  
"How to Evaluate and Manage Pediatric Patients with Pulmonary Hypertension"  
American Heart Association, Scientific Sessions 2004, New Orleans, LA
- 2004 Invited Faculty, Special Session  
"Twenty Year Retrospective: The Early Years and Later"  
Pediatric Cardiac Intensive Care Symposium, Miami, FL
- 2004 Invited Faculty  
"Nitric Oxide and the Intensive Care Setting"  
Pediatric Cardiac Intensive Care Symposium, Miami, FL
- 2004 Invited Faculty  
"How to Design and Conduct Drug Trials"  
Pediatric Cardiac Intensive Care Symposium, Miami, FL
- 2005 Invited Faculty  
"Therapies to Enhance the Effect of Inhaled Nitric Oxide"  
Symposium on New Directions in Nitric Oxide Therapy, Baylor College of Medicine, Texas  
Children's Hospital, Houston, Texas
- 2005 Invited Speaker  
"Pulmonary Hypertension: Approaches to Management", 21<sup>st</sup> Annual Fetus and Newborn  
Conference, Boston, MA

- 2005 Invited Moderator  
"Low Birth Weight Neonates with Congenital Heart Disease", Pediatric Cardiac Intensive Care Symposium 2005 (PCICS 2005), Miami, FL
- 2005 Invited Faculty  
Consensus Report on Treatment of Myocarditis. Pediatric Cardiac Intensive Care Symposium 2005 (PCICS 2005), Miami, FL
- 2006 Invited Faculty  
"Challenges in Industry Sponsored Trials" and "Management of PVR in the Neonate"  
Ninth Annual Update on Pediatric Cardiovascular Disease (Children's Hospital of Philadelphia), Scottsdale, AZ
- 2006 Invited Speaker  
Eddie Farrell Memorial Lecture, Massachusetts Society of Respiratory Care, Sturbridge, MA
- 2006 Invited Faculty  
Second International Conference on Heart Failure in Children and Young Adults Children's Hospital Orange County, Laguna Niguel, CA
- 2007 Invited Speaker  
"Pulmonary Vascular Alterations in CHD" & "Drug Treatment for Pulmonary Hypertension".  
First International Conference on Childhood Pulmonary Vascular Disease, San Francisco, CA
- 2008 Invited Speaker  
"Cardiac Critical Care: What's New and What Matters "STS Congenital Surgical Symposium, Ft. Lauderdale, FL.
- 2008 Invited Speaker  
Session Chair "Anticipating the Growing ACHD Population"  
Update on Pediatric Cardiovascular Disease - New and Evolving Concepts and Practices,  
Speaker: "Considerations for Caring for Adult Patients in a Pediatric ICU" & "Current Status of Inpatient Therapy"  
Scottsdale, AZ
- 2008 Invited Speaker  
Forum Moderator: "Inhaled Nitric Oxide in the OR"  
ASA 2008 Annual Meeting, Orlando, FL
- 2008 Invited Speaker  
"Postoperative Management and Outcome of the Term vs. Premature Newborn with Congenital Heart Disease"  
Management of Congenital Heart Disease in the Fetus & Neonate Symposium, Washington, DC
- 2008 Invited Speaker  
"Pulmonary Hypertension"  
NPCNA Annual Fall Conference, Innovation and Inquiry in Pediatric Cardiology Nursing  
Washington, DC
- 2008 Invited Speaker  
"Critical Treatment Strategies for Acute Pulmonary Hypertension in Infants and Children  
cGMP-related Drugs »  
PCICS Annual Symposium 2008, Miami, FL

- 2009 Invited Speaker  
Session Moderator. "Cardiac Surgery"  
38<sup>th</sup> Annual Critical Care Congress of the Society of Critical Care Medicine, Nashville, TN
- 2009 Invited Speaker  
Session Moderator. "Cardiac ECMO: State-of-the-Art"  
The 25<sup>th</sup> Annual CNMC Symposium: ECMO & The Advanced Therapies for Respiratory Failure  
Keystone, CO
- 2009 Invited Speaker  
Session Moderator. "Pulmonary Vascular Alterations in Congenital Heart Disease"  
The 2<sup>nd</sup> International Neonatal and Childhood Pulmonary Vascular Disease Conference  
San Francisco, CA
- 2009 Invited Speaker  
"Advances in Cardiac Intensive Care"  
9<sup>th</sup> Annual Cardiac Research Symposium – A.I. DuPont Hospital for Children, Nemours  
Symposia, Wilmington, DE
- 2010 Invited Speaker  
"Cardiac Intensive Care: Celebrating Successes, Meeting Challenges"  
3rd Annual John J. Downes Lecture in Pediatric Anesthesia and Critical Care Medicine  
Orlando, FL
- 2010 Invited Speaker  
"A Randomized Trial of Clopidogrel to Reduce Mortality and Shunt-Related Morbidity in Infants  
Palliated with a Systemic to Pulmonary Artery Shunt"  
Outstanding Research Awards (Council on Cardiovascular Disease in the Young)  
AHA Scientific Sessions, Chicago, IL
- 2011 Invited Speaker  
"Working with the FDA & Industry in Designing Pediatric Trials"  
The 27<sup>th</sup> Annual CNMC Symposium: ECMO & The Advanced Therapies for Respiratory Failure  
Keystone, CO
- 2011 Invited Speaker  
"Resuscitation of the Patient with Pulmonary Hypertension"  
4th International Neonatal and Childhood Pulmonary Vascular Disease  
San Francisco, CA

## INTERNATIONAL

- 1986 Invited Lecture  
"Recent Advances in the Intensive Treatment of Neonates with Congenital Heart Disease,"  
A Week with the Experts, Ospedale Pediatrico Bambino Gesù, Rome, Italy
- 1988 Invited Lecture  
"Perioperative Care of the Patient with HLHS"  
European Congress on Hypoplastic Left Heart Syndrome, Ospedale Pediatrico Bambino  
Gesù, Rome, Italy

- 1990 Invited Lecture  
"Perioperative Care of the Neonate with Congenital Heart Disease"  
Pediatric Critical Care Conference, Hospital for Sick Children, University of Toronto, Toronto  
Canada
- 1991 Invited Lecture  
"Perioperative Intensive Care of the Child with Congenital Heart Disease"  
First International Pediatric Intensive Care Congress, Buenos Aires, Argentina
- 1993 Invited Faculty  
"Regulation of the Pulmonary Circulation: Therapeutic Implications"  
First European Postgraduate Course in Neonatal and Pediatric Intensive Care, Berne,  
Switzerland
- 1993 Invited Faculty  
"Pulmonary Hypertension: Pathophysiologic and Therapeutic Implications in Post Surgical  
Patients" Third International Meeting on Pediatric Intensive Care, University of Padova, Italy
- 1993 Invited Lecture  
"Nitric Oxide to Test Pulmonary Vascular Reactivity to Control Hypertensive Crises and as a  
Potential Chronic Therapy" Canadian Cardiovascular Society, Vancouver, Canada
- 1993 Invited Lecture  
"Nitric Oxide Inhalation after Correction of Congenital Heart Defects"  
International Conference on ARDS, Tutzing, Germany
- 1994 Plenary Presentation  
"Perioperative Care of the Neonate"  
Cardiac Surgery Today: State of the Art, Onassis Medical Center, Athens, Greece
- 1995 Invited Faculty  
"Nitric Oxide in the Treatment of Congenital Heart Disease"  
Annual Meeting of the Austrian Society for Lung Diseases, Gmunden, Austria
- 1995 Plenary Speaker  
"Inhaled Nitric Oxide for Perioperative Management of Congenital Heart Disease"  
The VII Brazilian Congress of Intensive Care Medicine, Recife, Brazil
- 1996 Invited Lecture  
"Nitric Oxide in Pulmonary Hypertension after Surgery for Congenital Heart Defects"  
Annual Meeting, European Society of Cardiology, Birmingham, United Kingdom
- 1997 Symposium  
"The Failing Heart—Pediatric Aspects"  
The 7th World Congress of Intensive & Critical Care Medicine, Ottawa, Canada
- 1997 Plenary Session  
"Inhaled Nitric Oxide"  
XXX Brazilian Pediatrics Congress and International Pediatric Symposium, Rio de Janeiro,  
Brazil
- 1998 Invited Faculty  
Multiple lectures and workshops  
Pediatric Cardiac Intensive Care at the European Heart House  
European Society of Cardiology, Nice, France

- 1998      Invited Faculty  
Lectures on Congenital Heart Disease  
Argentine Congress of Cardiology, Buenos Aires, Argentina
- 1999      Invited Lecture  
"Critical Aortic Stenosis in the Neonate"  
Second Postgraduate Course on Congenital and Acquired Heart Disease, Modena, Italy
- 1999      Invited Lecture  
"Pathophysiology and Treatment of Pulmonary Hypertension"  
Lund University Hospital, Lund, Sweden
- 1999      Invited Lecture  
"Pulmonary Hypertension and Mechanical Support in Children with Heart Disease"  
Lindgren Children's Hospital at the Karolinska Institute, Stockholm, Sweden
- 1999      Plenary Speaker  
"Frontiers in Pediatric Intensive Care"  
Annual Meeting, Society of Anesthesia and Critical Care, Gothenburg, Sweden
- 1999      Invited Faculty  
"ICU Management of Two Stage Arterial switch"  
"The Role of Nitric Oxide in the Cardiac Patient"  
The First Hispano Latin American Course, Diagnosis and Management of Congenital Heart Disease, San Juan, Puerto Rico
- 1999      Invited Lecture  
"Current Concepts in Post-operative Management"  
"ECMO in the New Millennium"  
Symposium on Pediatric Cardiology, Cordoba, Argentina
- 1999      Invited Speaker  
"Inhaled Nitric Oxide"  
"Perioperative Care of the Newborn"  
The First Sino-American Symposium: New Developments in the Care of Children with Congenital Heart Disease, Shanghai Children's Medical Center, Shanghai, China
- 2000      Invited Faculty and Track Convener  
"Issues in Perioperative Care" and multiple lectures  
The Third International Symposium on Pediatric Cardiac Intensive Care, Montreal, Canada
- 2000      Invited Lecture  
"Endothelial Cell Function During Cardiopulmonary Bypass"  
5<sup>th</sup> World Congress on Trauma, Shock, Inflammation and Sepsis, Munich, Germany
- 2000      Invited Lecture  
"Inhaled Nitric Oxide Therapy in Children after Cardiac Surgery"  
American Thoracic Society, 96<sup>th</sup> International Conference, Toronto, Canada
- 2000      Invited Lecture  
"Pulmonary Hypertension and its Impact on Hemodynamics"  
Special Topics in Pediatric Cardiac Intensive Care Symposium, Royal Brompton & Harefield NHS Trust, London, United Kingdom



- 2000 Invited Faculty  
"Critical Care and Congenital Heart Disease"- diverse topics  
Pediatric FCCS Course, Taipei, Taiwan
- 2000 Invited Lecture  
"Advances in Perioperative Care of the Child with Congenital Heart Disease"  
Tenth Anniversary Lecture, Kaohsiung Veterans General Hospital, Taiwan
- 2000 Invited Lecture  
"Postoperative Care of the Child with AV Septal Defect"  
European Cardiovascular Surgery's Postgraduate Course, Frankfurt, Germany
- 2000 Seminar  
"Postoperative Care of Patients with Hypoplastic Left Heart Syndrome"  
European Association of Cardio-Thoracic Surgery, Annual Meeting, Frankfurt, Germany
- 2000 Plenary Lecture  
"Diagnosis and Treatment of Pulmonary Hypertension"  
XIX Pan American Congress of Pediatrics, Montevideo, Uruguay
- 2000 Invited Lecture  
"Postoperative Management of the Child with D-Transposition of the Great Arteries"  
"Diagnosis and Management of Pulmonary Arterial Hypertension"  
I Pediatric Cardiology Symposium, Dr. Aldo Castañeda, Guatemala City, Guatemala
- 2001 Invited Faculty  
"Pulmonary Hypertension and Nitric Oxide"  
"Assessing and Managing Premature Newborns for Surgical and Catheter Intervention"  
Harvard Winter Course in Congenital Heart Management, Dubai, United Arab Emirates
- 2001 Invited Lecture  
"Brain Protection During CPB"  
V European Postgraduate Course in Neonatal and Pediatric Intensive Care, Bern, Switzerland
- 2001 Invited Lecture  
"Strategic Management of the Patient after Surgery"  
Third World Congress of Pediatric Cardiology and Cardiac Surgery, Toronto, Canada
- 2001 Invited Faculty  
Special Topics in Paediatric Cardiac Intensive Care– 2001, The Challenging Neonate,  
The Royal Brompton Hospital & The National Heart & Lung Institute, London, England
- 2002 Moderator  
European Consensus Meeting on Inhaled Nitric Oxide  
European Society of Pediatric and Neonatal Intensive Care, Rome, Italy
- 2002 Invited Faculty  
"Assessment of Myocardial Function in the ICU"  
"Postoperative Management After Staged Repair of HLHS"  
"ECMO Management of the Single Ventricle Circulation"  
New Era in Congenital Heart Management  
Universidad Complutense Madrid and Real Colegio Complutense en Harvard, The Heart  
Institute Hospital, Universitario "12 de Octubre", Madrid, Spain

- 2002 Guest Lecturer  
 "Failing Hearts: The Paediatric Problem and Current Treatments"  
 "Inhaled Nitric Oxide and Pulmonary Vasodilators for the Failing Right Heart"  
 "Routine ECMO for Resuscitation"  
 The Third Special Topics in Paediatric Cardiac Intensive Care, The Failing Myocardium  
 Royal Brompton Hospital, Imperial College, London, United Kingdom
- 2003 Invited Faculty  
 "Support for the Failing Ventricle"  
 "Management of Pulmonary Hypertension: From the OR to the Home"  
 Debate: "Early Extubation is the Best Defense Against Postoperative Complications"  
 First Asia Pacific Symposium on Pediatric Cardiac Intensive Care, Phuket, Thailand
- 2003 Guest Lecturer  
 "Pharmacologic Management of Pulmonary Hypertension" and Other Topics  
 IX Curso de Actualización en Cardiología Pediátrica, Madrid, Spain
- 2003 Guest Lecturer  
 "Recent Advances in the Use of Inhaled Nitric Oxide in Patients with Congenital Heart Disease". Inhaled Nitric Oxide Symposium for Neonatologists. Madrid, Spain
- 2003 Invited Participant  
 Third World Symposium on Pulmonary Arterial Hypertension (WHO). Venice, Italy
- 2003 Special Guest Lecturer  
 "Indications for Inhaled Nitric Oxide in the Neonatal and Postoperative Care of Critically Ill Children"  
 Annual Meeting of the German Society of Pediatric Cardiology. Weimar, Germany
- 2003 Invited Speaker  
 "Predicting and Treating Low Cardiac Output in the Postoperative Patient"  
 Annual Meeting of the European Association of Cardiothoracic Surgeons. Vienna, Austria
- 2003 Invited Faculty  
 "The Paperless ICU"  
 "Pulmonary and Systemic Vasodilators"  
 "Genetic Basis for Heterotaxy"  
 Harvard Medical International, Children's Hospital Boston Course in Congenital Heart Disease  
 Abu Dhabi, United Arab Emirates
- 2003 Invited Speaker  
 "Extracorporeal Membrane Oxygenation for Cardiopulmonary Resuscitation in Children"  
 Hammersmith Hospital Workshop on Perfusion. London, United Kingdom
- 2004 Keynote Speaker  
 "Pulmonary Hypertension Therapy—Now and in the Future"  
 Pulmonary Hypertension in Early Life, St. Guys and St. Thomas' Hospital  
 London, United Kingdom
- 2004 Keynote Address  
 "Pulmonary Hypertension: State of the Art"  
 Opening Ceremony, Annual Meeting of the European Society of Pediatric and Neonatal  
 Intensive Care, London, United Kingdom

- 2005 Plenary Speaker  
"Recent Advances in Heart Failure and Pulmonary Hypertension", The Fourth World Congress of Pediatric Cardiology and Cardiac Surgery, Buenos Aires, Argentina.
- 2005 Invited Speaker  
Controversy Session: "Inhaled Iloprost is the Best Pulmonary Vasodilator?", The Fourth World Congress of Pediatric Cardiology and Cardiac Surgery, Buenos Aires, Argentina.
- 2005 Invited Speaker  
Chair, Oral Presentations: "Cardiac Intensive Care", The Fourth World Congress of Pediatric Cardiology and Cardiac Surgery, Buenos Aires, Argentina.
- 2006 Invited Faculty  
"Outcomes of Heart Failure in the ICU: Mechanisms of Postoperative Dysfunction." Congress of Ventricular Dysfunction in Childhood, OPBG Cardiovascular International. Rome, Italy
- 2007 Invited Speaker  
Multiple Oral Presentations and Panel Chair  
Fifth World Congress on Pediatric Critical Care, Geneva, Switzerland
- 2007 Invited Speaker  
"Cuidado perioperatorio del recién nacido con enfermedad cardiaca congénita", VI Annual Colombian Critical Care Congress, Medellín, Colombia
- 2007 Invited Speaker  
"Postoperative Treatment of Pulmonary Hypertension," & "Postoperative Care of Hypoplastic Left Heart: Comparing Norwood with BT Shunt vs. Sano from Birth through the Fontan."  
International Cardiology Meeting, Avignon, France
- 2008 Invited Faculty  
Plenary Lecture: "Pediatric Cardiac Intensive Care: Past, Present and Future"; "Dedicated Training Pathways in Pediatric Cardiac Intensive Care" & "How to plan a Research Study in ICU"  
PCICS Europe Symposium, Monte Carlo, Monaco
- 2009 Invited Speaker  
"Acute Heart Failure Pathophysiology", Treatment of Postoperative Acute Cardiac Failure",  
"Mechanical Support of Acute Cardiac Failure"  
International Pediatric Cardiology Conference  
Cartagena, Colombia
- 2010 Invited Faculty  
Session Moderator: Pulmonary Hypertension, Right Ventricular Function and Congenital Heart Disease  
3<sup>rd</sup> International Conference Neonatal and Childhood Pulmonary Vascular Disease  
Banff, Alberta, Canada
- 2010 Invited Speaker  
"Intraoperative Care and Perioperative Management for Transposition"  
The World Society for Pediatric and Congenital Heart Surgery  
Antigua, Guatemala

**10) GRANTS AWARDED****FUNDING INFORMATION**

- 1987-89 The effects of ventilation on pulmonary vascular resistance in infants following cardiopulmonary bypass. Principal Investigator, American Society of Anesthesiologists Research Starter Grant.
- 1988-91 Infant heart surgery: CNS sequelae of circulatory arrest. Co-Investigator, National Institutes of Health. Grant No. HL41786.
- 1993-96 Ischemic neonatal brain injury: clinical and basic science. Co-investigator, National Institutes of Health. Grant No. P20 NS32570
- 1994-96 Inhaled nitric oxide for the treatment of pulmonary hypertension and acute respiratory failure in children. Principal Investigator, Clinical Research Grant-in-Aid Award, Children's Hospital, Boston, Massachusetts. Grant No. CH 89430.
- 1994-99 Pathogenesis of brain injury in infant heart surgery. Clinical advisor / mentor to Dr. Adre J. DuPlessis, National Institutes of Health. Grant No. K08 NS01721
- 1996-99 Dose response of inhaled nitric oxide in congenital heart disease. Principal Investigator, U.S. Food and Drug Administration. Grant No. FD R-001316.
- 1997-99 Neurodevelopmental follow up of patients with PPHN in a randomized trial of nitric oxide. Principal Investigator, Industry Sponsored.
- 1997-00 Echocardiographic assessment of right ventricular function in patients with pulmonary hypertension. Sponsor for Dr. Ricardo Munoz (MCAP), National Institutes of Health Grant No. M01 RR02172.
- 2000-01 Prophylactic use of Primacor® in pediatric patients at high risk of developing low cardiac output syndrome following cardiac surgery. Principal Investigator, Industry Sponsored.
- 2004-06 Principal Investigator (Boston) on three industry sponsored trials of sildenafil for treatment of pediatric pulmonary hypertension (see below).
- 2004-08 A Randomized, Double-Blind, Placebo Controlled, Dose Ranging, Parallel Group Study of Oral Sildenafil in the Treatment of Children, Aged 1-16 Years, With Pulmonary Hypertension. Principal Investigator, Industry Sponsored
- 2004-08 Multicenter, Long-Term Extension Study to Assess Safety of Oral Sildenafil in the Treatment of Subjects Who Have Completed Study A1481131. Principal Investigator, Industry Sponsored
- 2004-06 7-Day, Open-Label, Multicenter, Pharmacokinetic Study (Part 1) of IV Sildenafil in the Treatment of Neonates With Persistent Pulmonary Hypertension of the Newborn (PPHN) or Hypoxic Respiratory Failure and at Risk for PPHN. Principal Investigator, Industry Sponsored
- 2006-08 Pilot Study of the Effects of Nesiritide on Hemodynamics and Urine Output Following Cardiopulmonary Bypass in Children. Co-investigator and mentor (John M. Costello); American Heart Association.
- 2006-10 Multinational Trial on the Efficacy and Safety of Clopidogrel in Infants with Cyanotic Congenital Heart Disease Palliated with a Systemic to Pulmonary Shunt (CLARINET). (Chair, Steering Committee, Institutional Co-investigator). Industry Sponsored (Sanofi-Aventis).

- 2009-14 Collaborative Pediatric Critical Care Research Network (CPCCRN). NIH-NICHD U10410HD049981. Principal Investigator, 20% effort. Base award over 5 years \$925,000 direct costs plus annual awards for protocol funds (e.g. 2010 = \$200,000)
- Critical Pertussis in US Children. Protocol #001
  - The Critical Illness Stress-induced Immune Suppression Prevention Trial (CRISIS). Protocol #003
  - Development of a Quantitative Functional Status Scale (FSS) for Pediatric Patients. Protocol #004
  - Therapeutic Hypothermia after Pediatric Cardiac Arrest Trials (THAPCA). Protocol #010
  - Cortisol Quantification Investigation. Protocol #012
  - Measuring Opioid Tolerance Induced by Fentanyl (or Other Opioids). Protocol #026
  - Physician's Perspectives on the Physician-Parent Follow-Up Conference.
  - Pediatric Intensive Care Unit Bereavement Study
  - CPCCRN Asthma Study

#### REPORT OF CURRENT RESEARCH ACTIVITIES

1. My primary current research activity involves designing and executing national and international pediatric clinical trials.
2. Safety and efficacy of type V phosphodiesterase inhibitors in children as selective pulmonary vasodilators and to augment vasodilatory potential of nitric oxide and attenuate rebound pulmonary hypertension. I was the overall primary scientific advisor in the development and execution of international multicenter randomized trials on type V inhibitors in pediatrics, Industry sponsored. Final publications in press.
3. Outcome studies evaluating ventilator management, inotropic agents, mechanical support of the circulation and new strategies in the critical care management and perioperative care of
  - a) premature newborns with congenital heart disease
  - b) newborns after reparative surgery involving the right ventricle
  - c) extracorporeal membrane oxygenation resuscitation of children with congenital heart disease.
4. Multinational Trial on the Efficacy and Safety of Clopidogrel in Infants with Cyanotic Congenital Heart Disease Palliated with a Systemic to Pulmonary Shunt (CLARINET). (Chair, Steering Committee, Institutional Co-investigator). Industry Sponsored.
5. I am the Principal Investigator (CNMC) and steering committee member for the NIH funded clinical research network with multiple active protocols listed above.

## 11) PUBLICATIONS

#### PAPERS IN REFEREED JOURNALS

1. Hickey PR, Hansen DD, Wessel DL, Lang P, Jonas RA. Pulmonary and systemic hemodynamic responses to fentanyl in infants. *Anesth Analg* 1985;64:483-6.
2. Hickey PR, Hansen DD, Wessel DL, Lang P, Jonas RA. Blunting of stress responses in the pulmonary circulation by fentanyl. *Anesth Analg* 1985;64:1137-42.
3. Wessel DL, Keane JF, Fellows KE, Robichaud H, Lock JE. Fibrinolytic therapy for femoral arterial thrombosis after cardiac catheterization in infants and children. *Am J Cardiol* 1986;58:347-51.
4. Wessel DL, Lock JE. Transcatheter umbrella closure of congenital cardiac defects: technical considerations. *Adv Bioeng (ASME)*. 1987;12:143-144.
5. Wessel DL, Keane JF, Parness I, Lock JE. Outpatient closure of the patent ductus arteriosus. *Circulation* 1988;77:1068-1071.

6. Castaneda AR, Mayer JE, Jonas RA, Lock JE, Wessel DL, Hickey PR. The neonate with critical congenital heart disease: repair - a surgical challenge. *J Thorac Cardiovasc Surg* 1989;98:869-75.
7. DiDonato RM, Wernovsky G, Walsh EP, Colan SD, Lang P, Wessel DL, Jonas RA, Mayer JE Jr, Castaneda AR. Results of the arterial switch operation for transposition of the great arteries with ventricular septal defect: Surgical considerations and midterm follow-up data. *Circulation* 1989;80:1689-1705.
8. Wernovsky G, Jonas RA, Colan SD, Sanders SP, Wessel DL, Castaneda AR, Mayer JE: Results of the arterial switch operation in patients with transposition of the great arteries and abnormalities of the mitral valve or left ventricular outflow tract. *J Am Coll Cardiol* 1990;16:1446-1454.
9. Bellinger DC, Wernovsky G, Rappaport LA, Mayer JE Jr, Castaneda AR, Farrell DM, Wessel DL, Lang P, Hickey PR, Jonas RA, Newburger JW. Cognitive development of children following early repair of transposition of the great arteries using deep hypothermic circulatory arrest. *Pediatrics* 1991;87:701-707.
10. Chang AC, Wernovsky G, Kulik TJ, Jonas RA, Wessel DL. Management of the neonate with transposition of the great arteries and persistent pulmonary hypertension. *Am J Cardiol* 1991;68:1253-1256.
11. Chang AC, Hanley FL, Weindling SN, Wernovsky G, Wessel DL. Left heart support with a ventricular assist device in an infant with acute myocarditis. *Crit Care Med* 1992;20:712-715.
12. Hickey PR, Wessel DL, Streitz SL, Fox ML, Kern FH, Bridges, ND, Hansen, DD. Transcatheter closure of atrial septal defects: Hemodynamic complications and anesthetic management. *Anesth Analg* 1992;74:44-50.
13. Wernovsky G, Giglia TM, Jonas RA, Mone SM, Colan SD, Wessel DL. Course in the intensive care unit after 'preparatory' pulmonary artery banding and aortopulmonary shunt placement for transposition of the great arteries with low left ventricular pressure. *Circulation* 1992;86[suppl II]:II133-139.
14. Wong PC, Barlow CF, Hickey PR, Jonas RA, Castaneda AR, Farrell DM, Lock JE, Wessel DL. Factors associated with choreoathetosis after cardiopulmonary bypass in children with congenital heart disease. *Circulation* 1992;86[suppl II]:II118-II126.
15. Chang AC, Wernovsky G, Wessel DL, Freed MD, Parness IA, Perry SB, O'Brien P, Van Praagh R, Hanley FL, Jonas RA, Castaneda AR, Mayer JE. Surgical management for late right ventricular failure after Mustard or Senning repair. *Circulation* 1992;86[suppl II]:II-140-II-149.
16. Chang AC, Kulik TJ, Hickey P, Wessel DL. Real-time gas exchange measurement of oxygen consumption in neonates and infants after cardiac surgery. *Crit Care Med* 1993;21:1287-1295.
17. Irazuzta J, Pearlman N, Pascucci R, Wessel DL. Effects of fentanyl administration on respiratory system compliance in infants. *Crit Care Med* 1993;21:1001-1004.
18. Chang AC, Hanley FL, Wernovsky G, Rosenfeld H., Wessel DL, Jonas RA, Mayer JE, Castaneda AR. Early bidirectional cavopulmonary shunt in young infants: postoperative course and early results. *Circulation* 1993; 86[suppl II]:II-149-II158.
19. Hanley FL, Heinemann MK, Jonas RA, Mayer JE, Cook NR, Wessel DL, Castaneda AR. Repair of truncus arteriosus in the neonate. *J Thorac Cardiovasc Surg* 1993;105:1047-1056.
20. Wessel DL. Hemodynamic responses to perioperative pain and stress in infants. *Crit Care Med* 1993; 21[suppl]:S361-S362.

21. Newburger JW, Jonas RA, Wernovsky G, Wypij D, Hickey PR, Kuban KCK, Farrell DM, Holmes GL, Helmers SL, Constantinou J, Carrazana E, Barlow JK, Walsh AZ, Lucius KC, Share JC, Wessel DL, Hanley FL, Mayer JE, Castaneda AR, Ware JH. A comparison of the perioperative neurologic effects of hypothermic circulatory arrest versus low-flow cardiopulmonary bypass in infant heart surgery. *N Engl J Med* 1993;329:1057-1064.
22. Wessel DL. Inhaled nitric oxide for the treatment of pulmonary hypertension before and after cardiopulmonary bypass. *Crit Care Med* 1993;21[suppl]:S344-S345.
23. Adatia I, Thompson J, Landzberg M, Wessel DL. Inhaled nitric oxide in chronic obstructive lung disease. *Lancet* 1993;341:307-308. (Letter)
24. Wessel DL, Adatia I, Giglia TM, Thompson JE, Kulik TJ. Use of inhaled nitric oxide and acetylcholine in the evaluation of pulmonary hypertension and endothelial function after cardiopulmonary bypass. *Circulation* 1993;88:2128-2138.
25. Wessel DL, Adatia I, Thompson JE, Hickey PR. Delivery and monitoring of inhaled nitric oxide in patients with pulmonary hypertension. *Crit Care Med* 1994;22:930938.
26. Drucker N, Colan S, Lewis AB, Beiser A, Wessel DL, Takahashi M, Rosen FS, Baker A, Perez A, Newburger JW. Gamma globulin treatment of acute myocarditis in the pediatric population. *Circulation* 1994;89:252-257.
27. Jonas RA, Hansen DD, Cook N, Wessel DL. Anatomic subtype and survival after reconstructive operation for hypoplastic left heart syndrome. *J Thoracic Cardiovasc Surg* 1994;107:1121-1128.
28. du Plessis AJ, Treves ST, Hickey PR, O'Tauma L, Barlow CF, Costello J, Castaneda AR, Wessel DL. Regional cerebral perfusion abnormalities after cardiac operations. *J Thoracic Cardiovasc Surg* 1994;107:1036-1043.
29. Chang AC, Hanley FL, Lock JE, Wessel DL. Management and outcome of low birth weight neonates with congenital heart disease. *J Pediatr* 1994;124:461-466.
30. Adatia I, Lillehei C, Arnold JH, Thompson JE, Palazzo R, Fackler JC, Wessel DL. Inhaled nitric oxide in the treatment of postoperative graft dysfunction after lung transplantation. *Ann Thor Surg* 1994;57:1311-1318.
31. du Plessis AJ, Kramer U, Jonas RA, Wessel DL, Riviello JJ. West syndrome following deep hypothermic infant cardiac surgery. *Pediatr Neurol* 1994;11:245-251.
32. Lillehei CW, Shamberger RC, Mayer JE, Burke RP, Koka BV, Arnold J, Wessel DL, Landzberg M, Palazzo R. Size disparity in pediatric lung transplantation. *J Pediatr Surg* 1994;29(8):1152-1155.
33. Chang AC, Zucker HE, Hickey PR, Wessel DL. Pulmonary vascular resistance in infants after cardiac surgery: role of carbon dioxide and hydrogen ion. *Crit Care Med* 1995;23:568-574.
34. Adatia I, Perry S, Landzberg M, Moore P, Thompson JE, Wessel DL. Inhaled nitric oxide and hemodynamic evaluation of patients with pulmonary hypertension before transplantation. *J Am Coll Cardiol* 1995;25:1656-1664.
35. du Plessis AJ, Chang AC, Wessel DL, Lock JE, Wernovsky G, Newburger JW, Mayer JE. Cerebrovascular accidents following the Fontan operation. *Pediatr Neurol* 1995;12:230-236.
36. Wernovsky G, Wypij D, Jonas RA, Mayer JE, Hanley FL, Hickey PR, Walsh AZ, Chang AC, Castaneda AR, Newburger JW, Wessel DL. Postoperative course and hemodynamic profile after the arterial switch operation in neonates and infants: A comparison of low-flow cardiopulmonary bypass and circulatory arrest. *Circulation* 1995;92:2226-2235.

37. Betit P, Adatia I, Benjamin P, Thompson JE, Wessel DL. Inhaled nitric oxide: evaluation of a continuous titration delivery technique for infant mechanical and manual ventilation. *Resp Care* 1995;40(7):706715.
38. Chang AC, Atz AM, Wernovsky G, Burke RP, Wessel DL. Milrinone: Systemic and pulmonary hemodynamic effects in neonates after cardiac surgery. *Crit Care Med* 1995;23:1907-1914.
39. Curran RD, Mavroudis C, Backer CL, Sautel M, Zales VR, Wessel DL. Inhaled nitric oxide for children with congenital heart disease and pulmonary hypertension. *Ann Thorac Surg* 1995;60:1765-1771.
40. Adatia I, Atz AM, Jonas RA, Wessel DL. Diagnostic use of inhaled nitric oxide after neonatal cardiac surgery. *J Thoracic Cardiovasc Surg* 1996;112:1403-1405.
41. Atz AM, Adatia I, Jonas RA, Wessel DL. Inhaled nitric oxide in children with pulmonary hypertension and congenital mitral stenosis. *Am J Cardiol* 1996;77:316-319.
42. Atz AM, Adatia I, Wessel DL. Rebound pulmonary hypertension following inhalation of nitric oxide. *Ann Thorac Surg* 1996;62:1759-1764.
43. Betit P, Grenier B, Thompson JE, Wessel DL. Evaluation of four analyzers used to monitor nitric oxide and nitrogen dioxide concentrations during inhaled nitric oxide administration. *Res Care* 1996;41(9):817825.
44. Wessel DL. Simple Gases and Complex Single Ventricles. *J Thoracic Cardiovasc Surg* 1996;112:655-7.
45. Hornberger LK, Colan SD, Lock JE, Wessel DL, Mayer JE. Outcome of patients with Ectopia Cordis and significant intracardiac defects. *Circulation* 1996;94[suppl II] :II-32-II-37.
46. du Plessis AJ, Jonas RA, Wypij D, Hickey PR, Riviello J, Wessel DL, Roth SJ, Burrows FA, Walter G, Farrell DM, Walsh AZ, Plumb CA, del Nido P, Burke RP, Castaneda AR, Mayer JE Jr., Newburger JW. Perioperative effects of alpha-stat versus pH-stat strategies for deep hypothermic cardiopulmonary bypass in infants.
47. Christou H, Adatia I, Van Marter LJ, Kane JW, Thompson JE, Stark AR, Wessel DL, Kourembanas S. Effect of inhaled nitric oxide on endothelin-1 and cyclic guanosine 5'-monophosphate plasma concentrations in newborns with persistent pulmonary hypertension. *J Pediatrics* 1997;130(4):603611.
48. Walsh EP, Saul P, Sholler G, Triedman JK, Jonas RA, Mayer JE, Wessel DL. Evaluation of a staged treatment protocol for rapid junctional ectopic tachycardia after surgery for congenital heart disease. *J Am Coll Cardiol* 1997;29(5):1046-1053.
49. Tabbutt S, Duncan BW, McLaughlin D, Wessel DL, Jonas RA, Laussen PC. Delayed sternal closure after cardiac operations in a pediatric population. *J Thorac Cardiovasc Surg* 1997;113(5):886-893.
50. Wessel DL, Adatia I, Thompson JE, Van Marter L, Kane JW, Stark AR, Kourembanas S. Improved oxygenation in a randomized trial of inhaled nitric oxide for persistent pulmonary hypertension of the newborn. *Pediatrics* 1997;100(5):1-7.
51. Atz AM, Wessel DL. Inhaled nitric oxide in sickle cell disease with acute chest syndrome. *Anesthesiology* 1997;87(4):988-990.
52. Atz AM, Wessel DL. Inhaled nitric oxide and heparin for infantile primary pulmonary hypertension. *The Lancet* 1998;351:1701.
53. Duncan BW, Ibrahim AE, Hraska V, del Nido PJ, Laussen PC, Wessel DL, Mayer JE Jr, Bower LK, Jonas RA. Use of rapid-deployment extracorporeal membrane oxygenation for the resuscitation of pediatric patients with heart disease after cardiac arrest. *J Thorac Cardiovasc Surg* 1998;116(2):305-311.



54. Weindling SN, Saul JP, Gamble WJ, Mayer JE, Wessel DL, Walsh EP. Duration of complete atrioventricular block after congenital heart disease surgery. *Am J Cardiol* 1998;82(2):525-527.
55. Atz AM, Adatia I, Lock JE, Wessel DL. Combined effects of nitric oxide and oxygen during acute pulmonary vasodilator testing. *J Am Coll Card* 1999;33(3):813-819.
56. Christou H, Magnani B, Morse DS, Allred EN, Van Marter LJ, Wessel DL, Kourembanas. Inhaled nitric oxide does not affect adenosine 5'-diphosphate-dependent platelet activation in infants with persistent pulmonary hypertension of the newborn. *Pediatrics* 1998;102:1390-1393.
57. Duncan BM, Hraska V, Jonas RA, Wessel DL, del Nido, PJ, Laussen PC, Mayer JE, Lapierre RA, Wilson JM. Mechanical circulatory support in children with cardiac disease. *J Thorac Cardiovasc Surg* 1999;117:529-542.
58. del Nido PJ, Duncan BW, Mayer JE, Wessel DL, LaPierre R, Jonas RA. Left ventricular assist device improves survival in children with left ventricular dysfunction after repair of anomalous origin of the left coronary artery from the pulmonary artery. *Ann Thorac Surg* 1999;67(1):169-172.
59. Atz AM, Feinstein JA, Perry SB, Wessel DL. Preoperative management of pulmonary venous hypertension in hypoplastic left heart syndrome with restrictive atrial septal defect. *Am J Card* 1999;83:1224-1228.
60. Atz AM, Wessel DL. Sildenafil ameliorates effects of inhaled nitric oxide withdrawal. *Anesthesiology* 1999;91:307-310.
61. Munoz R, Laussen PC, Palacio G, Zienko L, Piercey G, Wessel DL. Changes in whole blood lactate levels during cardiopulmonary bypass for surgery for congenital cardiac disease: An early indicator of morbidity and mortality. *J Thorac Cardiovasc Surg* 2000;119:155-162.
62. Munoz R, Laussen PC, Palacio G, Zienko L, Piercey G, Wessel DL. Whole blood ionized magnesium: Age-related differences in normal values and clinical implications of ionized hypomagnesemia in patients undergoing surgery for congenital cardiac disease. *J Thorac Cardiovasc Surg* 2000;119:891-898.
63. Cataltepe S, Van Marter LJ, Kozakewich H, Wessel DL, Lee PJ, Levy HL. Pulmonary hypertension associated with nonketotic hyperglycinemia. *J Inher Metab Dis* 2000;23:137-144.
64. Munoz R, Marcus E, Palacio G, Gauvreau K, Wessel DL, Colan SD. Reconstruction of three dimensional right ventricular shape and volume from three orthogonal planes. *J Am Soc Echocardiogr* 2000;13 (3):177-185.
65. Marcus EN, Munoz RA, Palacio G, Wessel DL, Colan SD. A new quantitative method for the diagnosis of right ventricular hypertensive disorders in 3 dimensions. *J Am Soc Echocardiogr* 2000;13(3):186-193.
66. Christou H, Van Marter LJ, Wessel DL, Allred EN, Kane JW, Thompson JE, Stark AR, Kourembanas S. Inhaled nitric oxide reduces the need for extracorporeal membrane oxygenation in infants with persistent pulmonary hypertension of the newborn. *Crit Care Med* 2000;28(11):3722-3727.
67. Ellington M Jr., O'Reilly D, Allred EN, McCormick MC, Wessel DL, Kourembanas S. Child health status, neurodevelopmental outcome, and parental satisfaction in a randomized, controlled trial of nitric oxide for persistent pulmonary hypertension of the newborn. *Pediatrics* 2001;107:1351-1356.
68. Bacha EA, Almodovar MC, Zurakowski D, Wessel DL, Mayer JE Jr., Jonas RA, del Nido PJ. Surgery for coarctation of the aorta in infants weighing less than 2 kg. *Ann Thorac Surg*. 2001;71(4):1260-4.
69. Duncan BW, Bohn DJ, Atz AM, French JW, Laussen PC, Wessel DL. Mechanical circulatory support for the treatment of children with acute fulminant myocarditis. *J Thorac Cardiovasc Surg* 2001; 22(3):440-8.

70. Rosales AM, Walsh EP, Wessel DL, Triedman JK. Postoperative ectopic atrial tachycardia in children with congenital heart disease. *Am J Cardiol* 2001; 88(10):1169-72.
71. Hoffman TM, Wernovsky G, Atz AM, Bailey JM, Akbary A, Kocsis JF, Nelson DP, Chang AC, Kulik TJ, Spray TL, Wessel DL. Prophylactic intravenous use of milrinone after cardiac surgery in pediatrics. (PRIMACORP) Study. *Am Heart J* 2002; 143:15-21.
72. du Plessis AJ, Bellinger D, Gauvreau K, Plumb C, Newburger JW, Jonas RA, Wessel DL. Choreoathetosis following cardiac surgery in children. Long-term neurologic, cognitive, and behavioral outcome. *Ped Neurol* 2002; 27:9-17.
73. Menache CC, du Plessis AJ, Wessel DL, Jonas RA, Newburger JW. Current incidence of acute neurologic complications following open-heart surgery in children. *Ann Thorac Surg* 2002; 73:1752-8.
74. Booth KL, Roth SJ, Perry SB, del Nido PJ, Wessel DL, Laussen PC. Cardiac catheterization of patients supported by extracorporeal membrane oxygenation. *J Am Coll Cardiol* 2002; 40:1681-6.
75. Marcus EN, Munoz RA, Margossian R, Colan SD, Wessel DL. Echocardiographic assessment of the right ventricular response to hypertension in neonates on the basis of average-shaped contraction models. *J Am Soc Echocardiogr* 2002; 15:1145-53.
76. Hoffman TM, Wernovsky G, Atz AM, Kulik TJ, Nelson DP, Chang AC, Bailey JM, Akbary A, Kocsis JF, Kaczmarek R, Spray TL, Wessel DL. Efficacy and safety of milrinone in preventing low cardiac output syndrome in infants and children after corrective surgery for congenital heart disease. *Circulation* 2003; 107:996-1002.
77. Atz AM, Munoz RA, Adatia I, Wessel DL. Diagnostic and therapeutic uses of inhaled nitric oxide in neonatal Ebstein's anomaly. *Am J Cardiol*. 2003 Apr 1;91(7):906-8.
78. Newburger JW, Wypij D, Bellinger DC, du Plessis AJ, Kuban KC, Rappaport LA, Almirall D, Wessel DL, Jonas RA, Wernovsky G. Length of stay after infant heart surgery is related to cognitive outcome at age 8 years. *J Pediatr*. 2003 Jul;143(1):67-73.
79. Bailey JM, Hoffman TM, Wessel DL, Nelson DP, Atz AM, Chang AC, Kulik TJ, Spray TL, Akbary A, Miller RP, Wernovsky G. A population pharmacokinetic analysis of Milrinone in pediatric patients after cardiac surgery. *Journal of Pharmacokinetics and Pharmacodynamics*, Vol 31, No 1, 2004
80. Fraisse A, Geva T, Gaudart J, Wessel DL. Predictive factors of Doppler echocardiography in persistent pulmonary artery hypertension of the neonate (French). *Arch Mal Coeur Vaiss*, 2004; May;97(5):501-506.
81. Fraisse A, Geva T, Gaudart J, Wessel DL. Doppler echocardiographic predictors of outcome in newborns with persistent pulmonary hypertension. *Cardiology in the Young* 2004 Jun;14(3):277-283.
82. Adatia I, Atz AM, Wessel DL. Inhaled nitric oxide does not improve systemic oxygenation after the bidirectional cavopulmonary anastomosis. *J Thorac Cardiovasc Surg* 2005; 129(1):217-9.
83. Kulik T, Giglia TM, Kocis KC, Mahoney LT, Schwartz SM, Wernovsky G, Wessel DL. ACCF/AHA/AAP recommendations for training in pediatric cardiology. Task forces 5: requirements for pediatric cardiac critical care. *J Am Coll Cardiol* 2005; vol 46(7): 1396-1399.

84. Graham TP, Beekman RH, Allen HD, Bricker JT, Wessel DL, et al. ACCF/AHA/AAP recommendations for training in pediatric cardiology. A report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence (ACC/AHA/AAP Writing Committee to Develop Training Recommendations for Pediatric Cardiology). *Circulation* 2005;vol 112(16):2555-2580.
85. Costello JM, Thiagarajan RR, Dionne RE, Allan CK, Booth KL, Burmester M, Wessel DL, Laussen PC. Initial experience with fenoldapam following cardiac surgery in neonates with an insufficient response to conventional diuretics. *Pediatr Crit Care Med* 2006;7:28-33
86. Cua C.L., Thiagarajan R.R., Gauvreau K., Lai L., Costello J.M., Wessel D.L., del Nido P.J., Mayer Jr J.E., Newburger J.W., Laussen P.C.. Post-operative outcomes in a concurrent series of infants with hypoplastic left heart syndrome undergoing stage I palliation operation with either modified Blalock-Taussig shunt or right ventricle to pulmonary artery conduit. *Pediatr Crit Care Med* 2006;7:238-244.
87. Allen HD, Bricker JT, Freed MD, Hurwitz RA, McQuinn TC, Schieken RM, Strong WB, Zahka KG, Sanders SP, Colan SD, Cordes TM, Donofrio MT, Ensing GJ, Geva T, Kimball TR, Sahn DJ, Silverman NH, Sklansky MS, Weinberg PM, Beekman RH 3rd, Hellenbrand WE, Lloyd TR, Lock JE, Mullins CE, Rome JJ, Teitel DF, Vetter VL, Silka MJ, Van Hare GF, Walsh EP, Kulik T, Giglia TM, Kocis KC, Mahoney LT, Schwartz SM, Wernovsky G, Wessel DL, Murphy DJ Jr, Foster E, Benson DW Jr, Baldwin HS, Mahoney LT, McQuinn TC; American College of Cardiology Foundation; American Heart Association; American Academy of Pediatrics. ACC/AHA/AAP recommendations for training in pediatric cardiology. *Pediatrics*. 2005 Dec;116(6):1574-96.
88. Wessel DL. Testing new drugs for heart failure in children. *Ped Crit Care Med* 2006. 7(5):493-4..
89. Schwartz SM, Wessel DL. Medical cardiovascular support in acute viral myocarditis in children. *Ped Crit Care Med* 2006;7:S12-S16.
90. Lai L, Laussen PC, Cua CL, Wessel DL, Costello JM, del Nido PJ, Mayer JE, Thiagarajan RR. Outcomes After Bidirectional Glenn Operation: Blalock-Taussig Shunt Versus Right Ventricle-to-Pulmonary Artery Conduit. *Ann Thorac Surg* 2007;83:1768-73.
91. Mullen MP, Wessel DL, Thomas KC, Gauvreau K, Neufeld EJ, McGowan FX Jr, Dinardo JA. The Incidence and Implications of Anti-Heparin-Platelet Factor 4 Antibody Formation in a Pediatric Cardiac Surgical Population. *Anesth Analg*. 2008 Aug;107(2):371-8.
92. Scheurer MA, Salvin JW, Vida VL, Fynn-Thompson F, Bacha EA, Pigula FA, Mayer JE Jr, del Nido PJ, Wessel DL, Laussen PC, Thiagarajan RR. Survival and Clinical Course at Fontan after Stage One Palliation with either a Modified Blalock-Taussig Shunt or a Right Ventricle to Pulmonary Artery Conduit. *J Am Coll Cardiol*. 2008 Jul 1;52(1):52-9.
93. Bacha EA, Cooper D, Thiagarajan R, Franklin RC, Krogmann O, Deal B, Mavroudis C, Shukla A, Yeh T, Barach P, Wessel DL, Stellin G, Colan SD. Cardiac Complications Associated with the Treatment of Patients with Congenital Heart Disease: Consensus Definitions from the Multi-Societal Database Committee for Pediatric and Congenital Heart Disease. *Cardiol Young*. 2008 Dec; 18 Suppl 2:196-201.
94. Larovere JM, Jeffries HE, Sachdeva RC, Rice TB, Wetzel RC, Cooper DS, Bird GL, Ghanayem NS, Checchia PA, Chang AC, Wessel DL. Databases for Assessing the Outcomes of the Treatment of Patients with Congenital and Paediatric Cardiac Disease – the Perspective of Critical Care. *Cardiol Young*. 2008 Dec; 18 Suppl 2:130-6.
95. Steinhorn R, Kinsella JP, Butrous G, Dilleen M, Oakes M, Wessel DL. Intravenous sildenafil in the treatment of neonates with persistent pulmonary hypertension. *J Pediatr*. 2009 Dec;155(6):841-847.e1.

96. Fraisse A, Butrous G, Taylor MB, Oakes M, Dilleen M, Wessel DL. Intravenous Sildenafil for Postoperative Pulmonary Hypertension in Children with Congenital Heart Disease. *Intensive Care Medicine* 2010 Nov 11.
97. Barst RJ, Agnoletti G, Fraisse A, Baldassarre J, Wessel, DL for the NO Diagnostic Study Group. Vasodilator Testing with Nitric Oxide and/or Oxygen in Pediatric Pulmonary Hypertension. *Pediatr Cardiol*. 2010 Jul;31(5):598-606. Epub 2010 Apr 20.
98. Fraisse A, Wessel, DL. Acute Pulmonary Hypertension in Infants and Children: cGMP-related drugs. *Pediatr Crit Care Med*. 2010 Vol. 11, No. 2 (Suppl.)
99. Pediatric basic and advanced life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Kleinman, ME and the Pediatric Basic and Advanced Life Support Chapter Collaborators. *Circulation* 2010 Oct 19; 122 (16 Suppl 2):S466-515.
100. Macrae D, Wessel DL. Iceberg or pyramid? *Pediatr Crit Care Med*. 2010 Mar;11(2 Suppl):S1-2.
101. Barst RJ, Ivy DD, Gaitan G, Szatmari A, Rudzinski A, Garcia A, Sastry BKS, Pulido T, Layton GR, Serdarevic-Pehar M, Wessel DL. A Double-Blind, Placebo-Controlled, Dose-Ranging Study of Oral Sildenafil Citrate in the Treatment of Children With Pulmonary Arterial Hypertension. Revised for *Circulation* 2010.
102. DL Wessel; F Berger; J S Li; S Fontecave; A Rakhit; J W Newburger; for the CLARINET Investigators. A Randomized Trial of Clopidogrel to Reduce Mortality and Shunt-Related Morbidity in Infants Palliated with a Systemic to Pulmonary Artery Shunt *Circulation*. 2010;122:A19459. Publication pending.

#### CHAPTERS, REVIEWS:

2. Hickey PR, Wessel DL. Anesthesia for repair of congenital heart disease. In: Kaplan JA, ed. *Cardiac anesthesia*. 2nd ed. New York: Grune and Stratton, 1987.
3. Crone RK, Hickey PR, Wessel DL. Development of the cardiovascular system. In: Shoemaker WC, Thompson WL, Holbrook PR, eds. *Textbook of critical care*. 2nd ed. Philadelphia: W.B. Saunders, 1988.
4. Hickey PR, Wessel DL. Anesthesia for congenital heart disease. In: Gregory FA, ed. *Pediatric anesthesia*. 2nd ed. New York: Churchill Livingstone, 1989.
5. Hansen DD, Wessel DL. The neonatal pulmonary circulation. *Current opinion in anesthesiology* 1988;1:38-44.
6. Wernovsky G, Erickson LC, Wessel DL. Cardiac emergencies. In: May HL, Aghababian RV, Fleisher, eds. *Emergency Medicine*. Boston: Little, Brown and Company, 1992;1914-1927.
7. Wessel DL. Postoperative management of the open heart surgery patient. In: *Pediatric Critical Care Review Series*. Anaheim: Critical Care Medicine, 1992.
8. Hickey PR, Wessel DL, Reich DL. Anesthesia for treatment of congenital heart disease. In: Kaplan JA, ed. *Cardiac Anesthesia* 3rd ed. Philadelphia: W. B. Saunders, 1993.
9. Wessel DL, Hickey PR. Anesthesia for congenital heart disease. In: Gregory GA, ed. *Pediatric Anesthesia* 3rd ed. New York: Churchill Livingstone, 1994.
10. Wessel DL. Perioperative management of the infant and neonate with congenital heart disease. In: Castaneda AR, Jonas RA, Mayer JE, Hanley FL, eds. *Cardiac surgery of the neonate and infant*. W.B. Saunders, 1994.

11. Wernovsky G, Chang AC, Wessel DL. Intensive Care. In: Adams FH, Emmanouilides GC, Riemenschneider TA, eds. Moss and Adams heart disease in infants, children, and adolescents. 5th ed. Williams & Wilkins, 1995.
12. Adatia I, Wessel DL. Therapeutic use of inhaled nitric oxide. *Current Opinion in Pediatrics*, 1994;6:583-590.
13. Wessel DL, Adatia I. The use of inhaled nitric oxide in the treatment of pulmonary hypertension in children. In: *Advances in Pharmacology*, Ignarro I, Murad F, eds. Nitric oxide: biochemistry, molecular biology, and therapeutic implications. Academic Press, 1995.
14. Adatia I, Wessel DL. The use of inhaled nitric oxide in congenital heart disease. In: Reeves J, Archer SL, Weir K, eds. Nitric oxide and radicals in the pulmonary vasculature. Armonk, NY: Futura Publishing Company, Inc. 1996.
15. Rykerson S, Thompson J, Wessel DL. Inhalation of nitric oxide: an innovative therapy for treatment of increased pulmonary vascular resistance. In: Hickey PA, ed. *The Nursing Clinics of North America*. 1995;30(2):381-389.
16. Wessel DL, Newburger JW. Research in the cardiac intensive care unit. *Progress in Pediatric Cardiology* 1995;(4):177-184.
17. Adatia I, Wessel DL. Diagnostic and therapeutic uses of inhaled nitric oxide in congenital heart disease. In: Zapol WM, Bloch KD, eds. *Nitric Oxide and the Lung*. Marcel Dekker, Inc., New York, NY 1997;165392.
18. Atz AM, Wessel DL. Delivery and monitoring of nitric oxide. *Current Opinion in Critical Care* 1997;3:243-249.
19. Atz AM, Wessel DL. Inhaled nitric oxide in the neonate with cardiac disease. In: D'Alton ME, Gross I, eds. *Seminars in Perinatology*. WB Saunders. 1997;21(5):441-455.
20. Atz AM, Wessel DL. Inhaled nitric oxide in the neonate with cardiac disease. *Seminars in Perinatology* 1997;21(5):441-455.
21. Atz AM, Wessel DL. Nitric oxide inhalation. In: Rubanyi GM, Furchgott R, Moncada S, eds. *The Pathophysiology and Clinical Application of Nitric Oxide*. Humana Press, 1998.
22. Nelson DP, Wessel DL. Normal physiology of the respiratory system. In: Chang AC, Hanley FL, Wernovsky G, Wessel DL, eds. *Pediatric Cardiac Intensive Care*. Williams & Wilkins, Baltimore, MD. 1998;6781.
23. Wernovsky G, Chang AC, Wessel DL. Intensive Care. In: Adams FH, Emmanouilides GC, Riemenschneider TA, eds. Moss and Adams heart disease in infants, children, and adolescents. 6th ed. Williams & Wilkins, Baltimore, MD. 1999.
24. Wessel DL. Postoperative care of the patient with congenital heart disease—nitric oxide. In: Mohan OE, Fineman JR, eds. *Current concepts in pediatric critical care-1999*. Society of Critical Care Medicine, Anaheim, CA. 1999;9-14.
25. Laussen PC, Wessel DL. Anesthesia for congenital heart disease. In: Gregory GA, ed. *Pediatric Anesthesia* 4th ed. New York: Churchill Livingstone, 2001.
26. Wessel DL, Almodovar MC, Laussen, PC. Intensive care management of cardiac patients on extracorporeal membrane oxygenation. In: Duncan BW, ed. *Mechanical Support for Cardiac Respiratory Failure in Pediatric Patients*. Marcel Dekker, Inc. 2001;75-111.
27. Wessel DL. Current and future strategies in the treatment of childhood pulmonary hypertension. In: Barst R, ed. *Progress in Pediatric Cardiology*. Elsevier Science Ireland Ltd. 2001;289318

28. Wessel DL, Managing low cardiac output syndrome after congenital heart surgery. In: Crit Care Med 2001 (10 Suppl):S220-30.
29. Barst R, Ivy D, Bridges H, Wessel DL. Controversies and Concerns: Pulmonary Arterial Hypertension in Congenital Heart Disease; In: Advances in Pulmonary Hypertension, vol 2, No. 2, 2003.
30. Wessel DL. Pharmacologic management of low cardiac output syndrome after congenital heart surgery. In: Shanley TB, ed. Current Concepts in Pediatric Critical Care 2004. Society of Critical Care Medicine, Des Plaines, IL 2004: 59-72.
31. Wessel DL and Laussen PC. Critical care for congenital cardiac disease. In: Furhman BP, Zimmerman JJ, ed. Pediatric Intensive Care 3<sup>rd</sup> Edition. Elsevier Science, St. Louis, MO, 2006.
32. Wessel DL, Laussen PC. Intensive Care Unit. In: Keane JF, Lock JE, Fyler DC, eds: Nadas' Pediatric Cardiology. 2<sup>nd</sup> ed. Elsevier, 2006.
33. Wessel DL. Treatment of postoperative pulmonary hypertension. In: Beghetti M, eds. Pulmonary Arterial Hypertension Associated with Congenital Heart Disease. Urban & Fischer Verlag. 2006.
34. Wernovsky G, Chang AC, Wessel DL, Ravishankar, C. Intensive care. In: Adams FH, Emmanouilides GC, Riemenschneider TA, eds. Moss and Adams Heart Disease in Infants, Children, and Adolescents. 7th ed. Williams & Wilkins, 2008.
35. Wessel DL, Mullen MP. Pulmonary vasodilators. In: Munoz R, Schmitt C, Roth S, Da Cruz E, eds. Handbook of Pediatric Cardiovascular Drugs. Springer London. 2008.
36. Fraisse A, Wessel DL. Preoperative Care of the Pediatric Cardiac Surgical Patient. In: Nichols David G ed. The Rogers Textbook of Pediatric Intensive Care, 4<sup>th</sup> Edition. Lippincott Williams & Wilkins. 2008; 1149-1158.
37. Fraisse A, Wessel DL. Postoperative Care of the Pediatric Cardiac Surgical Patient: General Considerations. In: Nichols David G ed. The Rogers Textbook of Pediatric Intensive Care, 4<sup>th</sup> Edition. Lippincott Williams & Wilkins. 2008; 1159-1179.
38. Rotta AT, Laussen PC, Wessel DL, Critical Care for Congenital Cardiac Disease. In: Furhman BP, Zimmerman JJ, ed. Pediatric Intensive Care. Elsevier Science, St. Louis, MO, 2011. In Press

#### BOOKS EDITED OR WRITTEN:

1. Pediatric Cardiac Intensive Care. Chang AC, Hanley FL, Wernovsky G, Wessel DL, eds. Williams and Wilkins, 1998.

#### OTHER PUBLICATIONS

##### PROCEEDINGS OF MEETINGS:

1. Lang P, Wessel DL, Wernovsky G, Jonas RA, Mayer JE, Castaneda AR. Hemodynamic effects of amrinone in infants after cardiac surgery. In Curpi G, Parenzan L, Anderson RH (eds.). Perspectives in pediatric cardiology, vol. 2, pediatric cardiac surgery, part 2. Futura Publishing Co., Inc., Mount Kisco, NY; 1989.
2. Wessel DL, du Plessis, AJ. Choreoathetosis. In: Jonas RA, Newburger JW, Volpe JJ, eds. Brain Injury and Pediatric Cardiac Surgery. Butterworth-Heinemann, Newton, MA. 1995.
3. Wessel DL, Atz AM. Inhaled nitric oxide. In: Yasuharu I, Kazuo M, eds. Proceedings of the Second World Congress of Pediatric Cardiology and Cardiac Surgery. Futura, Armonk, NY. 1998 332334.

4. Wessel DL; editor. Proceedings from the World Congress in Pediatric Critical Care Symposium on "New strategies in the treatment of pulmonary hypertension. University of Colorado Continuing Medical Education. 2004.

#### CLINICAL COMMUNICATIONS:

1. Belko J, Wessel DL, Malley R. Endocarditis due to *Corynebacterium Diphtheriae*: A case report and review of the literature. *Pediatr Infect Dis J* 2000;19:159-63.
2. Kulik TJ, Giglia TM, Mahoney LT, Schwartz SM, Wernovsky G, Wessel DL. Reply to letter to the editor. *J Am Coll Cardiol*. 2006 Jul 4;48(1):222-223.
3. Allen HD, Bricker JT, Freed MD, Hurwitz RA, McQuinn TC, Schieken RM, Strong WB, Zahka KG, Sanders SP, Colan SD, Cordes TM, Donofrio MT, Ensing GJ, Geva T, Kimball TR, Sahn DJ, Silverman NH, Sklansky MS, Weinberg PM, Beekman RH 3rd, Hellenbrand WE, Lloyd TR, Lock JE, Mullins CE, Rome JJ, Teitel DF, Vetter VL, Silka MJ, Van Hare GF, Walsh EP, Kulik T, Giglia TM, Kocis KC, Mahoney LT, Schwartz SM, Wernovsky G, Wessel DL, Murphy DJ Jr, Foster E, Benson DW Jr, Baldwin HS, Mahoney LT, McQuinn TC; American College of Cardiology Foundation; American Heart Association; American Academy of Pediatrics . Author reply. *Pediatrics*. 2005 Dec;116(6):1574-96.
4. Olivieri, L. et al, Hypoplastic Left Heart Syndrome with Intact Atrial Septum: Sequelae of Left Atrial Hypertension in Utero, *JACC*, in press

#### NONPRINT MATERIALS:

1. Wessel DL, Atz AM. Therapeutic use of inhaled nitric oxide. In: *Am Coll Cardiol. ACC Self-Assessment Programs on CD-ROM*. 1998.
2. Wessel DL; Session Chair, Inhaled nitric oxide therapy in newborns: reaching a European consensus. *ESPNIC, Rome 2002. CD-ROM*.
3. Kinsella J, Steinhorn R, Clark R, Wessel D, ed. Hypoxic respiratory failure in the neonate: diagnosis and treatment. . *CD-ROM and Slide Kit. iNO 2003*.
4. Wessel DL; editor. Proceedings from the World Congress in Pediatric Critical Care Symposium on "New strategies in the treatment of pulmonary hypertension." Monograph and CD-ROM. University of Colorado Continuing Medical Education.

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	10611384
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	94169
<b>Filer:</b>	Janis K. Fraser/Nancy Bechet
<b>Filer Authorized By:</b>	Janis K. Fraser
<b>Attorney Docket Number:</b>	26047-0003002
<b>Receipt Date:</b>	27-JUL-2011
<b>Filing Date:</b>	22-JUN-2010
<b>Time Stamp:</b>	16:44:54
<b>Application Type:</b>	Utility under 35 USC 111(a)

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Submitted with Payment	no
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### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	declaration0003002.pdf	2561931 <small>6fe8acaecd5975c6b069903a9b5d54102f6f1e62</small>	no	44

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Total Files Size (in bytes):

2561931

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**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/820,866	06/22/2010	James S. Baldassarre	26047-0003004

**CONFIRMATION NO. 2913**

**POA ACCEPTANCE LETTER**

94169  
Fish & Richardson PC  
P.O.Box 1022  
minneapolis, MN 55440



Date Mailed: 07/29/2011

**NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY**

This is in response to the Power of Attorney filed 07/21/2011.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/ddinh/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/820,866	06/22/2010	James S. Baldassarre	26047-0003002	2913

94169 7590 08/04/2011  
Fish & Richardson PC  
P.O.Box 1022  
minneapolis, MN 55440

EXAMINER
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ARNOLD, ERNST V

ART UNIT	PAPER NUMBER
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1613

MAIL DATE	DELIVERY MODE
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08/04/2011

PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

<b>Interview Summary</b>	<b>Application No.</b> 12/820,866	<b>Applicant(s)</b> BALDASSARRE ET AL.
	<b>Examiner</b> ERNST ARNOLD	<b>Art Unit</b> 1613
All participants (applicant, applicant's representative, PTO personnel):		
(1) <u>ERNST ARNOLD.</u>	(3)_____.	
(2) <u>Janis Fraser.</u>	(4)_____.	
<p>Date of Interview: <u>27 July 2011.</u></p> <p>Type: a) <input checked="" type="checkbox"/> Telephonic    b) <input type="checkbox"/> Video Conference  c) <input type="checkbox"/> Personal [copy given to: 1) <input type="checkbox"/> applicant    2) <input type="checkbox"/> applicant's representative]</p> <p>Exhibit shown or demonstration conducted: d) <input type="checkbox"/> Yes    e) <input type="checkbox"/> No.  If Yes, brief description: _____.</p> <p>Claim(s) discussed: <u>28.</u></p> <p>Identification of prior art discussed: <u>Atz (seminars in perinatology 1997, 21(5); pp 441-455).</u></p> <p>Agreement with respect to the claims f) <input type="checkbox"/> was reached.    g) <input type="checkbox"/> was not reached.    h) <input checked="" type="checkbox"/> N/A.</p> <p>Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: <u>See Continuation Sheet.</u></p> <p>(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)</p> <p>THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN A NON-EXTENDABLE PERIOD OF THE LONGER OF ONE MONTH OR THIRTY DAYS FROM THIS INTERVIEW DATE, OR THE MAILING DATE OF THIS INTERVIEW SUMMARY FORM, WHICHEVER IS LATER, TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.</p>		
/Ernst V Arnold/ Primary Examiner, Art Unit 1613		

## Summary of Record of Interview Requirements

### Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record

A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

### Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews

Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.

All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:

- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:

- 1) A brief description of the nature of any exhibit shown or any demonstration conducted,
- 2) an identification of the claims discussed,
- 3) an identification of the specific prior art discussed,
- 4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
- 5) a brief identification of the general thrust of the principal arguments presented to the examiner,  
(The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
- 6) a general indication of any other pertinent matters discussed, and
- 7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

### Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

Continuation of Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: Note: Due to the similarity in subject matter, copending 12/820980 also falls within the scope of this discussion. Discussed the reference of Atz in great detail. Applicant interprets Atz as teaching the neonate must satisfy 3 criteria before exclusion from iNO therapy: must have Left Ventricular Dysfunction (LVD), predominantly left to right shunting at the foramen ovale and exclusively right to left shunting at the ductus arteriosus and only under those conditions should NO be used with extreme caution, if at all. Applicant asserted that the discovery of the instant invention lies in newborns not dependent on right to left shunting of the blood but who have another form of LVD should not get inhaled NO (iNO). Thus, Applicant asserts that only those neonates who meet those criteria of Atz would be excluded but Applicant has discovered a new population for exclusion from iNO therapy. It was assumed that it was OK to provide iNO to patients with LVD if they did not have right to left shunting of blood. However, Applicant has discovered that neonates with other LVD should be excluded from iNO to reduce the risk of one or more adverse events. Applicant directed the Examiner to Dr. Wessels letter in the latest response. The Examiner said that he would consider all the documents filed and consult with a Quality Assurance Specialist in weighing the totality of evidence of record..

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : James S. Baldassarre et al.                      Art Unit : 1613  
Serial No. : 12/820,866    Examiner : Ernst V. Arnold  
Filed : June 22, 2010    Conf. No. : 2913  
Title : METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING  
HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR  
ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION

**Mail Stop Amendment**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

STATEMENT OF THE SUBSTANCE OF THE INTERVIEW

The undersigned representative thanks the Examiner for the courtesy of the telephonic interview held on July 27, 2011, to discuss the obviousness rejections pending in this application and a sister application (Application Serial No. 12/820,980). The Examiner's Interview Summary was mailed August 4, 2011. The present Statement of the Substance of the Interview is being filed prior to the September 4, 2011, deadline for doing so.

The substance of the interview focused primarily on the disclosure of Atz & Wessel, the primary reference cited in the obviousness rejection in each case. As the rejection centered on the safety concern expressed in Atz & Wessel at page 452 regarding inhaled nitric oxide treatment of newborns, the undersigned pointed out that Atz & Wessel limits this concern specifically to a contraindication that was widely known in the art, i.e., for newborns that have a combination of all three of the following conditions: "severe left ventricular dysfunction, predominantly left to right shunting at the foramen ovale and exclusively right to left shunting at the ductus arteriosus." This particular combination of three conditions leaves the newborn dependent (i.e., for survival) on right-to-left shunting of blood, the contraindication that had been set out in the FDA-approved prescribing information for INOmax® nitric oxide since this product was first marketed in 1999. That Atz & Wessel was referring to newborns having the

**CERTIFICATE OF MAILING BY EFS-WEB FILING**

I hereby certify that this paper was filed with the Patent and Trademark Office using the EFS-WEB system on this date: August 17, 2011

combination of all three conditions, and not to those who have just one of the conditions, is also clear from the wording of the reference itself: (a) the word “*and*” Atz & Wessel used to link the three listed conditions (rather than “*or*”); and (b) the reference in the next sentence of the article to “*adverse outcomes in this circumstance,*” with the singular form of the word “*circumstance*” implying that the “*adverse outcomes*” were observed solely in one sort of situation: i.e., the circumstance where the patients presented with a combination of all three listed conditions. The undersigned noted in the interview that nothing in Atz & Wessel suggested that the presence of left ventricular dysfunction alone presented any sort of risk of adverse events from inhaled nitric oxide therapy. The Examiner’s attention was drawn to a letter from Dr. David L. Wessel that was filed on July 8, 2011, as an exhibit attached to the Declaration of Douglas A Greene, M.D. under 37 C.F.R. § 1.132. Dr. Wessel, who is the senior author of Atz & Wessel, states in this letter that Atz & Wessel’s discussion about neonates at page 452 referred to:

the well-known contraindication...that iNO should not be used in newborns dependent upon right-to-left shunting of blood across a patent ductus [arteriosus] to avoid circulatory collapse. What we did not disclose or predict was that neonatal patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood would be at greater risk of adverse events.

A declaration of Dr. Wessel incorporating the above comments from the letter was subsequently filed on July 27, 2011.

It was the present inventors who discovered there is a previously-unidentified subset of newborns who are also at particular risk of adverse events when they are treated with inhaled nitric oxide to relieve their pulmonary hypertension: a subset who have left ventricular dysfunction but (unlike the newborns mentioned in Atz & Wessel) are not dependent on right-to-left shunting of blood.

After a parsing of claim 28 (as representative of the independent claims) to put the prior discussion of the invention and Atz & Wessel in context and to confirm his understanding of the technical issues, the Examiner agreed to consider with a Quality Assurance Specialist all of the evidence of record, including that newly filed on July 8, 2011. No other claims were explicitly discussed in the interview.



Applicant : James S. Baldassarre et al.  
Serial No. : 12/820,866  
Filed : 6/22/2010  
Page : 3

Attorney Docket No.: 26047-0003002

It is believed that no fees are due for this filing. If any fees are due, please charge them to Deposit Account No. 06-1050, referencing Attorney Docket No. 26047-0003002.

Respectfully submitted,

Date: August 17, 2011

/Janis K. Fraser/

Janis K. Fraser, Ph.D., J.D.

Reg. No. 34,819

Customer No. 94169  
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<b>EFS ID:</b>	10756254
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	94169
<b>Filer:</b>	Janis K. Fraser/Nancy Bechet
<b>Filer Authorized By:</b>	Janis K. Fraser
<b>Attorney Docket Number:</b>	26047-0003002
<b>Receipt Date:</b>	17-AUG-2011
<b>Filing Date:</b>	22-JUN-2010
<b>Time Stamp:</b>	14:37:57
<b>Application Type:</b>	Utility under 35 USC 111(a)

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### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant summary of interview with examiner	interview0003002.pdf	93255 <small>73f2e0d82f0bbe68c3bdc24c391e4281d058fde5</small>	no	3

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**New Applications Under 35 U.S.C. 111**

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**New International Application Filed with the USPTO as a Receiving Office**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/820,866	06/22/2010	James S. Baldassarre	26047-0003002	2913

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EXAMINER

ARNOLD, ERNST V

ART UNIT PAPER NUMBER

1613

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08/24/2011

PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

<b>Office Action Summary</b>	<b>Application No.</b> 12/820,866	<b>Applicant(s)</b> BALDASSARRE ET AL.
	<b>Examiner</b> ERNST ARNOLD	<b>Art Unit</b> 1613

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --**

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1)  Responsive to communication(s) filed on 08 July 2011.
- 2a)  This action is **FINAL**.                      2b)  This action is non-final.
- 3)  Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4)  Claim(s) 28-42 is/are pending in the application.  
4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5)  Claim(s) \_\_\_\_\_ is/are allowed.
- 6)  Claim(s) 28-42 is/are rejected.
- 7)  Claim(s) \_\_\_\_\_ is/are objected to.
- 8)  Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9)  The specification is objected to by the Examiner.
- 10)  The drawing(s) filed on \_\_\_\_\_ is/are: a)  accepted or b)  objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11)  The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

- 12)  Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
a)  All    b)  Some \* c)  None of:
1.  Certified copies of the priority documents have been received.
2.  Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3.  Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- |  |  |
|--|--|
| <p>1) <input type="checkbox"/> Notice of References Cited (PTO-892)</p> <p>2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)</p> <p>3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)<br/>Paper No(s)/Mail Date <u>7/8/11</u>.</p> | <p>4) <input type="checkbox"/> Interview Summary (PTO-413)<br/>Paper No(s)/Mail Date. _____.</p> <p>5) <input type="checkbox"/> Notice of Informal Patent Application</p> <p>6) <input type="checkbox"/> Other: _____.</p> |
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### **DETAILED ACTION**

Claims 1-27 have been cancelled and claims 28-42 are new. Applicant has filed a new IDS and Applicants amendments have necessitated a new ground of rejection. Accordingly, this Action is FINAL.

#### ***Information Disclosure Statement***

The information disclosure statements (IDS) submitted on 7/8/11 was filed after the mailing date of the Office Action on 6/8/11. The submission is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner to the extent that English language translations, abstracts or relevance has been provided for foreign references. References without a date have not been considered and a line has been drawn through the reference.

#### **Withdrawn rejections:**

Applicant's Declarations, amendments and arguments filed 6/8/11 are acknowledged and have been fully considered. Any rejection and/or objection not specifically addressed below is herein withdrawn. Since Applicant has cancelled all previously rejected claims, then all previous claim rejections have been rendered moot and are withdrawn.

The following rejections and/or objections are either reiterated or newly applied. They constitute the complete set of rejections and/or objections presently being applied to the instant application.

***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

Claims 28-42 are rejected under 35 U.S.C. 103(a) as being unpatentable over INOmax® insert (2007; IDS filed on 7/8/11) and Atz et al. (Seminars in Perinatology 1997, 21(5), pp 441-455) and Kinsella et al. (The Lancet 1999, 354, 1061-1065) and Loh et al. (Circulation 1994, 90, 2780-2785).

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later

invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

Applicants claims, for example:

28. (New) A method of reducing the risk of occurrence, in a term or near-term neonate patient, of one or more adverse events or serious adverse events associated with a medical treatment comprising inhalation of nitric oxide gas, said method comprising:
- (a) identifying a term or near-term neonate patient in need of inhaled nitric oxide treatment, wherein the patient is not known to be dependent on right-to-left shunting of blood;
  - (b) determining that the patient identified in (a) has pre-existing left ventricular dysfunction; and
  - (c) excluding the patient from inhaled nitric oxide treatment based on the determination that the patient has pre-existing left ventricular dysfunction.

### **Determination of the scope and content of the prior art**

#### **(MPEP 2141.01)**

The INOmax® insert teaches that in the NINOS study (page 1, upper right) neonates with hypoxic respiratory failure were treated with inhaled NO (iNO) resulting in fewer deaths than the control (14% vs 20%)(page 1, right column). Adverse events were presented in a Table on page 2 of the insert:



**ADVERSE EVENTS IN THE CIRGI TRIAL**

<b>Adverse Event</b>	<b>Placebo (n=89)</b>	<b>Inhaled iNO (n=97)</b>
Hypotension	9 (10%)	13 (13%)
Withdrawal	9 (10%)	12 (12%)
Atelectasis	8 (9%)	9 (9%)
Hematuria	5 (6%)	8 (8%)
Hyperglycemia	6 (7%)	8 (8%)
Sepsis	2 (2%)	7 (7%)
Infection	3 (3%)	6 (6%)
Stridor	3 (3%)	5 (5%)
Cellulitis	0 (0%)	5 (5%)

As can be seen in the Table, there is a higher percentage of Adverse events associated with iNO than the placebo in all categories. In addition, the insert also teaches on page 2, left column:

**In the NINOS study, treatment groups were similar with respect to the incidence and severity of intracranial hemorrhage, Grade IV hemorrhage, periventricular leukomalacia, cerebral infarction, seizures requiring anticonvulsant therapy, pulmonary hemorrhage, or gastrointestinal hemorrhage.**

This teaching fairly suggests that iNO increases the risk of adverse events over a broad variety of events above that of the placebo. Accordingly, the ordinary artisan understands that there is an increased risk of adverse events in administering iNO over that of a placebo. *In other words, the administration of iNO increases the risk of adverse events in neonates and consequently the ordinary artisan understands that by not administering iNO the risk of*

occurrence of adverse events is reduced as shown by the Table above. From this piece of art, the Examiner can make the following reasonable conclusion:

**Finding of Fact #1: Administration of iNO is not without risk of adverse events.**

**Inhaled NO increases the risk of adverse events in neonates and the corollary that exclusion of the patient from iNO, the placebo above, has a reduced risk of the the occurrence of adverse events from iNO.**

Atz et al. teach methods using inhaled nitric oxide in the **neonate** with cardiac disease, hence an **identified patient** in need of nitric oxide treatment, (title and Abstract) which intrinsically provides pharmaceutically acceptable NO gas for inhalation to a medical provider to provide to the patient. Atz et al. warn that sudden pulmonary vasodilation may produce **pulmonary edema** (page 452, left column). Atz et al. teach that: "Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension." (page 452, left column). Since pulmonary hypertension is instantly claimed, then the subject intrinsically has hypoxic respiratory failure. Atz et al. continues with: "Therefore, in newborns with severe left ventricular dysfunction, predominantly left to right shunting at the foramen ovale and exclusively right to left shunting at the ductus arteriosus, NO should be used with extreme caution, if at all. We and others have reported adverse outcomes in this circumstance." (page 452, left column) (Examiner added emphasis). Artz et al. thus identify conditions in the patients which is screening of the patient. Thus, Atz et al. fairly teaches excluding patients which include neonates with left ventricular dysfunction from inhaled NO treatment because the Examiner interprets "if at all" to mean no treatment and hence exclusion from treatment. The left ventricular dysfunction is intrinsically pre-existing.

To summarize, the methods disclosed by Atz et al. are interpreted to mean:

- identifying a patient eligible for NO treatment;
- diagnosing/identifying if the patient has left ventricular dysfunction;
- excluding that patient with left ventricular dysfunction from treatment with NO but treating the patient with NO for other conditions discussed by Atz et al. with inhalation of NO thereby reducing the risk of adverse events associated with the medical treatment.

Atz et al. teach neonates with pulmonary hypertension (Abstract and page 442, left column to right column) and it is irrelevant to the Examiner as to how the pulmonary hypertension was diagnosed whether by echocardiographic evidence or clinical evidence. The fact that matters is that the hypertension is diagnosed in the patient population. From this piece of art, the Examiner can make the following reasonable conclusion:

**Finding of Fact #2: Adverse outcomes are known to occur to neonates treated with iNO that have pre-existing left ventricular dysfunction and consequently the art cautions against the use of iNO to such patients.**

Kinsella et al. teach excluding patients (premature neonates) from inhaled nitric oxide treatment if they have fatal congenital anomalies or congenital heart disease (Abstract and page 1062, Methods). Since left ventricular dysfunction is a congenital heart disease, as acknowledged by Applicant, (see specification [0028]), and it would be pre-existing, then the methods of Kinsella et al. intrinsically exclude this patient population from the method. The patients also had pulmonary hypertension which would be associated with the cardiac function (Abstract). Thus, one or more adverse events are reduced in the neonates excluded from the method. The patients

are intrinsically identified for nitric oxide inhalation treatment, diagnosed for congenital heart disease which intrinsically includes left ventricular dysfunction, and if the patient meets the criteria than treatment with NO is performed thereby reducing the risk of adverse events associated with the treatment. From this piece of art, the Examiner can make the following reasonable conclusion:

**Finding of Fact #3: Neonates with fatal congenital anomalies or congenital heart disease are excluded from iNO therapy but those neonates who meet the criteria for therapy are provided iNO therapy.**

Loh et al. teach that inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure (Title and Abstract). Loh et al. clearly teaches that patients with pulmonary artery wedge pressure, which is synonymous with the instantly claimed pulmonary capillary wedge pressure, ***of greater than or equal to 18 mm Hg*** had a greater effect of inhaled NO due to the greater degree of reactive pulmonary hypertension present in such patients (page 2784, left column). Loh et al. state: "*Since the degree of reactive pulmonary hypertension is generally related to the severity of hemodynamic compromise in patients with LV failure, it might be anticipated that patients with more severe heart failure will have a more marked hemodynamic response to inhaled NO.*" Loh et al. examined this prediction further and verified it (page 2784, left column). From this piece of art, the Examiner can make the following reasonable conclusion:

**Finding of Fact #4: Patients with a pulmonary capillary wedge pressure of greater than or equal to 18 mm Hg have a more marked hemodynamic response to inhaled NO**

**which results in the finding that inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure.**

**Ascertainment of the difference between the prior art and the claims**

**(MPEP 2141.02)**

1. The difference between the instant application and INOmax®, Atz et al., Loh et al., and Kinsella et al., is that INOmax®, Atz et al., Loh et al., and Kinsella et al., do not expressly teach the method of reducing the risk of occurrence in a term or near term neonate patient of one or more adverse events or serious adverse events associated with iNO therapy comprising identifying a term or near term neonate patient in need of iNO treatment and is not known to be dependent on right to left shunting of blood, determining if the patient has pre-existing LVD and excluding the patient from iNO treatment if they have pre-existing LVD or administering iNO if they do not have pre-existing LVD of instant claims 28-42. This deficiency in the cited references is cured by the common sense of the ordinary artisan.

**Finding of prima facie obviousness**

**Rational and Motivation (MPEP 2142-2143)**

1. It would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to perform the method of INOmax®, Atz et al., Loh et al., and Kinsella et al., and perform the method steps of instant claims 28-42 and produce the instant invention.

One of ordinary skill in the art would have been motivated to do this because: 1) iNO has risk of adverse events as taught by INOmax®; 2) if the neonate has left ventricular dysfunction

(LVD), then Atz et al. clearly teach using extreme caution or not using NO at all in the treatment of patients with LVD which would also render obvious other forms of LVD not known to be dependent on right to left shunting of blood; and 3) the art of Kinsella et al. establishes excluding certain patients (premature neonates) from inhaled nitric oxide treatment if they have fatal congenital anomalies or congenital heart disease. Thus it is simply no stretch of the imagination to exclude patients such as term or near term neonates with LVD and not known to be dependent on right to left shunting of the blood from inhaled nitric oxide therapy in order to avoid adverse outcomes as taught by Atz et al. which intrinsically include all the adverse events recited by Applicant including pulmonary edema as discussed above. The ordinary artisan would err on the side of caution for the benefit of the patient. Identification of a plurality of patients in need of iNO treatment and determining which patient has pre-existing LVD and which does not is simply screening of patients. Administration of iNO to neonates without LVD is already known in the art.

Furthermore, it is already known through the teachings of Loh et al. that a pulmonary capillary wedge pressure (PCWP) of greater than 18 mm Hg serves as a guidepost for alerting the artisan to adverse events from inhaled NO. Thus, it is not inventive to exclude patients with a PCWP of greater than 20 mm Hg when the art already suggests the risk of trouble of treating patients with a PCWP of 18 mm Hg because inhaled NO increases the wedge pressure as taught by Loh et al. (see entire document).

In summary, it remains the position of the Examiner, which is in alignment with the written opinion of the international search authority, that it is simply not inventive to 'inform' a medical provider that a neonate with LVD is at risk of adverse/serious adverse events from iNO

therapy when the art already has established that fact and the ordinary artisan is alerted to this fact. If the patient has LVD then they are at risk of adverse and/or serious adverse events from iNO therapy and it is not inventive to further identify other secondary conditions/risk factors associated with LVD and provide further warnings for secondary conditions/risk factors that are separate and independent from the first condition/risk factor but nevertheless associated with LVD to the medical provider. Screening for conditions that predispose the patient to adverse/serious adverse effects from medical treatment of iNO is obvious given the teachings above. Respectfully, the instantly claimed method steps are in the realm of common sense and not in the dominion of invention because it is already known in the art that patients with pre-existing LVD are at risk of adverse effects from iNO. In other words, not every finding in the scientific kingdom is patentable. It is obvious to the ordinary artisan that if the neonate has LVD, then in order to avoid the risk of adverse or serious adverse events associated with iNO, to then exclude the neonate from iNO therapy. In other words, given the art as a whole, determination of further conditions/risk factors that would exclude the neonate from iNO therapy is obvious given the teachings in the art as discussed above which direct the artisan to screen neonates about to undergo treatment with NO by inhalation and to exclude those with LVD from such treatment.

In light of the forgoing discussion, the Examiner concludes that the subject matter defined by the instant claims would have been obvious within the meaning of 35 USC 103(a).

From the teachings of the references, it is apparent that one of ordinary skill in the art would have had a reasonable expectation of success in producing the claimed invention.

Therefore, the invention as a whole was *prima facie* obvious to one of ordinary skill in the art at

the time the invention was made, as evidenced by the references, especially in the absence of evidence to the contrary.

**Response to Arguments:**

The Examiner has considered Applicants arguments as they pertain to the previous rejection(s) of record. This is a new rejection of record and arguments/Declarations directed to the previous rejection(s) of record are now moot since those rejections have been rendered moot by the cancellation of all previously pending claims and introduction of all new claims.

Respectfully, none of Applicants arguments or Declarations are persuasive. The Examiner has carefully considered the Declarations by Dr. Wessel, Dr. Greene and Dr. Baldassarre as well as all remarks and arguments. However, the position of the Examiner remains immutable and the Examiner does not concede or acquiesce to any of Applicant's arguments, points or positions.

The fundamental question concerning the instant case is **whether or not** it is inventive to exclude a neonatal patient that has pre-existing left ventricular dysfunction but is not known to be dependent on right to left shunting of blood from iNO therapy to reduce the risk of occurrence of one or more adverse events or serious adverse events associated with inhalation of nitric oxide gas. Based upon the preponderance of evidence, the Examiner can only conclude based upon the facts and not impermissible hindsight reconstruction that the instant claims are not inventive. Certainly, Applicant and the panel of experts *must* be aware of the adverse events associated with iNO therapy as provided by INOmax® insert. Inhaled NO is not without inherent risk of adverse events. It is then no stretch of the imagination to exclude patients, including a neonatal patient that has pre-existing left ventricular dysfunction but is not known to be dependent on right to left shunting of blood from iNO therapy to reduce the risk of occurrence of



one or more adverse events or serious adverse events associated with inhalation of nitric oxide gas because it is already known that iNO has a risk of adverse events. In other words, it does not matter if the neonate has a foot fungus, is polydactyly or has pre-existing left ventricular dysfunction because the risk of occurrence of adverse events from iNO therapy will be reduced if the patient is excluded from iNO therapy. Applicant argues that it would not have been common sense for a physician to exclude a neonatal LVD patient from a potentially life-saving treatment with iNO without a legitimate medical justification for doing so. Applicant also states:

**skill. No physician who believed it "obvious" that inhaled nitric oxide treatment would be harmful to patients who have a particular condition would approve a study of inhaled nitric oxide that includes those patients. That is simply common sense. That multiple physicians who are experts in this field**

However, it is already known that iNO has the risk of adverse effects as shown by INOmax®. Thus, the statement above carries no weight because each and every time iNO is administered there is a risk of adverse effects.

The Examiner believes that Applicant has lost sight of the forest for the trees. To bring the issues into perspective:

- Administration of iNO is not without risk of adverse effects (INOmax®).
- Administration of iNO to neonates with LVD, predominantly left to right shunting at the foramen ovale and exclusively right to left shunting at the ductus arteriosus is warned against because of adverse outcomes (Atz et al.).
- Neonates with congenital heart disease have already been excluded from iNO therapy (Kinsella et al.).
- Inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure (Loh et al.).

Consequently, the art as a whole paints a picture that patients, including neonates, are at risk of adverse events from iNO therapy even if the iNO therapy is beneficial in other aspects and it remains obvious to exclude patients, including neonates, from iNO therapy to reduce the risk of occurrence of such adverse events. While the Examiner acknowledges the instant claims have a real world utility and can perhaps save the lives of neonates, the instant claims do not rise to the level of invention but rather remain on the plane of obvious to the person of ordinary skill in the art based on the art as a whole. This is the unwavering position of the Examiner backed by Quality Assurance.

#### ***Double Patenting***

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the “right to exclude” granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

1. Claims 28-42 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 29-42 of copending Application No. 12/820980. Although the conflicting claims are not identical, they are not patentably distinct from each other because the instant subject matter embraces or is embraced by the subject matter of the copending subject matter. Both applications are drawn to methods of reducing one or more adverse events in a term or near term neonates by excluding from treatment anyone with pre-existing left ventricular dysfunction.

Therefore one of ordinary skill in the art would have recognized the obvious variation of the instant application over the copending application.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

2. Claims 28-42 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 21-30 of copending Application No. 12/821020. Although the conflicting claims are not identical, they are not patentably distinct

from each other because the instant subject matter embraces or is embraced by the subject matter of the copending subject matter. Both applications are drawn to methods of reducing one or more adverse events in a patient population by excluding from treatment anyone with pre-existing left ventricular dysfunction.

The copending application does not expressly teach the intended population as having one or more conditions.

However the copending application is drawn to the same patient population which intrinsically has one or more conditions/risk factors as instantly claimed.

Therefore one of ordinary skill in the art would have recognized the obvious variation of the instant application over the copending application.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

3. Claims 28-42 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 21-29 and 37 of copending Application No. 12/821041. Although the conflicting claims are not identical, they are not patentably distinct from each other because the instant subject matter embraces or is embraced by the subject matter of the copending subject matter. Both applications are drawn to methods of reducing one or more adverse events in a patient population by excluding from treatment anyone with pre-existing left ventricular dysfunction.

The copending application does not expressly teach the intended population as having one or more conditions.

However the copending application is drawn to the same patient population which intrinsically has one or more conditions/risk factors as instantly claimed.

Therefore one of ordinary skill in the art would have recognized the obvious variation of the instant application over the copending application.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

### *Conclusion*

No claims are allowed.

Applicant's submission of an information disclosure statement under 37 CFR 1.97(c) with the fee set forth in 37 CFR 1.17(p) on 7/8/11 prompted the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 609.04(b). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the mailing date of this final action.

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).


A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ERNST V. ARNOLD whose telephone number is (571)272-8509. The examiner can normally be reached on M-F 7:15-4:45.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Brian Kwon can be reached on 571-272-0581. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Ernst V Arnold/  
Primary Examiner, Art Unit 1613

<b>Search Notes</b>  	<b>Application/Control No.</b>  12820866	<b>Applicant(s)/Patent Under Reexamination</b>  BALDASSARRE ET AL.
	<b>Examiner</b>  ERNST V ARNOLD	<b>Art Unit</b>  1616

<b>SEARCHED</b>			
<b>Class</b>	<b>Subclass</b>	<b>Date</b>	<b>Examiner</b>

<b>SEARCH NOTES</b>		
<b>Search Notes</b>	<b>Date</b>	<b>Examiner</b>
inventor name EAST/PALM	8/10/10	eva
EAST 424/718 text limited all databases	8/10/10	eva
google	8/10/10	eva
consultation Brian Kwon SPE 1613 and Jean Vollano QAS	10/24/10	eva
consultation Jean Vollano QAS on claims and rejections	8/11	eva
updated IDS	8/22/11	eva

<b>INTERFERENCE SEARCH</b>			
<b>Class</b>	<b>Subclass</b>	<b>Date</b>	<b>Examiner</b>

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<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b> ( Not for submission under 37 CFR 1.99)	Application Number	12820866
	Filing Date	2010-06-22
	First Named Inventor	James S. Baldassarre
	Art Unit	1613
	Examiner Name	Ernst V. Arnold
	Attorney Docket Number	I001-0002USC1

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<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b> ( Not for submission under 37 CFR 1.99)	Application Number	12820866
	Filing Date	2010-06-22
	First Named Inventor	James S. Baldassarre
	Art Unit	1613
	Examiner Name	Ernst V. Arnold
	Attorney Docket Number	I001-0002USC1

/E.A./	1	Berst, et al. "Vasodilator Testing with Nitric Oxide and/or Oxygen in Pediatric Pulmonary Hypertension" Received: 14 September 2009 / Accepted: 19 January 2010 Springer Science+Business Media, LLC 2010, 9 pages	<input type="checkbox"/>
/E.A./	2	Bates, inhaled Nitric Oxide: A Selective Pulmonary Vasodilator, 2004, 9 pages	<input type="checkbox"/>
/E.A./	3	Beggs, et al., "Cardiac Failure in Children" 17th Expert Committee on the Selection and Use of Essential Medicines, Geneva, March 2009, 31 pages	<input type="checkbox"/>
/E.A./	4	Copy of the Canadian Office Action mailed May 31, 2011 for Canadian patent application No. 2671029, a counterpart foreign application of US patent application No. 12/494,598	<input type="checkbox"/>
/E.A./	5	Douwes, et al. "The Maze of Vasodilator Response Criteria" Published online: 26 November 2010, <i>Pediatr Cardiol</i> (2011) 32: pp. 245-246	<input type="checkbox"/>
/E.A./	6	Fraisse, et al., "Acute pulmonary hypertension in infants and children: cGMP-related drugs" <i>Pediatric Crit Care Med</i> 2010, Vol 11, No. 2 (Suppl.), 4 pages	<input type="checkbox"/>
/E.A./	7	INOmax (nitric oxide) for inhalation 100 and 800 ppm (parts per million), drug label insert, 2007, 2 pages	<input type="checkbox"/>
/E.A./	8	Kay, et al. "Congestive heart failure in pediatric patients," From the Department of Pediatrics, Duke University Medical Center, 2001 by Mosby, Inc., 6 pages	<input type="checkbox"/>
/E.A./	9	Definition of Contraindication on Medicine.net.com; <a href="http://www.medterms.com/script/main/art.asp?articlekey=17824">http://www.medterms.com/script/main/art.asp?articlekey=17824</a> ; retrieved 3/14/2011, 2 pages	<input type="checkbox"/>
/E.A./	10	Murray, Angiotensin Converting Enzyme Inhibitory Peptides Derived from Food Proteins: Biochemistry, Bioactivity and Production; <i>Current Pharmaceutical Design</i> , 2007, 773-791	<input type="checkbox"/>
/E.A./	11	Non-Final Office Action for US Patent Application 12/820,980, mailed on June 10, 2011, James Baldassarre, "METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION"	<input type="checkbox"/>

<b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b> ( Not for submission under 37 CFR 1.99)	Application Number	12820866
	Filing Date	2010-06-22
	First Named Inventor	James S. Baldassarre
	Art Unit	1613
	Examiner Name	Ernst V. Arnold
	Attorney Docket Number	I001-0002USC1

/E.A./	12	UCI General Clinical Research Center, Federal Regulations 21 CFR Part 312, << <a href="http://www.gcrc.uci.edu/rsa/aer.cfm">http://www.gcrc.uci.edu/rsa/aer.cfm</a> >>, retrieved 9/13/2010, 2 pages	<input type="checkbox"/>
/E.A./	13	NIH CC: Critical Care Services, <a href="http://www.cc.nih.gov/ccmd/clinical_services.html">http://www.cc.nih.gov/ccmd/clinical_services.html</a> ; retrieved 3/10/2011, 3 pages	<input type="checkbox"/>
/E.A./	14	Guidelines for Industry: Clinical Safety Data Management << <a href="http://www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidance/ucm073087.pdf">www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidance/ucm073087.pdf</a> >>, March 1995, 17 pages	<input type="checkbox"/>
	15		<input type="checkbox"/>

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**EXAMINER SIGNATURE**

Examiner Signature	/Ernst Arnold/	Date Considered	08/22/2011
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\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

<sup>1</sup> See Kind Codes of USPTO Patent Documents at [www.USPTO.GOV](http://www.USPTO.GOV) or MPEP 901.04. <sup>2</sup> Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). <sup>3</sup> For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. <sup>4</sup> Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. <sup>5</sup> Applicant is to place a check mark here if English language translation is attached.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : James S. Baldassarre et al.                      Art Unit : 1613  
Serial No. : 12/820,866    Examiner : Ernst V. Arnold  
Filed : June 22, 2010    Conf. No. : 2913

Title : METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING  
HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR  
ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION

**MAIL STOP AF**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

NOTICE OF APPEAL

Applicant hereby appeals to the Board of Patent Appeals and Interferences from the action dated August 24, 2011, finally rejecting claims 28-42.

The appeal fee in the amount of \$540 is being paid concurrently herewith on the Electronic Filing System (EFS) by way of Deposit Account authorization. Please apply any necessary charges or credits to Deposit Account 06 1050, referencing the above attorney docket number.

Respectfully submitted,

Date: September 1, 2011

/Janis K. Fraser/  
Janis K. Fraser, Ph.D., J.D.  
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**CERTIFICATE OF MAILING BY EFS-WEB FILING**

I hereby certify that this paper was filed with the Patent and Trademark Office using the EFS-WEB system on this date: September 01, 2011.

## Electronic Patent Application Fee Transmittal

<b>Application Number:</b>	12820866			
<b>Filing Date:</b>	22-Jun-2010			
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION			
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre			
<b>Filer:</b>	Janis K. Fraser/Nancy Bechet			
<b>Attorney Docket Number:</b>	26047-0003002			
Filed as Large Entity				
<b>Utility under 35 USC 111(a) Filing Fees</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent Appeals-and-Interference:</b>				
Notice of appeal	1401	1	540	540
<b>Post-Allowance-and-Post-Issuance:</b>				
<b>Extension-of-Time:</b>				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
<b>Miscellaneous:</b>				
<b>Total in USD (\$)</b>				<b>540</b>

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	10864054
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	94169
<b>Filer:</b>	Janis K. Fraser/Nancy Bechet
<b>Filer Authorized By:</b>	Janis K. Fraser
<b>Attorney Docket Number:</b>	26047-0003002
<b>Receipt Date:</b>	01-SEP-2011
<b>Filing Date:</b>	22-JUN-2010
<b>Time Stamp:</b>	15:28:01
<b>Application Type:</b>	Utility under 35 USC 111(a)

### Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	\$ 540
RAM confirmation Number	1898
Deposit Account	061050
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

<b>File Listing:</b>					
<b>Document Number</b>	<b>Document Description</b>	<b>File Name</b>	<b>File Size(Bytes)/ Message Digest</b>	<b>Multi Part /.zip</b>	<b>Pages (if appl.)</b>
1	Notice of Appeal Filed	noticeofappeal260470003002.pdf	66349 1c263a2dff009478dbb9e3c95873b2016c155bf	no	1
<b>Warnings:</b>					
<b>Information:</b>					
2	Fee Worksheet (SB06)	fee-info.pdf	30685 f1e6cd33d51daa344d2a3bab09c785c4d45d89e0	no	2
<b>Warnings:</b>					
<b>Information:</b>					
<b>Total Files Size (in bytes):</b>			97034		
<p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>  If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>  If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>  If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p>					



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : James S. Baldassarre et al.                      Art Unit : 1613  
Serial No. : 12/820,866    Examiner : Ernst V. Arnold  
Filed : June 22, 2010    Conf. No. : 2913

Title : METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING  
HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR  
ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION

**Mail Stop Appeal Brief - Patents**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

BRIEF ON APPEAL

This application is under Accelerated Examination.

Appellant is appealing the final rejection of claims 28-42 in the Final Office Action dated August 24, 2011. A Notice of Appeal was filed and received by the U.S. Patent and Trademark Office on September 1, 2011.

**I. Real Party in Interest**

The Real Party in Interest is Ikaria Holdings, Inc., the assignee of record. Affiliates of Ikaria Holdings, Inc. include Ikaria, Inc. and INO Therapeutics LLC.

**II. Related Appeals and Interferences**

There are no prior or pending related appeals, judicial proceedings, or interferences.

CERTIFICATE OF (A) MAILING BY FIRST CLASS MAIL OR (B) TRANSMISSION  
I hereby certify under 37 CFR §1.8(a) that this correspondence is either (A) addressed as set out in 37 CFR §1.1(a) and being deposited with the United States Postal Service as first class mail with sufficient postage, or (B) being transmitted by facsimile in accordance with 37 CFR § 1.6(d) or via the Office electronic filing system in accordance with 37 CFR § 1.6(a)(4), on the date indicated below.

October 4, 2011

Date of Deposit or Transmission

/Lisa G. Gray/

Signature

Lisa G. Gray

Typed or Printed Name of Person Signing Certificate

### III. Status of Claims

Claims 1-27 are canceled.

Claims 28-42 are rejected and under appeal.

### IV. Status of Amendments

No amendments have been filed subsequent to the August 24, 2011, mailing date of the Final Office Action, and none are being submitted herewith.

### V. Summary of Claimed Subject Matter

Independent claims 28, 32 and 37 are summarized below. Support in the specification is indicated by paragraph numbers derived from the specification as filed.

**Independent claim 28** is directed to a method of reducing the risk of occurrence, in a term or near-term neonate patient (i.e., >34 weeks gestation; see the specification at paragraph [0033]), of one or more adverse events or serious adverse events associated with a medical treatment comprising inhalation of nitric oxide gas. (“Adverse events” and “serious adverse events” are terms of art describing two related but distinct categories of events in the pharmaceutical field; see, e.g., the definitions in the specification at paragraphs [0025] and [0027].) The method includes the steps of (a) identifying a term or near-term neonate patient in need of inhaled nitric oxide treatment, wherein the patient is not known to be dependent on right-to-left shunting of blood; (b) determining that the patient identified in (a) has pre-existing left ventricular dysfunction; and (c) excluding the patient from inhaled nitric oxide treatment based on the determination that the patient has pre-existing left ventricular dysfunction. Support for claim 28 can be found, e.g., at paragraphs [0004], [0007], [0008], [0020] (as amended in the Response filed July 8, 2011, to include material previously incorporated by reference), [0025], [0027], [0028], [0033], and [0051] of the specification.

**Independent claim 32** is directed to a method of reducing the risk of occurrence, in a term or near-term neonate patient, of one or more adverse events or serious adverse events associated with a medical treatment comprising inhalation of nitric oxide gas. The method includes the steps of (a) identifying a term or near-term neonate patient in need of inhaled nitric oxide treatment, wherein the patient is not known to be dependent on right-to-left shunting of blood; (b) determining by diagnostic screening that the patient identified in (a) has pre-existing left ventricular dysfunction; and (c) excluding the patient from treatment with inhaled nitric oxide based on the determination that the patient has pre-existing left ventricular dysfunction. This claim is similar to claim 28, except that step (b) of claim 32 specifies use of “diagnostic screening.” See, e.g., the specification at paragraph [0028].

Support for claim 32 can be found, e.g., at paragraphs [0004], [0007], [0008], [0020] (as amended in the Response filed July 8, 2011, to include material previously incorporated by reference), [0025], [0027], [0028], [0033], and [0051] of the specification.

**Independent claim 37** is directed to a method of reducing the risk of occurrence, in a plurality of term or near-term neonate patients, of one or more adverse events or serious adverse events associated with medical treatment comprising inhalation of nitric oxide gas. The method includes the steps of (a) identifying a plurality of term or near-term neonate patients who are in need of inhaled nitric oxide treatment, wherein the patients are not known to be dependent on right-to-left shunting of blood; (b) determining that a first patient of the plurality has pre-existing left ventricular dysfunction and a second patient of the plurality does not; (c) administering the inhaled nitric oxide treatment to the second patient; and (d) excluding the first patient from treatment with inhaled nitric oxide, based on the determination that the first patient has pre-existing left ventricular dysfunction.

Support for claim 37 can be found, e.g., at paragraphs [0004], [0007], [0008], [0020] (as amended in the Response filed July 8, 2011, to include material previously incorporated by reference), [0025], [0027], [0028], [0033], and [0051] of the specification. In particular, the concept of a “plurality” of patients is supported by the discussion of “patients” (plural) at paragraph [0004] and “a patient population” at paragraph [0007]. Paragraph [0007]

also supports the recitation of a first patient who is determined to have left ventricular dysfunction and so is excluded from treatment with inhaled nitric oxide. The recitation of a second patient who is determined not to have left ventricular dysfunction and so is administered inhaled nitric oxide is supported, e.g., at paragraph [0008]. (The terms “first” and “second” in claim 37 are merely standard linguistic devices useful to distinguish between two patients, and do not imply any particular temporal order.)

As required by the accelerated examination program of which this application is a part, Appellant does not separately argue the patentability of any dependent claim in this appeal brief. Appellant agrees that the dependent claims are grouped together with, and not argued separately from, the independent claim from which they depend.

#### **VI. Ground of Rejection to be Reviewed on Appeal**

The sole ground of rejection to be reviewed on appeal is whether claims 28-42 are unpatentable under 35 U.S.C. § 103(a) over a combination of four references: the 2007 drug label insert for INOmax® (nitric oxide) for inhalation (“the 2007 INOmax® insert”; included as Exhibit 1 for the Board’s convenience); Atz & Wessel (*Seminars in Perinatology* 1997, 21(5), 441-455; Exhibit 2); Kinsella et al. (*The Lancet* 1999, 354, 1061-1065; Exhibit 3); and Loh et al. (*Circulation* 1994, 90, 2780-2785; Exhibit 4).<sup>1</sup>

Claims 28-42 are also provisionally rejected as being unpatentable for nonstatutory obviousness-type double patenting over claims 29-42 of co-pending U.S. Application No. 12/820,980; over claims 21-30 of copending Application No. 12/821,020; and over claims 21-29 and 37 of copending Application No. 12/821,041.<sup>2</sup> For purposes of the present appeal, Appellant does not contest these provisional rejections insofar as they are applied to the claims as currently written, and intends to file appropriate Terminal Disclaimers to moot these rejections if doing so is warranted at the time the present claims are otherwise deemed

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<sup>1</sup> Final Office Action, August 24, 2011 (the “Final Office Action”), at 3.

<sup>2</sup> *Id.* at 14-17.

allowable. Accordingly, the Board of Patent Appeals and Interferences need not address the obviousness-type double patenting rejections at this time.<sup>3</sup>

## VII. Argument

### A. Summary of the Argument

The issue presented on this appeal is simple and straightforward. The claimed invention is directed to a method of reducing the risk of adverse events in neonate patients that suffer from left ventricular dysfunction (LVD) and are **not** dependent on right-to-left shunting of blood.<sup>4</sup> For simplicity, this set of neonates is referred to herein as the "Claimed Patient Population." The present inventors discovered that the Claimed Patient Population suffers from an elevated risk of adverse events when treated with inhaled nitric oxide.<sup>5</sup> The Examiner does not dispute that this discovery is novel and not anticipated by any of the cited prior art references.<sup>6</sup>

The prior art does teach, however, that administration of inhaled nitric oxide may result in adverse events in **two other distinct patient populations**: (i) neonate patients dependent on right-to-left shunting of blood, and (ii) adults suffering from LVD (together, the "Prior Art Patient Populations").<sup>7</sup> The three **very** distinct patient populations at issue are summarized in the diagram below:

<sup>3</sup> *Ex Parte Moncla*, 95 U.S.P.Q.2d 1884 (B.P.A.I. June 22, 2010).

<sup>4</sup> See Declaration of Douglas A. Greene, M.D. under 37 C.F.R. § 1.132, dated April 29, 2011 ("First Greene Dec."), ¶¶ 10-14 (discussing neonate cardiology and right-to-left shunting of blood at a patent ductus arteriosus). The First Greene Dec. was originally submitted with the May 2, 2011 Reply filed by Appellant. A copy of the First Greene Dec. is enclosed in the Evidence Appendix (ix) as Exhibit 5.

<sup>5</sup> Declaration of David L. Wessel, M.D., under 37 CFR § 1.132 ("Wessel Dec."), ¶ 9. The Wessel Dec. was made of record on July 27, 2011, and is enclosed in the Evidence Appendix (ix) as Exhibit 6.

<sup>6</sup> Final Office Action at 9 ("The difference between the instant application and INOmax®, Atz et al., Loh et al., and Kinsella et al., is that INOmax®, Atz et al., Loh et al., and Kinsella et al., do not expressly teach the method of reducing the risk of occurrence in a term or near term neonate patient of one or more adverse events or serious adverse events associated with iNO therapy comprising identifying a term or near term neonate patient in need of iNO treatment and is **not known to be dependent on right to left shunting of blood**, determining if the patient has pre-existing LVD and excluding the patient from iNO treatment if they have pre-existing LVD or administering iNO if they do not have pre-existing LVD of instant claims 28-42." (Emphasis added)).

<sup>7</sup> Wessel Dec. ¶ 7.

	<b>Patient has LVD and <i>IS</i> dependent on right-to-left shunting of blood</b>	<b>Patient has LVD and <i>IS NOT</i> dependent on right-to-left shunting of blood</b>
<b>Adults</b>	Not Applicable	Prior Art Patient Population
<b>Neonates</b>	Prior Art Patient Population	Claimed Patient Population

The Examiner contends that disclosure of an increased likelihood of adverse events in the Prior Art Patient Populations would have made it obvious to expect a similar increase in adverse events in the Claimed Patient Population.<sup>8</sup> The Board should reverse this rejection because: (i) it is contrary to historical fact, and (ii) the Examiner provides no analysis based upon the etiology and/or pathophysiology of the various conditions that would explain why a risk of adverse events in the Prior Art Patient Populations would lead one skilled in the art to expect an increased likelihood of adverse events in the Claimed Patient Population.<sup>9</sup> In fact, all of the evidence of record is to the contrary and demonstrates that the etiology and pathophysiology of these patient populations are clinically distinct and would not justify any such conclusion.<sup>10</sup>

The evidence of record supporting reversal of the Examiner's rejection includes the following:

**1. Direct evidence that those skilled in the art were well aware for many years of the increased risk of adverse events in the Prior Art Patient Populations and nevertheless did not predict an increased risk of adverse events in the Claimed Patient Population.**

a. The record includes declaration testimony (including the declaration of Dr. Wessel, senior author of the Atz & Wessel reference relied on extensively by the Examiner) that, immediately prior to Appellants' invention, three leading experts in inhaled nitric oxide

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<sup>8</sup> Final Office Action at 9.

<sup>9</sup> See generally Final Office Action (entirely failing to address (a) Appellant's evidence of why experts in the field did not expect increased risk to the Claimed Patient Population and (b) physical attributes of the Prior Art Patient Populations that might provide a clue that the Claimed Patient Population would be adversely affected by inhaled nitric oxide).

<sup>10</sup> See, e.g., Declaration of Douglas A. Greene, M.D. under 37 C.F.R. § 1.132, dated July 7, 2011 ("Second Greene Dec."), ¶¶ 8-9, 22, 25, 27. The Second Greene Dec. was originally submitted with the July 8, 2011 Reply. A copy of the Second Greene Dec. is enclosed in the Evidence Appendix (ix) as Exhibit 7.

therapy designed a study protocol that was reviewed and approved by 18 Institutional Review Boards and Independent Ethics Committees composed of over 100 specialists at leading medical institutions in the United States and Europe.<sup>11</sup> Not one of these experts or other experienced specialists predicted the increased risk of adverse events in the Claimed Patient Population that the Examiner, with 20-20 hindsight, now concludes should have been obvious to those practitioners.<sup>12</sup> As pointed out by Dr. Wessel in his declaration, it is ironic that his own Atz & Wessel reference is so heavily relied on by the Examiner to suggest the obviousness of an increased risk of adverse events in the Claimed Patient Population when he himself, the publication's senior author, failed to anticipate or predict this increased risk.<sup>13</sup> Notably, the Examiner does not dispute the historical facts described above and does not cite any evidence tending to contradict the conclusion that, in the real world prior to Appellant's invention, actual practitioners who routinely administered inhaled nitric oxide to actual neonates in need thereof did not consider the Claimed Patient Population to be at increased risk of adverse events.

b. The record includes direct evidence that, prior to Appellant's invention, experts at the U.S. Food and Drug Administration (FDA) and a number of other national Health Authorities outside the United States had multiple separate opportunities to consider the question of whether inhaled nitric oxide should be withheld from the Claimed Patient Population, and each time did not reach that conclusion.<sup>14</sup> Only after Appellant's invention did FDA require an amendment to the label for inhaled nitric oxide warning about the potential for increased adverse events in patients with LVD.<sup>15</sup> Again, the Examiner does not dispute these historical facts, and does not cite or rely on any evidence tending to contradict the conclusion that the regulatory

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<sup>11</sup> Wessel Dec. ¶ 8; *See also* the Declaration of James S. Baldassarre, M.D. under 37 C.F.R. § 1.132, dated July 7, 2011 ("Second Baldassarre Dec."), ¶ 11. The Second Baldassarre Dec. was originally submitted with the July 8, 2011 Reply and is enclosed in the Evidence Appendix (ix) as Exhibit 8.

<sup>12</sup> Second Baldassarre Dec. ¶ 8.

<sup>13</sup> Wessel Dec. ¶ 8.

<sup>14</sup> *See, e.g.*, Second Baldassarre Dec. ¶ 8-11. *See also* <http://www.fda.gov/drugs/resourcesforyou/consumers/ucm143534.htm> ("Most drugs that undergo preclinical (animal) testing never even make it to human testing and review by the FDA. The drugs that do must undergo the agency's rigorous evaluation process, which scrutinizes everything about the drug--from the design of clinical trials to the severity of side effects to the conditions under which the drug is manufactured.")

<sup>15</sup> Declaration of James S. Baldassarre, M.D. under 37 C.F.R. § 1.132, dated Sept. 29, 2010 ("First Baldassarre Dec.") ¶ 16. The First Baldassarre Dec. was originally submitted with the October 1, 2010 Reply and is included in the Evidence Appendix (ix) as Exhibit 9.

agencies actually charged with ensuring the public's safety did not consider the Claimed Patient Population to be at increased risk of adverse events before Appellant's invention.

**2. Direct evidence that the etiology and pathophysiology of the Claimed Patient Population is clinically differentiated from the Prior Art Patient Populations so that it would not have been obvious to expect adverse events in the Claimed Patient Population in view of risks in the Prior Art Patient Populations.**

a. The record includes declaration testimony that the physiological reason that inhaled nitric oxide is dangerous for the first Prior Art Patient Population (i.e., neonates with LVD who are dependent on right-to-left shunting of blood) is that these neonates have a combination of cardiac anomalies that leaves their systemic circulation utterly dependent on a right-to-left flow of blood through a patent (open) ductus arteriosus; inhaled nitric oxide, by diverting blood to the lungs at the expense of the ductus arteriosus, can precipitate collapse of the systemic circulation and death in this particular population.<sup>16</sup> This issue of systemic circulatory collapse is wholly inapplicable to the Claimed Patient Population since, by definition, the latter patients are **not** dependent on right-to-left shunting of blood.<sup>17</sup> Accordingly, the known risk of adverse events in neonates dependent on right-to-left shunting of blood through a patent ductus arteriosus would not cause one to predict similar adverse events in the Claimed Patient Population.<sup>18</sup> The Examiner does not address these scientific facts and does not cite or rely on any evidence tending to contradict the conclusion that adverse events from inhaled nitric oxide in neonates dependent on right-to-left shunting of blood would be considered by those skilled in the art to be irrelevant to the Claimed Patient Population.

b. The record includes declaration testimony that LVD in the second Prior Art Patient Population (i.e., adults with LVD) results primarily from **diastolic** dysfunction caused by a stiff, non-compliant heart that cannot fill properly.<sup>19</sup> This pathology is entirely different than that of neonates with LVD, who suffer primarily from **systolic** dysfunction resulting from a soft, flabby heart that cannot push blood out.<sup>20</sup> The record further includes

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<sup>16</sup> First Greene Dec. ¶¶ 13-14.

<sup>17</sup> *Id.* ¶¶ 13-16.

<sup>18</sup> *Id.* ¶ 20.

<sup>19</sup> *Id.* ¶¶ 15-16.

<sup>20</sup> *Id.*



express declaration testimony that, in light of these pathological differences, “the hemodynamic responses to pulmonary vasodilation by inhaled NO in children or neonates . . . cannot be reasonably predicted from the hemodynamic responses to pulmonary vasodilation by inhaled NO of adults . . . .”<sup>21</sup> Again, the Examiner does not address these scientific facts and does not cite or rely on any evidence tending to contradict the conclusion that adverse events from inhaled nitric oxide in this Prior Art Patient Population would not suggest to those skilled in the art anything relevant with respect to the Claimed Patient Population.

Unlike most cases considered by this Board, the record of this case includes an overwhelming volume of highly pertinent factual evidence establishing that persons skilled in the art did not consider the claimed subject matter to be obvious at the time of Appellant's invention.<sup>22</sup> In fact, the factual evidence contains evidence that leading experts considered this a startling discovery.<sup>23</sup> Further, the record includes declaration evidence explaining in detail the etiological and pathophysiological mechanisms underlying the conditions of the Prior Art Patient Populations and why those conditions fail to suggest an increased risk of adverse events in the Claimed Patient Population.<sup>24</sup> In response, the Examiner cites no countervailing evidence and provides no alternative explanation that even attempts to establish any sort of etiological or pathophysiological link between the Claimed Patient Population and the Prior Art Patient Populations. It is not appropriate for the Examiner to substitute his own personal opinion without any evidence to the contrary. Accordingly, the rejection of the present claims under 35 U.S.C. § 103 for obviousness should be reversed.

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<sup>21</sup> Second Greene Dec. ¶ 22.

<sup>22</sup> See, e.g., Wessel Dec. ¶ 6; First Baldassarre Dec. ¶ 11; First Greene Dec. ¶ 17.

<sup>23</sup> Wessel Dec. ¶ 9 (“it was unanticipated and surprising that children with left ventricular dysfunction who are not dependent on right-to-left shunting would be at increased risk”); First Greene Dec. ¶ 21 (“Surprisingly and unexpectedly, severe adverse events . . . were noted during the early phase of the study, and the study was stopped.”); Second Baldassarre Dec. ¶ 12 (“unexpected serious adverse events (including at least one death) occurred during the course of the . . . study” and “the study protocol was amended”).

<sup>24</sup> Second Greene Dec. ¶ 22.

B. Background

1. *Inhaled Nitric Oxide*

Inhaled nitric oxide is a pulmonary-specific vasodilator that has been administered for more than a decade to a total of over 300,000 critically ill patients at hospitals around the world to alleviate what can be life-threatening pulmonary hypertension in neonates and other patients.<sup>25</sup> Nitric oxide for inhalation was approved by FDA in December 1999, and is marketed under the trademark INOmax®.<sup>26</sup> INOmax® is FDA-approved for term and near-term neonates (defined as >34 weeks gestation) with hypoxic respiratory failure associated with clinical or echocardiographic evidence of pulmonary hypertension, where it improves oxygenation and reduces the need for extracorporeal membrane oxygenation (ECMO).<sup>27</sup>

2. *The INOT22 Study*

Beginning in 2004, INO Therapeutics LLC ("INOT") sponsored a clinical trial formally entitled "Comparison of Supplemental Oxygen and Nitric Oxide for Inhalation Plus Oxygen in the Evaluation of the Reactivity of the Pulmonary Vasculature During Acute Pulmonary Vasodilatory Testing"<sup>28</sup> and known as the INOT22 Study. The purpose of the study was to assess the safety and effectiveness of inhaled nitric oxide as a diagnostic agent in pediatric patients undergoing assessment of pulmonary hypertension (primary objective), and to confirm the hypothesis that inhaled nitric oxide is selective for the pulmonary vasculature (secondary objective).<sup>29</sup>

As described in the First Baldassarre Declaration, "the INOT22 Study was an open, prospective, randomized, multi-center, controlled diagnostic trial, with an expected total enrollment of a minimum of 150 patients, in approximately 18 study sites in the US and Europe over approximately 2 years."<sup>30</sup> "The expected patient population for enrollment into the INOT22 Study were subjects between the ages of 4 weeks and 18 years with idiopathic pulmonary arterial

<sup>25</sup> First Greene Dec. ¶ 8; CritiCally caring about CritiCal Care, <http://www.slideshare.net/changezkn/critically-caring-about-critical-care> (last visited Sep. 20, 2011).

<sup>26</sup> INOmax, <http://inonax.com/about-ikaria> (last visited Sep. 20, 2011).

<sup>27</sup> See the "Indications" section at the top of page 2 of the 2007 INOmax® insert.

<sup>28</sup> First Baldassarre Dec. ¶ 4.

<sup>29</sup> First Greene Dec. ¶ 18.

<sup>30</sup> First Baldassarre Dec. ¶ 5.

hypertension, congenital heart disease with pulmonary hypertension and cardiomyopathies, and who were undergoing diagnostic right heart catheterization scheduled to include pulmonary vasodilation testing to assess pulmonary vasoreactivity.”<sup>31</sup>

The INOT22 Study was designed by the study sponsor, INOT, and a Steering Committee made up of internationally recognized experts in the field of pediatric heart and lung disease.<sup>32</sup>

The Steering Committee consisted of:

- a. **David L. Wessel, MD**, presently Division Chief, Pediatric Critical Care Medicine at Children's National Medical Center, Washington, DC;
- b. **Robyn J. Barst, MD**, presently Professor Emeritus of Pediatrics and Medicine, Columbia University College of Physicians and Surgeons, New York; and
- c. **Duncan J. Macrae, MD**, presently Director, Pediatric Intensive Care, Royal Brompton Hospital, London, U.K.<sup>33</sup>

The original exclusion criteria for the INOT22 Study did **not** exclude patients in the Claimed Patient Population (i.e., patents with pre-existing left ventricular dysfunction who are not dependent on right-to-left shunting of blood).<sup>34</sup> In particular, the original INOT22 Study protocol contained the following inclusion and exclusion criteria:

**Inclusion Criteria**

*The patient must meet the following criteria:*

*1. Have any one of the three disease categories:*

- a. *Idiopathic Pulmonary Arterial Hypertension*
  - i. *PAPm >25mmHg at rest, PCWP ≤ 15mmHg, and PVRI > 3 u.m<sup>2</sup> or diagnosed clinically with no previous catheterization*
  - b. *CHD [Congenital Heart Disease] with pulmonary hypertension repaired and unrepaired,*
    - i. *PAPm >25mmHg at rest, and PVRI > 3 u.m<sup>2</sup> or diagnosed clinically with no previous catheterization*
- c. *Cardiomyopathy*

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<sup>31</sup> *Id.* ¶ 6.

<sup>32</sup> *Id.* ¶ 7.

<sup>33</sup> *Id.* ¶ 8.

<sup>34</sup> *Id.* ¶ 11.

*i. PAPm >25mmHg at rest, and PVRI > 3 u.m<sup>2</sup>  
or diagnosed clinically with no previous catheterization*

*2. Scheduled to undergo right heart catheterization to assess pulmonary vasoreactivity by acute pulmonary vasodilation testing.*

*3. Males or females, ages 4 weeks to 18 years, inclusive.*

*4. Signed IRB/IEC approved informed consent (and assent if applicable).*

**Exclusion Criteria**

*The patient will be excluded from enrollment if any of the following are true:*

*1. Focal pulmonary infiltrates on chest radiograph.*

*2. Diagnosed with severe obstructive or restrictive pulmonary disease that is significantly contributing to the patient's pulmonary hypertension.*

*3. Received treatment with nitric oxide for inhalation within 30 days prior to study initiation, are on other investigational medications, nitroglycerin, sodium nitroprusside, sildenafil, other PDE-5 inhibitors, or prostacyclin.*

*4. Pregnant (urine HCG +).<sup>35</sup>*

The original INOT22 investigational plan and study protocol were reviewed and approved by the Institutional Review Board (IRB) and/or Independent Ethics Committee (IEC) at each of the 18 participating study institutions, including review by the principal investigator within each study institution.<sup>36</sup> The original study protocol was also reviewed by experts at FDA and each National Health Authority (European equivalent to FDA) within the four European countries participating in the INOT22 Study: United Kingdom, France, Netherlands, and Spain.<sup>37</sup> In addition, INOT regularly requested input and scientific guidance on clinical trials, such as the INOT22 Study, from its own Scientific Advisory Board (SAB).<sup>38</sup>

At no time did the study sponsor, any of the experts on the Steering Committee, any of the principal investigators, any of the IRBs, any of the IECs, any of the SAB members,

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<sup>35</sup> *Id.* ¶ 9.

<sup>36</sup> *Id.* ¶ 10.

<sup>37</sup> Second Greene Dec. ¶ 26.

<sup>38</sup> Second Baldassarre Dec. ¶ 8.

any of the FDA experts, or any of the European Health Authority experts (altogether estimated to total at least 115 medical professionals) suggest that the exclusion criteria for the INOT22 Study protocol be amended to exclude the Claimed Patient Population.<sup>39</sup> **In other words, of the estimated 115+ medical professionals tasked with the duty to consider potential safety issues for INOT22 Study patients, none—not a single one—suggested there was a chance that inhaled nitric oxide might increase the likelihood of adverse events in the Claimed Patient Population.**<sup>40</sup>

Upon administration of inhaled nitric oxide to the first 24 subjects enrolled in INOT22, five serious adverse events were recorded – a rate much higher than expected based on prior clinical experience with inhaled nitric oxide. Each of these five serious adverse events (SAEs) was a cardiovascular event, such as pulmonary edema, cardiac arrest or hypotension (low blood pressure).<sup>41</sup>

In February 2005, INOT and the Steering Committee convened to review the unexpected SAEs described above, and upon review and discussion, submitted a protocol amendment to FDA to thereafter exclude subjects from enrollment if they demonstrated an elevated pulmonary capillary wedge pressure (PCWP), defined within the study as subjects having a PCWP greater than 20 mmHg, a symptom of LVD. All study sites were notified immediately.<sup>42</sup>

After conclusion of the study, analysis of the data revealed that modification of the exclusion criteria significantly reduced the rate of serious adverse events (including serious adverse events associated with heart failure). This analysis demonstrated that there were 5 SAEs among the first 24 subjects (i.e., those enrolled prior to amendment of the exclusion criteria), but only 2 SAEs among the next 80 subjects in the study (i.e., enrolled after amendment of the exclusion criteria). Further analysis of the data showed that a total of four subjects had pre-existing LVD, and of these four, 50% experienced SAEs. Of the 120 subjects not found to have

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<sup>39</sup> *Id.*

<sup>40</sup> *Id.* ¶ 11.

<sup>41</sup> First Baldassarre Dec. ¶ 12.

<sup>42</sup> *Id.* ¶ 13.

evidence of LVD, only 4% experienced SAEs. This result was unexpected and came as a great surprise to those working on the study.<sup>43</sup>

In light of this important and unexpected result, on February 25, 2009, INOT submitted a label supplement to the FDA seeking to amend the prescribing information for INOmax® to include a new warning statement for physicians stating that use of inhaled nitric oxide in patients with LVD could cause serious adverse events, such as pulmonary edema.<sup>44</sup> On August 28, 2009, FDA approved an INOmax® label supplement that included the following two new warnings:

*WARNINGS AND PRECAUTIONS*

*Heart Failure: In patients with pre-existing left ventricular dysfunction, inhaled nitric oxide may increase pulmonary capillary wedge pressure leading to pulmonary edema (5.4).*

5 *WARNINGS AND PRECAUTIONS*

5.4 *Heart Failure: Patients who had pre-existing left ventricular dysfunction treated with inhaled nitric oxide, even for short durations, experienced serious adverse events (e.g., pulmonary edema).*<sup>45</sup>

Thereafter, similar warnings regarding this risk were added to the INOmax® label in Japan, Europe, Canada, and Australia.<sup>46</sup>

C. The Law of Obviousness

Obviousness is a question of law based on underlying facts.<sup>47</sup> The facts to be considered in determining obviousness include: (i) the scope and content of the prior art, (ii) the

<sup>43</sup> *Id.* ¶¶ 14-15; *See also* Wessel Dec. ¶ 9.

<sup>44</sup> First Baldassarre Dec. ¶ 15.

<sup>45</sup> *See*, section 5.4 on page 2 and also the Warnings and Precautions section on page 1 of the revised prescribing information for INOmax®, filed with the September 17, 2010 Reply and included in the Evidence Appendix (ix) as Exhibit 10 (the "2009 INOmax® insert").

<sup>46</sup> Second Greene Dec. ¶ 15.

<sup>47</sup> *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 427 (2007) (citing *Graham v. John Deere*, 383 U.S. 1, 17 (1966)).

differences between the prior art and the claims in issue, and (iii) the level of ordinary skill in the pertinent art.<sup>48</sup>

In making an obviousness determination, the examiner must consider the claimed invention as a whole and must view the references without using hindsight afforded by the claimed invention.<sup>49</sup> Any rejection of a claim for obviousness must establish that there would have been a *reason* that would have prompted a person of ordinary skill in the relevant field to carry out the claimed new invention.<sup>50</sup> As the Federal Circuit explained in *W.L. Gore & Assocs., Inc. v. Garlock, Inc.*, “[t]o imbue one of ordinary skill in the art with knowledge of the invention in suit, when no prior art reference or references of record convey or suggest that knowledge, is to fall victim to the insidious effect of a hindsight syndrome wherein that which only the inventor taught is used against its teacher.”<sup>51</sup>

Objective evidence demonstrating how those of ordinary skill in the art viewed the subject matter of the invention is particularly probative on the question of obviousness.<sup>52</sup> As noted in *In re Kotzab*: “A critical step in analyzing the patentability of claims pursuant to section 103(a) is casting the mind back to the time of invention, to consider the thinking of one of ordinary skill in the art, guided only by the prior art references *and the then-accepted wisdom in the field*.”<sup>53</sup> Facts demonstrating that an invention was “contrary to the accepted wisdom [are] ‘strong evidence of unobviousness.’”<sup>54</sup>

“Evidence traversing rejections, when timely presented, must be considered by the examiner whenever present. . . . Where the evidence is insufficient to overcome the rejection, the examiner must specifically explain why the evidence is insufficient. General statements such as ‘the declaration lacks technical validity’ or ‘the evidence is not commensurate with the scope of the claims’ without an explanation supporting such findings are insufficient.”<sup>55</sup>

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<sup>48</sup> *KSR*, 550 U.S. at 406; *Graham*, 383 U.S. at 17.

<sup>49</sup> *Graham*, 383 U.S. at 36.

<sup>50</sup> *KSR*, 550 U.S. at 418.

<sup>51</sup> 721 F.2d 1540, 1553 (Fed. Cir. 1983).

<sup>52</sup> *In re Hedges*, 783 F.2d 1038, 1041 (Fed. Cir. 1986).

<sup>53</sup> 217 F.3d 1365, 1369 (Fed. Cir. 2000) (internal citations omitted; emphasis added).

<sup>54</sup> *Hedges*, 783 F.2d at 1041.

<sup>55</sup> MPEP §716.01(B).

The Examiner is not free to simply disregard facts established in submitted declarations. Rather, “[f]acts established by rebuttal evidence must be evaluated along with the facts on which the conclusion of a *prima facie* case [of obviousness] was reached . . . .”<sup>56</sup> Moreover, “[w]hen *prima facie* obviousness is established and evidence is submitted in rebuttal, the decision-maker must start over. . . . An earlier decision should not [ ] be considered as set in concrete, and applicant’s rebuttal evidence then be evaluated only on its knockdown ability.”<sup>57</sup>

D. Direct and Unrebutted Evidence of Record Establishes that the Claimed Invention was Not Obvious to those Skilled in the Art.

The record includes unrebutted objective evidence demonstrating that, prior to applicants’ invention, medical professionals working in the real world did not exclude the Claimed Patient Population from inhaled nitric oxide therapy.<sup>58</sup> As discussed below, this record evidence includes declaration testimony that, immediately prior to applicants’ invention, over 100 experts worldwide and the regulatory authorities of five countries considered what patient populations to exclude from the INOT22 Study and did not exclude the Claimed Patient Population from that study.<sup>59</sup> **There are only two possible explanations for this fact:**

- (1) The Examiner is wrong, and it would not have been obvious to exclude the Claimed Patient Population from inhaled nitric oxide therapy at the time the INOT22 Study protocol was designed; **or**
- (2) All of these 115+ experts and five regulatory authorities involved in the design of the INOT22 Study protocol committed malpractice and negligently put the lives of children at risk.

It is respectfully submitted that the actions of those skilled in the art are more probative of obviousness than the alleged factual findings and inferences relied on by the Examiner in the Final Office Action. Those actions definitively demonstrate that excluding the Claimed Patient Population from inhaled nitric oxide therapy was not obvious to those skilled in the art at the time of Appellant’s invention.

<sup>56</sup> MPEP §716.01(d).

<sup>57</sup> *In re Pieszecki*, 745 F.2d 1468, 1472 (Fed. Cir. 1984) (quoting *In re Rimehart*, 531 F.2d 1048, 1052 (C.C.P.A. 1976)).

<sup>58</sup> First Baldassarre Dec. ¶¶ 9-11.

<sup>59</sup> Second Baldassarre Dec. ¶ 11.



1. *Dr. David Wessel, senior author of the cited Art & Wessel reference, and over 115 other skilled persons reviewed the INOT22 Study protocol, and none of these experts predicted an increased risk of adverse events in the Claimed Patient Population*

Dr. David Wessel chaired the INOT22 Steering Committee that in 2005 designed the original protocol for the INOT22 Study.<sup>60</sup> This same Dr. Wessel is the senior author of Atz & Wessel, a primary reference cited by the Examiner to support his obviousness rejection.<sup>61</sup>

As senior author of Atz & Wessel, Dr. Wessel was obviously well aware of that reference and its teachings. It is therefore telling that Dr. Wessel did not initially exclude the Claimed Patient Population from the INOT22 Study. As Dr. Wessel explains in his declaration, he did not exclude the Claimed Patient Population from the INOT22 Study because it was unanticipated at the time the protocol was first designed that “a child with left ventricular dysfunction who is not dependent on right-to-left shunting of blood [i.e., the Claimed Patient Population] would be at additional risk when treated with inhaled nitric oxide (iNO).”<sup>62</sup>

Dr. Wessel was not alone in this conclusion. It was seconded by literally more than one hundred other medical professionals belonging to the IRBs and IECs at each of the 18 medical institutions in the United States and Europe that participated in the study. Each of these IRBs and IECs reviewed the original INOT22 Study protocol design prior to study initiation and enrollment. This included review by the principal investigator within each study institution.<sup>63</sup>

As described in the Second Baldassarre Declaration, FDA regulations require an Institutional Review Board (IRB) to comprise a group of professionals appropriately constituted and formally designated to review and monitor biomedical research involving human subjects.<sup>64</sup> In accordance with FDA regulations, an IRB has the authority to approve, require modifications in (to secure approval), or disapprove research. This group review serves an important role and responsibility in the protection of the rights and welfare of human research subjects and in ensuring that appropriate steps are taken to protect human subjects participating in clinical

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<sup>60</sup> Wessel Dec. ¶ 5.

<sup>61</sup> *Id.* ¶ 8.

<sup>62</sup> *Id.* ¶ 6.

<sup>63</sup> Second Baldassarre Dec. ¶¶ 8-11.

<sup>64</sup> *Id.* ¶ 9.

research. An IRB must have at least five members, and each member must have enough expertise to make an informed decision on whether the research is ethical, the informed consent is sufficient, and the appropriate safeguards to protect patient safety have been put in place prior to starting a clinical trial.<sup>65</sup>

In Europe, the analog of an IRB is an Independent Ethics Committee (IEC), an independent body consisting of healthcare professionals and non-medical members whose responsibility is to protect the rights, safety, and well being of human subjects involved in a clinical trial and to provide public assurance of that protection by expressing an opinion on a proposed clinical trial protocol, the suitability of the investigators, and the adequacy of facilities involved in a trial. Like an IRB, an IEC will review a clinical trial protocol with the intent of protecting patient safety prior to clinical enrollment.<sup>66</sup>

In sum, IRBs and IECs are composed of qualified medical professionals tasked with reviewing all clinical trial protocols proposed at their respective institutions and empowered to make or suggest changes to a given protocol that are deemed necessary to best ensure patient safety during the clinical trial. *Naturally, any obvious safety concerns arising from a proposed clinical trial protocol will be identified by an IRB/IEC and the protocol will be amended to avoid obvious and unnecessary clinical risks.*<sup>67</sup> *If a given safety issue is not flagged by the reviewing IRB/IEC, it by definition is not obvious to the members of the IRB/IEC.*

In addition, the original INOT22 Study protocol was also separately reviewed by FDA and each national Health Authority within the four European countries participating in the INOT22 Study (United Kingdom, France, Netherlands and Spain) prior to study initiation and enrollment.<sup>68</sup> INOT also regularly requested input and scientific guidance on clinical trials from its own Scientific Advisory Board.<sup>69</sup> In total, at least 115 individuals experienced in, and responsible for, the review of clinical trial protocols for patient safety reviewed the original INOT22 Study protocol prior to initiating the INOT22 Study.<sup>70</sup> At no time did any of these 115+ members of the Steering Committee, INOT Advisory Board, IRBs, IECs, FDA or European

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<sup>65</sup> *Id.*

<sup>66</sup> *Id.* ¶ 10.

<sup>67</sup> *Id.* ¶¶ 9-10.

<sup>68</sup> *Id.* ¶ 8.

<sup>69</sup> *Id.*

<sup>70</sup> *Id.* ¶ 11

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Health Authorities suggest that the Claimed Patient Population should be excluded from the study.<sup>71</sup>

In response to this large body of direct evidence that numerous experienced medical professionals with a duty to protect the safety interests of clinical trial participants did not find it obvious to exclude the Claimed Patient Population from the INOT22 Study, the Examiner states only:

Respectfully, none of Applicants arguments or Declarations are persuasive. The Examiner has carefully considered the Declarations of Dr. Wessel, Dr. Greene and Dr. Baldassarre as well as all remarks and arguments. However, the position of the Examiner remains immutable and the Examiner does not concede or acquiesce to any of Applicant's arguments, points or positions.<sup>72</sup>

This sort of general statement that none of Appellant's declarations are persuasive is insufficient as a matter of law.<sup>73</sup> Where, as here, Appellant has demonstrated that persons skilled in the art *and working in the real world* in fact did not consider it obvious to withhold inhaled nitric oxide therapy from the Claimed Patient Population, it is the Examiner's burden to provide some credible explanation for this fact that is consistent with his obviousness rejection.<sup>74</sup>

In other words, the Examiner must answer the following question:

**If, as the Examiner contends, it was obvious to withhold inhaled nitric oxide therapy from the Claimed Patent Population, why was the INOT22 Study protocol approved without excluding that population from the study?**

The Final Office Action provides no answer to this question.

2. *The claimed invention was not obvious to FDA or multiple other national Health Authorities.*

**The original INOmax® drug labeling did not include a warning or exclusion for the Claimed Patient Population.** Under the Food, Drug and Cosmetic Act (FDCA), FDA is

<sup>71</sup> See First Baldassarre Dec. ¶ 11; Second Baldassarre Dec. ¶ 11; Wessel Dec. ¶ 6.

<sup>72</sup> Final Office Action at 12.

<sup>73</sup> MPEP 716.01(B).

<sup>74</sup> *Id.*

charged with ensuring not only that drugs are safe and effective,<sup>75</sup> but also that their labels contain adequate directions for use, including appropriate disclosure of known safety issues.<sup>76</sup> A drug Sponsor, typically a pharmaceutical company, will work with FDA to design clinical trials for testing the safety and efficacy of any new, unapproved drug (typically consisting of Phase 1, 2a, 2b and 3 clinical trials). Upon completion of the clinical trial process, the Sponsor will submit a New Drug Application (NDA) to FDA to obtain marketing approval for a drug within the U.S. The NDA will contain extensive and detailed data regarding the safety and efficacy of the drug that the Sponsor obtained during its research and development. These data include the results of clinical trials, pharmacology and toxicology data, chemistry and manufacturing data, and proposed packaging and labeling information. Throughout the process, FDA and the Sponsor communicate through in-person meetings, telephone conferences, letters, e-mails, and faxes.<sup>77</sup>

Toward the end of the review process, FDA and the Sponsor negotiate the drug's final package label.<sup>78</sup> Each element of the label requires FDA approval, including the indications, dosing, directions for use, and safety information. Once all the reviews are complete, the division director and/or the office director evaluate the reviews and make FDA's decision.<sup>79</sup>

Inhaled nitric oxide was approved as a drug by FDA in December 1999, after extensive clinical study and FDA review.<sup>80</sup> Upon approval, and up to the time the present invention was made, the INOmax® label<sup>81</sup> contained language communicating, in pertinent part, the following general warnings and contraindication (emphasis added):

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<sup>75</sup> The FDA was first given responsibility for ensuring the efficacy of prescription drugs under the 1962 Kefauver-Harris amendments to the Food, Drug, and Cosmetic Act, Pub. L. No. 87-781, 76 Stat. 780 (1962) (codified as amended at 21 U.S.C. § 301 et. seq. (1998)).

<sup>76</sup> See FDCA, § 502(f) (codified as amended at 21 U.S.C. § 352(f) (1998)).

<sup>77</sup> 21 C.F.R. § 312.

<sup>78</sup> 21 C.F.R. § 201.

<sup>79</sup> 21 C.F.R. § 314.105.

<sup>80</sup> 2007 INOmax® Insert (describing in detail the three major clinical studies conducted during the INOmax® approval process).

<sup>81</sup> See, e.g., the 2007 INOmax® Insert at page 2, in the "Dosage and Administration," "Precautions" and "Contraindications" sections.

*INOMax® should not be discontinued abruptly, as it may result in an increase in pulmonary artery pressure (PAP) and/or worsening of blood oxygenation (PaO<sub>2</sub>).*

*Deterioration in oxygenation and elevation in PAP may also occur in children with no apparent response to INOMax....*

*Methemoglobinemia increases with the dose of nitric oxide. ... Following discontinuation or reduction of nitric oxide the methemoglobin levels returned to baseline over a period of hours....*

*INOMax should be administered with monitoring for PaO<sub>2</sub>, methemoglobin and NO<sub>2</sub>...*

*INOMax® should not be used in the treatment of neonates known to be dependent on right-to-left shunting of blood.*

Thus, although the 2007 INOMax® insert (and predecessor INOMax® labels) included an express contraindication for one of the prior art patient populations cited by the Examiner (i.e., neonates dependent on right-to-left shunting of blood), it did not include any warning or precaution with respect to the Claimed Patient Population, and in fact was entirely silent about the latter.<sup>82</sup>

The Examiner makes no attempt to reconcile his obviousness rejection with FDA's failure to include in the original INOMax® labeling what the Examiner considers to be obvious safety information. In fact, the Final Office Action does not address this evidence at all.<sup>83</sup>

**Neither FDA nor other National Health authorities reviewing the original protocol for the INOT22 Study suggested that the Claimed Patient Population should be excluded from this study.<sup>84</sup>** Sponsors of clinical investigations are required to provide oversight to ensure adequate protection of the rights, welfare, and safety of human subjects and the quality and integrity of the resulting data submitted to FDA.<sup>85</sup> Accordingly, the original INOT22 protocol was submitted to and approved by FDA prior to starting enrollment in the

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<sup>82</sup> *Id.* After approval by FDA, INOMax® was also approved for use in Europe, Canada, Australia, Mexico and Japan by the National Health Authorities of those countries. Like the U.S. label, the original INOMax® drug labels in those countries did not contain any warning or precaution to refrain from administering inhaled nitric oxide to the Claimed Patient Population.

<sup>83</sup> See generally Final Office Action.

<sup>84</sup> Second Baldassarre Dec. ¶ 8.

<sup>85</sup> See generally Responsibilities of Sponsors and Investigators, 21 C.F.R. § 312, subpart D; See also Responsibilities of Sponsors, 21 C.F.R. § 812, subpart C.

study.<sup>86</sup> It was similarly submitted to and approved by the National Health Authorities of each country containing a clinical trial center participating in the INOT22 Study (United Kingdom, France, Netherlands and Spain).<sup>87</sup> Not a single individual in any of these regulatory organizations suggested that administering inhaled nitric oxide to the Claimed Patient Population might lead to an increased risk of adverse events.<sup>88</sup>

Again, the Examiner makes no attempt to reconcile his rejection with the actions of FDA and other National Health authorities that are entirely inconsistent with his obviousness rejection. In fact, the Final Office Action does not address this evidence at all.

**The FDA and multiple other National Health authorities amended the INOmax® drug labeling as a result of Appellant's invention.**<sup>89</sup> FDA does not take drug warnings lightly, and would not approve changes to a drug label that merely restate existing warnings.<sup>90</sup> As outlined above in section VII.B.2, upon conclusion of the INOT22 Study and completion of the final study report, applicants discovered that the Claimed Patient Population was at increased risk for adverse events. Because this was an important and unexpected finding, INOT submitted a label supplement to the FDA on February 25, 2009, seeking to amend the prescribing information for INOmax® to include a warning statement for physicians.<sup>91</sup> On August 28, 2009, FDA approved the INOmax® label supplement to include the following new information:

*WARNINGS AND PRECAUTIONS*

*Heart Failure: In patients with pre-existing left ventricular dysfunction, inhaled nitric oxide may increase pulmonary capillary wedge pressure leading to pulmonary edema (5.4).*

5 *WARNINGS AND PRECAUTIONS*

5.4 *Heart Failure: Patients who had pre-existing left ventricular dysfunction treated with inhaled nitric oxide, even*

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<sup>86</sup> Second Baldassarre Dec. ¶ 8.

<sup>87</sup> *Id.*

<sup>88</sup> *Id.*

<sup>89</sup> First Greene Dec. ¶ 22.

<sup>90</sup> Second Greene Dec. ¶ 15.

<sup>91</sup> First Baldassarre Dec. ¶ 15.

*for short durations, experienced serious adverse events (e.g., pulmonary edema).*<sup>92</sup>

Thereafter, similar warnings regarding the Claimed Patient Population were added to the INOmax® label in Japan, Europe, Canada and Australia.<sup>93</sup>

The Examiner makes no attempt to reconcile his obviousness rejection with this record evidence that FDA and the Health Authorities modified the INOmax® label in response to Appellant's invention. In fact, the Final Office Action does not address this evidence at all.

E. The Examiner's Rejection is Premised on Improper Fact Findings and Unwarranted Inferences Unsupported by the Prior Art

The Examiner's rejection is based on four prior art references: the 2007 INOmax® Insert, Atz & Wessel, Kinsella et al., and Loh et al.<sup>94</sup> From these references, the Examiner derives four alleged findings of fact. Reduced to their essence, these alleged facts are:

1. The 2007 INOmax® insert would have taught persons skilled in the art that, as a general matter, patients receiving inhaled nitric oxide are more likely to experience adverse events than those who do not.<sup>95</sup>

*- As discussed in more detail in Section VII.F.1. below, this alleged fact is both irrelevant and inaccurate. In a perfect world, all neonates would be born healthy and none would require any sort of medical treatment or be subject to the adverse events that often accompany such treatment. Given that some neonates do require iNO therapy, however, the question becomes whether there exist particular patient populations at increased risk of adverse events (as compared to the general population in need of such therapy) that should be excluded from receiving the treatment. The present invention is directed to one such patient population. Moreover, contrary to the Examiner's analysis, the study results reported in the 2007 INOmax® Insert do not indicate that patients treated with inhaled*

<sup>92</sup> See 2009 INOmax® Insert; *see also* First Baldassarre Dec. ¶ 16.

<sup>93</sup> Second Greene Dec. ¶ 15.

<sup>94</sup> Final Office Action at 3.

<sup>95</sup> Final Office Action at 4-6.

*nitric oxide fared any worse than those treated with placebo.*

2. Atz & Wessel would have taught persons skilled in the art to expect adverse events from administration of INOmax® to patients with LVD.<sup>96</sup>

*- As discussed in more detail in Section VII.F.2. below, this alleged fact is a gross overgeneralization and materially misleading. The pathologies that are associated with a dysfunctional left ventricle vary widely. Atz & Wessel mention only two of these pathologies, neither of which is applicable to patients belonging to the Claimed Patient Population.*

3. Kinsella et al. would have taught persons skilled in the art that INOmax® should not be administered to patients with congenital anomalies or heart disease.<sup>97</sup>

*- As discussed in more detail in Section VII.F.3. below, this alleged fact is simply false. Inhaled nitric oxide therapy has been routinely and successfully administered to patients with congenital heart defects since its approval in 1999 and continues to be administered to such patients today.*

4. Loh et al. would have taught persons skilled in the art that INOmax® should not be administered to patients with an elevated wedge pressure of 18 mm, a symptom of LVD.<sup>98</sup>

*- As discussed in more detail in Section VII.F.4. below, this alleged factual finding (like the Examiner's second finding) is a severe overgeneralization and materially misleading. Loh et al. deal only with one type of LVD, a type that is inapplicable to patients belonging to the Claimed Patient Population.*

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<sup>96</sup> Final Office Action at 6-7.

<sup>97</sup> Final Office Action at 7-8.

<sup>98</sup> Final Office Action at 8-9.



Starting from these overbroad and flawed findings of fact, the Examiner infers that "it is no stretch of the imagination to exclude patients, including a neonatal patient that has pre-existing left ventricular dysfunction but is not known to be dependent on right to left shunting of blood from iNO therapy to reduce the risk of occurrence of one or more adverse events . . . ."99

*- Here again, the Examiner is simply wrong on the science. As discussed in more detail in Section VII.G. below, none of the prior art references relied on by the Examiner relates to the Claimed Patient Population, and those references would not teach or suggest to those skilled in the art that the Claimed Patient Population should be excluded from iNO therapy.*

F. The Examiner's Four "Findings of Fact" are Irrelevant and Inaccurate

1. *The Examiner's Finding of Fact #1 mischaracterizes the 2007 INOmax® Insert and is wholly irrelevant to the patentability of the claimed subject matter*

The Final Office Action begins at pages 4-6 by pointing to disclosure in the 2007 INOmax® Insert reporting results of early clinical trials in which inhaled nitric oxide was tested against placebo. This portion of the Final Office Action focuses on a table containing data regarding the frequency of certain adverse events observed with placebo and with inhaled nitric oxide in the so-called CINRGI clinical trial, followed by some quoted text regarding the NINOS trial.<sup>100</sup> Based on this, the Examiner asserts (emphasis in original):

As can be seen in the Table, there is a higher percentage of Adverse events associated with iNO than the placebo in all categories.... This teaching fairly suggests that iNO increases the risk of adverse events over a broad variety of events above that of the placebo. Accordingly, the ordinary artisan understands that there is an increased risk of adverse events in administering iNO over that of a placebo. *In other words, the administration of iNO increases the risk of adverse events in neonates and consequently the ordinary artisan understands that by not administering iNO the risk of occurrence of adverse events is reduced as shown by the Table above.* From this piece of art, the Examiner can make the following reasonable conclusion:

<sup>99</sup> Final Office Action at 10.

<sup>100</sup> *Id.* at 5.

**Finding of Fact #1: Administration of iNO is not without risk of adverse events. Inhaled NO increases the risk of adverse events in neonates and the corollary that exclusion of the patient from iNO, the placebo above, has a reduced risk of the the [sic] occurrence of adverse events from iNO.<sup>101</sup>**

Appellant respectfully disagrees with both the above characterization of the data disclosed in the 2007 INOmax® Insert and the significance the Examiner has apparently assigned to the data. It is rather puzzling that the Examiner has chosen to lead off with a reference on the basis of its alleged disclosure that giving a placebo instead of the drug will reduce the risk of occurrence of adverse events from the drug. No drug can be said to be “without risk of adverse events.” If the Examiner’s point is that a disclosure such as in the table makes it obvious to refrain from treating all patients with inhaled nitric oxide in order to reduce all risk of adverse events, then no one would ever treat any patient with inhaled nitric oxide, thereby eliminating all the adverse events. (Of course, many patients would then die from lack of treatment, or would be given ECMO treatment instead<sup>102</sup> and would suffer the destructive adverse events routinely caused by that invasive procedure, but that aspect does not seem to have been factored into the Examiner’s “finding of fact.”)

If instead the Examiner is trying to make the point that the disclosure in the 2007 INOmax® Insert regarding adverse events contributes to an understanding that one should avoid giving inhaled nitric oxide to the Claimed Patient Population in particular, Appellant fails to see the connection. The cited table from the CINRGI trial and passage from the NINOS study says nothing about LVD, nor about pulmonary edema, increased wedge pressure, or any other sort of adverse event now known to be associated with administering inhaled nitric oxide to the Claimed Patient Population.<sup>103</sup> Nothing suggests that the patients of the CINRGI trial who suffered the various adverse events listed in the table had an underlying condition related to LVD. Thus, even if the data in the table had been accurately characterized in the Final Office Action, they would not support the obviousness rejection. It is therefore almost superfluous to point out how

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<sup>101</sup> *Id.* at 5-6.

<sup>102</sup> *See* VII.B.1.

<sup>103</sup> Final Office Action at 5.

the data from the CINRGI table and the NINOS study have been mischaracterized and misinterpreted. Appellant will nonetheless do so, to correct the record.

First, Appellant draws the Board's attention to the actual words of the passage about the NINOS study quoted in the Final Office Action on page 5. This passage says that **"treatment groups were similar with respect to the incidence and severity"** of several types of adverse events.<sup>104</sup> In other words, the group treated with inhaled nitric oxide fared the same as did the group treated with placebo, with respect to those types of adverse events. Despite this passage's unambiguous characterization of the data as demonstrating that inhaled nitric oxide was as safe as placebo (i.e., the **"treatment groups were similar"**), the Examiner inexplicably interprets it as supporting the opposite conclusion, saying **"This teaching fairly suggests that iNO increases the risk of adverse events over a broad variety of events above that of the placebo."**<sup>105</sup> Appellant cannot fathom how the Examiner read the passage as suggesting any such thing.

Second, the 2007 INOmax® Insert explicitly says that the table of adverse events in the CINRGI trial (i.e., the table pasted on page 5 of the Final Office Action) was limited to just those adverse events that were more common on INOmax® than on placebo.<sup>106</sup> There is therefore no significance to the fact emphasized in the Final Office Action that "all categories" in the table showed more adverse events with INOmax®—in fact, it is quite possible that there were several other undisclosed categories of adverse events that happened to show up in the trial as more common on placebo than on INOmax®, by random chance. The drafter of the label would have realized there was no point in presenting the latter categories on the label insert. Appellant notes that the differences between INOmax® and placebo as reported in this table are in most cases trivial, and there is no discussion of whether they are statistically or medically significant. Notably, none of the listed adverse events was considered significant enough by the drafters of the 2007 INOmax® Insert and by FDA to warrant a warning or contraindication.

Third, though the Final Office Action acknowledges on page 4 that in the NINOS trial, fewer neonates died when treated with inhaled nitric oxide than when treated with the

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<sup>104</sup> 2007 INOmax® Insert at "Adverse Reactions" (emphasis added).

<sup>105</sup> Final Office Action at 5 (emphasis added).

<sup>106</sup> 2007 INOmax® Insert (See the sentence on page 2 of the 2007 INOmax insert immediately above the table at the bottom of the left column).

control, this fact (and the fact that neonates treated with inhaled nitric oxide were less likely than control neonates to end up having to be put on ECMO to save their lives) is simply ignored in the Final Office Action's subsequent discussion about how one of ordinary skill in the art would have considered it obvious to avoid all use of inhaled nitric oxide in all patients merely to avoid any adverse events.<sup>107</sup>

In sum, it is unclear why the Final Office Action has cited the 2007 INOmax® Insert at all. It would be logical to assume that any truly "obvious" risk to a defined subset of the target population of neonates would have been explicitly disclosed as a warning or contraindication on the 2007 INOmax® insert, just as the well-known risk to neonates dependent on right-to-left shunting of blood was disclosed. **Since the 2007 INOmax® insert was entirely silent about any potential risk to the Claimed Patient Population, this document actually supports Appellant's position that the claimed methods would not have been obvious to one of ordinary skill in the art at the time the invention was made.**

2. *The Examiner's Finding of Fact #2 is a Gross Overgeneralization that improperly lumps together all patients that suffer from LVD into a single patient population*

The Examiner's second fact finding is based on the Atz & Wessel reference.<sup>108</sup> The Final Office Action summarizes the Examiner's views with respect to this reference as follows:

To summarize, the methods disclosed by Atz et al. are interpreted to mean:

identifying a patient eligible for NO treatment;

diagnosing/identifying if the patient has left ventricular dysfunction;

excluding that patient with left ventricular dysfunction from treatment with NO but treating the patient with NO for other conditions discussed by Atz et al. with inhalation of NO thereby reducing the risk of adverse events associated with the medical treatment.

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<sup>107</sup> Final Office Action at 5-6.

<sup>108</sup> *Id.* at 6-7.

**Finding of Fact #2: Adverse outcomes are known to occur to neonates treated with iNO that have pre-existing left ventricular dysfunction and consequently the art cautions against the use of iNO to such patients.**<sup>109</sup>

This “finding of fact” does not accurately represent what Atz & Wessel actually disclose. Contrary to the Examiner’s view, Atz & Wessel do not teach that **all** patients with left ventricular dysfunction (LVD) should be excluded from treatment with inhaled nitric oxide. Rather, as discussed below, Atz & Wessel disclose two separate and distinct patient populations that are subsets of LVD patients (neither of which overlaps with the Claimed Patient Population) who may be harmed in different ways when their pulmonary hypertension is reduced by treatment with inhaled nitric oxide.<sup>110</sup>

**The Adult Population.** The first patient population addressed by Atz & Wessel is adults suffering from LVD (the “Adult Population”). With respect to this population, Atz & Wessel state the following:

In adults with ischemic cardiomyopathy, sudden pulmonary vasodilation may occasionally unload the right ventricle sufficiently to increase pulmonary blood flow and harmfully augment preload in a compromised left ventricle. The attendant increase in left atrial pressure may produce pulmonary edema.<sup>111</sup>

As the Board will recognize, this disclosure is explicitly limited to adult patients and does not address the potential impact of inhaled nitric oxide on neonates. Contrary to the Examiner’s contention, those skilled in the art would not have extrapolated from Atz & Wessel’s disclosure concerning the Adult Population to a general caution concerning all patients with all forms of LVD. Rather, as thoroughly explained in the Second Greene Declaration, persons skilled in the art would have realized that Atz & Wessel’s teachings about the LVD associated with ischemic cardiomyopathy in an adult are not applicable to other forms of LVD, such as the form of LVD that occurs in newborns.<sup>112</sup>

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<sup>109</sup> *Id.* at 7.

<sup>110</sup> Second Greene Dec. ¶¶ 8-9.

<sup>111</sup> Atz & Wessel at 452.

<sup>112</sup> Second Greene Dec. ¶¶ 8, 27.

As Dr. Greene explains in the First Greene Declaration, the hearts of the Adult Population are clinically distinct from the hearts of the Claimed Patient Population due to the fact that the etiology and pathophysiology of the left ventricular dysfunction present in the Claimed Patient Population is markedly different from what is present in the Adult Population. Left ventricular dysfunction comes in two broad types: systolic and diastolic. As detailed in paragraphs 15-16 of the First Greene Declaration, left-sided ventricular dysfunction in the Claimed Patient Population is generally associated with a soft, overly elastic heart that cannot push blood out, resulting in impaired emptying, i.e., *systolic dysfunction*. Conversely, in the Adult Population, left-sided ventricular dysfunction is generally ischemic or hypertensive in origin, and is associated with a stiff, non-compliant left ventricle that cannot fill properly, i.e., *diastolic dysfunction*. In addition, this population is inherently different than the Claimed Patient Population in that the Adult Population does not suffer from congenital heart disease.<sup>113</sup> Given these dramatic anatomical differences between adult LVD and neonate LVD, those skilled in the art do not consider LVD in adults as analogous to, or predictive of risks associated with, LVD in the Claimed Patient Population.<sup>114</sup>

Because of this important clinical and etiological distinction, one would have had no reason to expect an elevated risk of pulmonary edema or cardiac complications (or any other adverse event) when using inhaled nitric oxide in the Claimed Patient Population. For this reason, the Examiner's inference that Atz & Wessel's disclosure concerning the Adult Population would be read as a general warning concerning all patients with LVD is simply incorrect.

**The Shunt Reliant Population.** The second patient population addressed by Atz & Wessel is neonates suffering from LVD that are reliant on right-to-left shunting of blood at the patent ductus arteriosus (the "Shunt Reliant Population").<sup>115</sup> The Shunt Reliant Population is entirely distinct from the Claimed Patient Population, and the physiological reasons why inhaled

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<sup>113</sup> Congenital heart disease is a problem with the heart's structure and function due to abnormal heart development before birth. "Congenital" means present at birth. National Heart Lung and Blood Institute, <http://www.nhlbi.nih.gov/health/health-topics/topics/chd/>.

<sup>114</sup> First Greene Dec. ¶¶ 15-16.

<sup>115</sup> Second Greene Dec. ¶ 9.

nitric oxide is not recommended for use the Shunt Reliant Population are wholly different from the physiological reasons behind the claimed invention.

With respect to the Shunt Reliant Population, Atz & Wessel disclose:

A different but related phenomenon may be operative in the newborn with severe left ventricular dysfunction and pulmonary hypertension. In these patients, the systemic circulation may depend in part on the ability of the right ventricle to sustain cardiac output through a right-to-left shunt across the patent ductus arteriosus. Selective pulmonary vasodilation may redirect the right ventricular output to the lungs and away from the systemic circulation. **Therefore, in newborns with severe left ventricular dysfunction, predominantly left to right shunting at the foramen ovale and exclusively right-to-left shunting at the ductus arteriosus, NO should be used with extreme caution, if at all.** We and others have reported adverse outcomes in this circumstance.<sup>116</sup>

Importantly, Atz & Wessel's "caution" regarding use of inhaled nitric oxide in neonates is explicitly limited to neonates who present with a **combination of three conditions**:

Therefore, in newborns with severe **left ventricular dysfunction, predominantly left to right shunting at the foramen ovale and exclusively right-to-left shunting at the ductus arteriosus**, NO should be used with extreme caution, if at all. We and others have reported adverse outcomes in this circumstance.<sup>117</sup>

As explained by Dr. Wessel and Dr. Greene in their declarations, Atz & Wessel are not saying that treatment with inhaled nitric oxide poses a risk for a neonate who has just one of the three conditions; in fact, inhaled nitric oxide was **routinely** used to treat pulmonary vasoconstriction in neonates presenting with left ventricular dysfunction alone OR an open foramen ovale alone OR an open ductus arteriosus alone (and continues to be used to treat the latter two groups).<sup>118</sup> Rather, this disclosure in Atz & Wessel is directed to one particular circumstance where inhaled nitric oxide therapy should not be used, i.e., **where the patient is dependent on right-to-left shunting**. Note that the Atz & Wessel reference includes no

<sup>116</sup> Atz & Wessel at 452 (emphasis added).

<sup>117</sup> *Id.*

<sup>118</sup> Wessel Dec. ¶ 6-8; First Greene Dec. ¶ 12-13.

discussion whatsoever concerning neonates with LVD who do *not* have right-to-left shunting at the ductus arteriosus, so are *not* dependent on right-to-left shunting of blood (i.e., the Claimed Patient Population).

To understand the significance of the Azt & Wessel disclosure about the Shunt Reliant Population and why it is not at all predictive of risks in the Claimed Patient Population, it is useful to review the physiology of these two distinct groups of neonates and the mechanism of inhaled nitric oxide's action in these patients.

As explained by Dr. Greene,<sup>119</sup> constriction of pulmonary blood vessels to minimize blood flow through the lungs is a normal and beneficial phenomenon in a fetus *in utero*. Since the fetus' blood is oxygenated by the placenta, and not by the fetal lungs, there is no need for blood to circulate through the fetal lungs prior to birth. Thus, both the right and the left sides of the fetal heart are dedicated to pumping blood through the placenta and the systemic vasculature, mostly bypassing the blood vessels of the lungs. However, once the child is born and begins breathing air, there is necessarily a dramatic shift in blood circulation. The newborn's previously-constricted pulmonary vasculature normally will dilate at birth to permit blood to flow freely through his lungs, pumped by the right side of the heart (the right atrium and right ventricle). After passing through the lungs and becoming oxygenated, the blood returns to the heart, where it enters at the left atrium and then is pumped by the left ventricle of the heart to the rest of the body.

For this shift in the circulation to take place properly after birth so that the newborn can immediately rely on his lungs for oxygenation, it is essential that the constricted blood vessels of the lungs dilate. If instead, the pre-birth pulmonary vasoconstriction persists after birth (a condition referred to as Persistent Pulmonary Hypertension of the Newborn, or PPHN), the newborn will be unable to pump blood adequately through the blood vessels of his lungs because of the abnormally high vascular resistance in the lungs. In such a PPHN patient, blood is poorly oxygenated even though the patient is breathing normally, and he appears a characteristic dusky color, i.e., a "blue baby." Treatment with inhaled nitric oxide gas (a vasodilator specific for pulmonary blood vessels) instantly relaxes the constricted pulmonary

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<sup>119</sup> First Greene Dec. ¶¶ 8, 10-14.



blood vessels, allowing blood to flow more freely from the heart through the lungs and markedly improving the infant's overall oxygenation. The "blue baby" is transformed into a pink baby. Inhaled nitric oxide treatment has to a large extent supplanted the prior standard (and highly invasive) treatment for PPHN: extracorporeal membrane oxygenation, or "ECMO." In fact, one of the clinical trial end points described in the 2007 INOmax Insert was the reduction of initiation of ECMO in PPHN patients.<sup>120</sup>

Although treatment with inhaled nitric oxide has proven to be enormously beneficial to PPHN patients and other neonates with pulmonary hypertension, it was recognized early on that a particular subset of neonates with pulmonary hypertension may, because of their peculiar cardiac physiology, suffer fatal complications if they receive this therapy. This subset of neonates is identified in the 2007 INOmax Insert as those who are "dependent on right-to-left shunting of blood."<sup>121</sup> The First Greene Declaration explains that this condition occurs in neonates who have a particular combination of congenital conditions including, in addition to pulmonary hypertension: (a) an open (or "patent") ductus arteriosus (a passageway between the right atrium of the heart and the systemic circulation that is supposed to close at birth, when it is no longer needed); (b) a patent foramen ovale (a hole between the right and left atria that, like the ductus arteriosus, is supposed to close shortly after birth, when it is no longer needed); and (c) a dysfunctional left ventricle that is unable to handle its usual role of pumping blood through the systemic circulation. As noted by Dr. Greene, the pulmonary hypertension and resulting high vascular resistance in the lungs of these infants means that the blood pressure in the right atrium of the heart is kept abnormally high. This forces blood from the right atrium through the still-patent ductus arteriosus and directly into the systemic circulation, a situation known as "right-to-left shunting of blood." This blood entering the systemic circulation from the right atrium is partially oxygenated by virtue of oxygenated blood leaking through the patent foramen ovale from the left to the right atrium and mixing with the deoxygenated blood normally in the right atrium. Because the dysfunctional left ventricle in these patients is not able to supply the systemic circulation with blood, the patients end up relying on this abnormal right-to-left shunting of blood to keep a life-sustaining level of partially oxygenated blood flowing through

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<sup>120</sup> 2007 INOmax Insert, page 1, right column, first paragraph.

<sup>121</sup> *Id.*, page 2, left column, second paragraph ("Contraindications").

their systemic circulation. *If the right-to-left shunt ceases for any reason, and there is no compensating mechanism to supply blood to the systemic circulation, the result would be catastrophic: total systemic circulatory collapse—and death.* In these infants, reducing pulmonary hypertension by treatment with inhaled nitric oxide will redirect blood flow from the right atrium into the lungs and away from the ductus arteriosus, cutting off the right-to-left shunt on which the patient desperately depends for survival. That is why this particular subset of pulmonary hypertension patients (the Shunt-Reliant Population) has long been excluded from treatment with inhaled nitric oxide. *See*, paragraphs 10-14 of the First Greene Declaration.

Thus, Atz & Wessel's teaching that the Shunt-Reliant Population should not be treated with inhaled nitric oxide reflects what was widely understood in the art years before the INOT22 Study.<sup>122</sup> In fact, an express contraindication for the Shunt-Reliant Population has been highlighted in the INOmax® label since the approval of the drug by FDA in December 1999,<sup>123</sup> and, of course, no such patients were admitted to the INOT22 Study.<sup>124</sup> It is absurd for the Examiner to suggest that the discovery resulting from the INOT22 Study that the Claimed Patient Population may experience an increased risk of adverse events (such as pulmonary edema) from treatment with inhaled nitric oxide therapy was somehow foreshadowed by Atz & Wessel's disclosure concerning the Shunt-Reliant Population, in whom inhalation of nitric oxide may trigger catastrophic systemic circulatory collapse due to redirection of blood away from the patent ductus arteriosus on which this group of patients relies for survival.

The differences in etiology and pathophysiology between the prior art and the claimed invention are summarized in the table below:

<b>Adult Population</b>	<b>Shunt Reliant Population</b>	<b>Claimed Patient Population</b>
<ul style="list-style-type: none"><li>• Congestive Heart Failure</li><li>• Diastolic Dysfunction - stiff, non-compliant left ventricle</li></ul>	<ul style="list-style-type: none"><li>• Dependent on right-to-left shunting of blood through a patent ductus arteriosus</li><li>• Heart Failure associated with Congenital Heart Disease</li><li>• Systolic Dysfunction - soft, overly elastic heart</li></ul>	<ul style="list-style-type: none"><li>• No right-to-left shunting of blood</li><li>• Heart Failure associated with Congenital Heart Disease</li><li>• Systolic Dysfunction - soft, overly elastic heart</li></ul>

<sup>122</sup> First Greene Dec. ¶ 14.

<sup>123</sup> Second Greene Dec. ¶ 10. *See also* 2007 INOmax® Insert § 4.

<sup>124</sup> Second Greene Dec. ¶ 11.

As noted by the Federal Circuit: "It is impermissible within the framework of section 103 to pick and choose from any one reference only so much of it as will support a given position to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one skilled in the art."<sup>125</sup> Yet the Examiner has done exactly what the Court warns is impermissible: i.e., the Examiner has "picked and chosen" only the LVD aspect of Atz & Wessel's disclosure, excluding the rest of that reference's disclosure from his summary and "Finding of Fact #2" and thereby entirely distorting what the reference says in a way that supports the rejection, but is plainly inaccurate. If, as the Examiner implies, the authors of Atz & Wessel had been aware that all patients with LVD (including neonates who are not dependent on a right-to-left shunting of blood through a patent ductus arteriosus) were at increased risk for adverse events when treated with inhaled nitric oxide, or even had suspected that would be the case, one would expect they would have mentioned it in their publication. The Examiner offers no rationale as to why Atz & Wessel failed to note this supposedly "obvious" risk to the Claimed Patient Population.

Appellant's reading of the Atz & Wessel reference is supported by Dr. Wessel's Declaration of record. In particular, Dr. Wessel states that he and his co-author (Atz) "did not disclose or predict...that neonatal patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood [i.e., the Claimed Patient Population] would be at greater risk of adverse events."<sup>126</sup> Dr. Wessel also declares that "it was unanticipated and surprising that children with left ventricular dysfunction who are not dependent on right-to-left shunting [i.e., the Claimed Patient Population] would be at increased risk of adverse events when administered iNO."<sup>127</sup>

In particular, Dr. Wessel states:

Neither the Atz et al. article that I co-authored, nor the medical literature or medical experience of which I was aware at the time, predict this risk. Instead, Atz et al. describes two distinct, independent precautions with

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<sup>125</sup> *Bausch & Lomb, Inc. v. Barnes-Hind/Hydrocurve, Inc.*, 796 F.2d 443, 448 (Fed. Cir. 1986) (internal citations omitted).

<sup>126</sup> Wessel Dec. ¶¶ 7-8 (emphasis in original).

<sup>127</sup> *Id.* ¶ 9.

respect to the use of iNO. First, with respect to adults, Atz et al., stated that iNO may be more effective in newborns than in older patients, and noted that it should be used with caution in adults with ischemic cardiomyopathy in whom a risk of pulmonary edema is a consideration (see page 452, left column). Second, with respect to neonates, we stated the well-known contraindication (currently found in the INOMAX® prescribing information) that iNO should not be used in newborns dependent upon right-to-left shunting of blood across a patent ductus arteriosus to avoid circulatory collapse. What we did **not** disclose or predict was that neonatal patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood would be at greater risk of adverse events.

It is ironic that my own publication would be cited to suggest that it would have been obvious to predict the adverse events and outcomes of the INOT22 Study when I, the senior author of Atz et al., failed to anticipate or predict these unexpected outcomes at the time I participated in drafting the original INOT22 Study protocol. If so, I would have been acting either negligently or intentionally to harm babies, and I most certainly was not.<sup>128</sup>

This evidence flatly contradicts the Examiner's unduly broad interpretation of what Atz & Wessel discloses, undermining the factual basis for the entire *prima facie* obviousness rejection. The Examiner does not explain why he does not find Dr. Wessel's evidence convincing on this point. In fact, the Final Office Action does not address the evidence at all.

Thus, contrary to the Final Office Action's summary of Atz & Wessel quoted above, and contrary to the "Finding of Fact #2," Atz & Wessel does **not** teach, even by implication, that any and all patients diagnosed as having LVD, nor even all neonates diagnosed as having LVD, should be excluded from treatment with inhaled NO. In fact, it is clear that the warning in Atz & Wessel regarding excluding certain newborns is based solely upon their dependence on right-to-left shunt in conjunction with LVD (since that warning focuses on the

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<sup>128</sup> *Id.* ¶ 7-8 (emphasis in original).

danger of abrogating the right-to-left shunt by redirecting blood to the lungs and away from the systemic circulation in these newborns), and not because of the LVD itself.

3. *The Examiner's Finding of Fact # 3 is simply wrong and contrary to the INOmax® standard of care in iNO therapy*

The Final Office Action cites Kinsella et al. as allegedly teaching:

[E]xcluding patients (premature neonates) from inhaled nitric oxide treatment if they have fatal congenital anomalies or congenital heart disease....Since left ventricular dysfunction is a congenital heart disease...and it would be pre-existing, then the methods of Kinsella et al. intrinsically exclude this patient population from the method.<sup>129</sup>

From this teaching, the Examiner mistakenly derives the following finding of fact (emphasis in original):

**Finding of Fact #3: Neonates with fatal congenital anomalies or congenital heart disease are excluded from iNO therapy but those neonates who meet the criteria for therapy are provided iNO therapy.**<sup>130</sup>

Once again, this fact finding significantly mischaracterizes the disclosure on which it is based. For example, the clinical trial that is the subject of Kinsella et al. did not study “neonates” in general, as implied by the Finding of Fact, but rather was limited to premature neonates – a patient population clinically distinct from the Claimed Patient Population.<sup>131</sup> Thus, the Examiner incorrectly implies that premature neonates (“preemies”) of Kinsella et al. are the same as the Claimed Patient Population. Furthermore, Kinsella et al. studied only those premature neonates who had severe respiratory failure due to immature lungs and surfactant deficiency, rather than those suffering from pulmonary hypertension.<sup>132</sup> The Kinsella et al. population is therefore distinctly different in a number of important ways from the term and near-term neonates suffering from pulmonary hypertension who are the subject of the presently claimed methods.

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<sup>129</sup> Final Office Action at 7.

<sup>130</sup> *Id.* at 8.

<sup>131</sup> Second Greene Dec. ¶ 17.

<sup>132</sup> *Id.*

Finding of Fact #3 also fails to take into account the highly salient fact that Kinsella et al.'s exclusion from the trial of those preemies that have fatal congenital anomalies or congenital heart disease was due to a reason entirely unrelated to a desire to reduce the risk of treatment-related adverse events, and so irrelevant to the presently claimed methods. As explained in the Second Greene Declaration, the exclusion of patients from a clinical study may occur for a variety of reasons other than safety concerns.<sup>133</sup> The exclusion criteria in the Kinsella et al. study were designed to eliminate variables (here, underlying potentially fatal conditions unrelated to the condition being studied) that would complicate interpretation of the trial results. The Second Greene Declaration explains this point as follows:

For example, clinical trial inclusion and exclusion criteria are often chosen to define or restrict the study population in order to maximize homogeneity, thereby minimizing the presence of potentially confounding factors. This exclusion greatly facilitates the interpretation of the study results, and increases the soundness of the conclusions reached in the study. Accordingly, patients with background disease sufficiently severe to overwhelm or confound an expected treatment effect are systematically identified and excluded quite independently from considerations of anticipated safety or efficacy of the test article in this particular patient group. For example, patients with malignancy are often excluded from non-oncologic clinical trials, not because the test agents are unsafe, pose any specific risk in this population, or will not work, but rather because the clinical results will be confounded by the wholly unrelated effects of the underlying malignancy, thereby reducing the power of the clinical trial to answer a specific hypothesis regarding the test treatment. As a specific example, exclusion of patients with malignancy or advanced heart failure from cholesterol lowering trials does not imply that statins are unsafe or ineffective in these patients, but rather that their inclusion would confound the potential effects of statins on overall mortality or cardiovascular events. In the specific case of Kinsella et al., it is clear that one of ordinary skill in the art would understand that the patients having fatal congenital anomal[ies] or congenital heart disease were excluded not because of a suspected safety risk of treating these patients with inhaled NO (e.g., a risk of pulmonary edema), but rather solely because the inclusion of such patients would have made it much more difficult – if not impossible - for Kinsella et al. to interpret

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<sup>133</sup> *Id.* ¶ 18-20.

the target outcomes of the study (i.e., would have “confounded” the results).<sup>134</sup>

That Dr. Greene’s above-described view of Kinsella et al. is the view that would be shared by those of ordinary skill in the art upon reading that reference is clear from other objective evidence already of record. See, for example, the post-filing publication Fraisse & Wessel, “Acute pulmonary hypertension in infants and children: cGMP-related drugs.”<sup>135</sup> The abstract of this article states:

Inhaled nitric oxide is extremely efficacious in increasing cGMP and selectively reducing mean pulmonary arterial pressure in pediatric cardiac patients. It is considered standard treatment in most centers.

This view of the value of inhaled nitric oxide for treating pediatric patients with congenital heart disease is confirmed in the body of the article, where the authors again state:

[I]nhaled NO is extremely efficacious in selectively reducing mean pulmonary arterial pressure (PAP) in cardiac patients and is considered standard treatment in most centers.<sup>136</sup>

These statements extolling the benefits of inhaled nitric oxide as being “extremely efficacious” and a “standard treatment” in pediatric cardiac patients, most of whom have congenital heart disease, were made by the authors in 2010, *eleven years* after Kinsella et al. was published. If those of skill in the art had read Kinsella et al.’s exclusion criteria to mean that infants with congenital heart disease in general should be excluded from treatment with inhaled nitric oxide for safety reasons, this treatment would certainly not have achieved its present status of a “standard treatment” for pediatric cardiac patients. The quoted statements from Fraisse & Wessel are cogent, objective evidence that the Final Office Action misinterpreted Kinsella et al.’s rationale for excluding congenital heart disease patients from their study and made an inaccurate assessment of how those of ordinary skill in the art would have understood

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<sup>134</sup> *Id.*

<sup>135</sup> *Pediatric Critical Care Med.* 2010, Vol. 11, No. 2 (Suppl.), pages S37-S40; originally made of record on July 8, 2011, and now included in the Evidence Appendix (ix) as Exhibit 11.

<sup>136</sup> *Id.* at S37.

Kinsella et al.'s exclusion criteria. Properly interpreted, Kinsella et al. does not support the present rejection at all.

Moreover, as explained in the Second Greene Declaration, the patients included in the Kinsella et al. trial are differentiated from the term and near-term neonates of the present claims by age, etiology and pathophysiology. In particular, unlike the term and near-term neonates of the present claims, the preemies of Kinsella et al. suffer from severe respiratory failure due to immature lungs and surfactant deficiency, not pulmonary hypertension. Indeed, none of the premature neonates enrolled in Kinsella et al. suffered from pulmonary hypertension. Thus, the patients included in Kinsella et al. are totally unrelated to the term and near-term neonates addressed in the present claims.<sup>137</sup>

Although the above arguments and evidence regarding Kinsella et al. were presented in the July 8, 2011 Reply, the Final Office Action unfortunately does not even address them, much less offer a rebuttal. It is therefore a mystery to Appellant as to why the Examiner did not find them persuasive.

4. *The Examiner's Finding of Fact #4 (Like Finding of Fact #2) is a Gross Overgeneralization*

The Final Office Action cites Loh et al. as allegedly teaching

that inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure ... Loh et al. clearly teaches that patients with pulmonary artery wedge pressure...*of greater than or equal to 18 mm Hg* had a greater effect of inhaled NO due to the greater degree of reactive pulmonary hypertension present in such patients.... Loh et al. state: "*Since the degree of reactive pulmonary hypertension is generally related to the severity of hemodynamic compromise in patients with LV failure, it might be anticipated that patients with more severe heart failure will have a more marked hemodynamic response to inhaled NO.*" Loh et al. examined this prediction further and verified it.

From this piece of art, the Examiner can make the following reasonable conclusion:

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<sup>137</sup> Second Greene Declaration ¶ 17.



**Finding of Fact #4: Patients with a pulmonary capillary wedge pressure of greater than or equal to 18 mm Hg have a more marked hemodynamic response to inhaled NO which results in the finding that inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure.**<sup>138</sup>

Like Fact Finding #2 above, this fact finding is misleading in that it does not specify that Loh et al. was talking solely about adult patients with the adult form of LVD (i.e., diastolic dysfunction: a “stiff” left ventricle that cannot expand normally), a type of LVD that is entirely distinct from the LVD typically found in neonates (i.e., systolic dysfunction: a “flabby” left ventricle that expands readily, but is unable to contract normally). Loh et al.’s patients had class III or class IV (congestive) heart failure secondary to left ventricular dysfunction from ischemic cardiomyopathy or idiopathic dilated cardiomyopathy.<sup>139</sup> As explained by Dr. Greene, one cannot predict from Loh et al.’s observations in adults that there would have been any risk in the Claimed Patient Population, who typically have a very different form of LVD arising from very different causes, and also have pulmonary hypertension arising from very different causes than the pulmonary hypertension seen in adults with the type of LVD studied by Loh et al.<sup>140</sup>

Dr. Greene thoroughly describes the anatomic and etiologic differences between these two classes of patients, and then concludes:

Therefore, the hemodynamic responses to pulmonary vasodilation by inhaled NO in children or neonates, without right-to-left shunting of blood, but with significant pulmonary hypertension and left ventricular dysfunction cannot be reasonably predicted from the hemodynamic responses to pulmonary vasodilation by inhaled NO of adults with advanced atherosclerotic congestive heart failure and reactive neuro-humoral pulmonary vascular constriction (with or without pulmonary hypertension) as described by Loh et al.<sup>141</sup>

Given these specific physiological traits of Loh et al.’s Adult Population with congestive heart failure, those skilled in the art would not consider Loh et al.’s teachings to

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<sup>138</sup> *Id.* at 8, emphasis in original.

<sup>139</sup> Second Greene Dec. ¶ 22.

<sup>140</sup> *Id.*

<sup>141</sup> *Id.*

broadly cover all patients with LVD, and certainly would not consider those teachings to cover the Claimed Patient Population, with its entirely different pathology.

The Final Office Action does not address Appellant's evidence of record regarding these clear and important factual distinctions between the Adult Population and the Claimed Patient Population, much less explain why the Loh et al. reference continues to be cited against the claims despite Appellant's evidence of its irrelevance.

G. The Examiner's Obviousness Rejection is Based on Flawed and Legally Improper Reasoning and Should be Reversed

1. *The prima facie obviousness case is fundamentally flawed*

The Final Office Action summarizes the Examiner's view regarding obviousness as follows:

It would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to perform **the method of INOmax®, Atz et al., Loh et al., and Kinsella et al.**, and perform the method steps of instant claims 28-42 and produce the instant invention.<sup>142</sup>

Appellant does not understand this statement. The Examiner refers to "the method of INOmax®, Atz et al., Loh et al., and Kinsella et al." as though there exists one identifiable method disclosed collectively by the four cited references—which of course is not even close to the truth. Further, there is no way to imagine a single method that represents a compilation of the methods disclosed in the four references, since the references are directed to entirely different patient populations (term or near-term neonates, premature neonates, and adults) with different disease conditions characteristic of the different age groups, some of which involve pulmonary hypertension and some that do not. Accordingly, it is difficult to know what to make of the quoted statement.

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<sup>142</sup> Final Office Action at 9 (emphasis added).

Having erroneously concluded that the four cited references disclose a single coherent method, the Examiner proceeds to explain the supposed motivation to perform that method:

One of ordinary skill in the art would have been motivated to do this because:

- 1) iNO has risk of adverse events as taught by INOmax®;
- 2) if the neonate has left ventricular dysfunction (LVD), then Atz et al. clearly teach using extreme caution or not using NO at all in the treatment of patients with LVD which would also render obvious other forms of LVD not known to be dependent on right to left shunting of blood; and
- 3) the art of Kinsella et al. establishes excluding certain patients (premature neonates) from inhaled nitric oxide treatment if they have fatal congenital anomalies or congenital heart disease.<sup>143</sup>

Appellant addresses in turn each of the three points quoted above.

1) In Appellant's detailed discussion above of the 2007 INOmax® Insert, Appellant showed that this alleged conclusion is both inaccurate and irrelevant. The only adverse events that the reference clearly correlates with use of inhaled nitric oxide are in neonates dependent on right-to-left shunting of blood,<sup>144</sup> a subset of patients that does not overlap with the Claimed Patient Population. Moreover, if the Examiner is implying that a teaching regarding avoiding use of inhaled nitric oxide in one subset of patients makes it obvious to avoid use of inhaled nitric oxide in all patients, including those who could benefit from the treatment, Appellant believes it is sufficient to note the illogic of this position, given the acknowledged efficacy and life-saving ability of inhaled nitric oxide.

2) As apparently recognized by the Examiner, neither of the two patient populations discussed in Atz & Wessel encompasses the Claimed Patient Population, nor does Atz expressly state that one should refrain from administering inhaled nitric oxide to the Claimed Patient Population due to an increased risk of adverse events.<sup>145</sup> Appellant has established above that Atz & Wessel's disclosure is in fact solely directed to two set of patients: (i) the Adult

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<sup>143</sup> Final Office Action at 9-10.

<sup>144</sup> 2007 INOmax® Insert.

<sup>145</sup> Final Office Action at 9.

Population, and (ii) the Shunt-Reliant Population (the latter characterized as having a combination of three conditions: severe left ventricular dysfunction plus predominantly left to right shunting at the foramen ovale plus exclusively right to left shunting at the ductus arteriosus).<sup>146</sup> The Examiner has focused on just one of those three neonatal conditions (left ventricular dysfunction) and has chosen to ignore the fact that Atz & Wessel says that it is the combination of the three, and not just one, that should trigger caution in using inhaled nitric oxide in the Shunt-Reliant population (and further that it is the right-to-left shunt that is key to the risk in this population). The Examiner persists in his position on this point despite the fact that Appellant has provided evidence explaining how those of ordinary skill in the art would have interpreted Atz & Wessel—including a declaration by Dr. Wessel himself—and objective evidence that physicians routinely used inhaled nitric oxide in LVD neonatal patients even after Atz & Wessel's publication date—clearly indicating they did not believe the danger to be “obvious.”

The Examiner here makes the entirely unwarranted assertion that what Atz & Wessel say about LVD in the context of the combination of the three conditions (i.e., in the context of dependence on right-to-left shunting of blood) “would also render obvious other forms of LVD not known to be dependent on right to left shunting of blood”<sup>147</sup> (i.e., the Claimed Patient Population). **No justification is offered for this assertion, though it is really the crux of the obviousness rejection.** The Examiner simply deems it so. Appellant again points out that the contraindication for patients dependent on right-to-left shunting of blood is based on the danger of systemic circulatory collapse that would occur if the right-to-left shunt is bypassed, a danger that is not present in those patients who are not known to be dependent on right-to-left shunting of blood. Thus, one cannot logically extrapolate from what was taught in Atz & Wessel about neonates with the combination of three conditions that includes a right-to-left shunt, that other neonates with LVD who are not dependent on a right-to-left shunt should not get inhaled nitric oxide.

3) Appellant has explained that the group of premature neonates excluded from the Kinsella et al. study were excluded because they suffered from a confounding condition

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<sup>146</sup> Second Greene Dec. ¶¶ 8-9.

<sup>147</sup> Final Office Action at 10.

unrelated to the condition Kinsella et al. sought to study. As a result, including these patients would have confounded the results of the study.<sup>148</sup> There is no evidence that Kinsella et al. sought to exclude these patients due to a perception that the excluded patients were at particular risk of adverse events due to inhaled nitric oxide. Appellant has submitted evidence to show that neonates with congenital heart disease in fact are routinely treated with inhaled nitric oxide to alleviate their pulmonary hypertension—in fact, this is considered a standard treatment for such patients (so long as they are not dependent on a right-to-left shunt), with no concerns expressed in the art that just because they have congenital heart disease, they are at particular risk of adverse events due to the treatment.<sup>149</sup> Thus, one of ordinary skill in the art would not have read Kinsella et al. as implying that patients with congenital heart disease should not be treated with inhaled nitric oxide because of a risk of adverse events. The Examiner has not explained why his reading of Kinsella et al. as being relevant to the present claims is not neutralized by the evidence supplied by Appellant. In fact, the Final Office Action does not even comment on any of the evidence supplied by Appellant, other than to dismiss it all as “not persuasive” and to opine that “Applicant has lost sight of the forest for the trees.”<sup>150</sup> This wholesale dismissal of Appellant’s evidence is improper as a matter of law.<sup>151</sup> It is well established that “[Objective] evidence can often serve as insurance against the insidious attraction of the siren hindsight when confronted with a difficult task of evaluating the prior art.”<sup>152</sup> Such evidence “may be the most pertinent, probative, and revealing evidence available to aid in reaching a conclusion on the obvious/nonobvious issue.”<sup>153</sup>

The Final Office Action continues with the following statement:

Thus **it is simply no stretch of the imagination** to exclude patients such as term or near term neonates with LVD and not known to be dependent on right to left shunting of the blood from inhaled nitric oxide therapy in order to avoid adverse

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<sup>148</sup> Second Greene Dec. ¶ 20.

<sup>149</sup> See, Fraise & Wessel.

<sup>150</sup> Final Office Action at 13.

<sup>151</sup> MPEP 716.01(B) (“All entered...declarations traversing rejections [must be] acknowledged and commented upon by the examiner...[g]eneral statements such as ‘the declaration lacks technical validity’ or ‘the evidence is not commensurate with the scope of the claims’ [or ‘Applicant has lost sight of the forest for the trees’] without an explanation supporting such findings are insufficient.”).

<sup>152</sup> *W.L. Gore & Assocs., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1553 (Fed. Cir. 1983).

<sup>153</sup> *Id* at 1555.

outcomes as taught by Atz et al. which intrinsically include all the adverse events recited by Applicant including pulmonary edema as discussed above. The ordinary artisan would err on the side of caution for the benefit of the patient.<sup>154</sup>

First, Appellant points out that the Examiner's "**no stretch of the imagination**" test is not the proper standard to be applied in an obviousness analysis. The question is not whether it is possible for the Examiner to imagine carrying out the claimed invention, but rather whether those of ordinary skill in the art at the time the invention was made would have considered the invention to be obvious.<sup>155</sup> "Resolution of this issue [of obviousness] entails a difficult process of turning back the clock to a time when the invention was made and asking *what one of ordinary skill in the art might have thought.*"<sup>156</sup> Appellant has provided extensive evidence explaining, in physiological terms, *why* one of ordinary skill in the art would not have expected that there was any particular risk of adverse events when giving inhaled nitric oxide treatment to the Claimed Patient Population.<sup>157</sup> Further, Appellant has provided extensive evidence demonstrating that, in fact, those of ordinary skill in the art—and even those considered highly expert in the art—did not hesitate to treat the Claimed Patient Population with inhaled nitric oxide.<sup>158</sup> This is cogent evidence that those of skill in the art did not, in fact, consider the risk to be "obvious." It is inconceivable that a physician, though recognizing as "obvious" an elevated risk in the Claimed Patient Population, would proceed to treat those patients anyway, in utter disregard of the risk.

Notably, the last sentence of the above-quoted language from the Final Office Action actually suggests that the Examiner agrees with Appellant's position on this point. If it is true that "[t]he ordinary artisan would err on the side of caution for the benefit of the patient,"<sup>159</sup> and if the ordinary artisan understood that the safety risk of inhaled nitric oxide treatment in the Claimed Patient Population outweighed the possible benefit of giving the treatment to those neonates, then one would expect there to be concrete evidence in the art that practitioners did

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<sup>154</sup> Final Office Action at 10 (emphasis added).

<sup>155</sup> See, e.g., 35 USC § 103(a).

<sup>156</sup> *Litton Systems, Inc. v. Honeywell, Inc.*, 87 F.3d 1559, 1566-1567 (Fed. Cir. 1996) (emphasis added).

<sup>157</sup> See, e.g., Second Greene Dec. ¶ 22.

<sup>158</sup> Wessel Dec. ¶ 8; Second Baldassarre Dec. ¶ 11.

<sup>159</sup> Final Office Action at 10.

“err on the side of caution,” avoiding giving inhaled nitric oxide to the Claimed Patient Population. In point of fact, all of the evidence of record is to the contrary. The risk to this subset of neonates was plainly not “obvious” to anyone at the time the invention was made—if it were, it would have been widely publicized and discussed in the literature, with warnings circulated to practicing physicians.

As noted in *In re Kotzab*: “A critical step in analyzing the patentability of claims pursuant to section 103(a) is casting the mind back to the time of invention, to consider the thinking of one of ordinary skill in the art, guided only by the prior art references *and the then-accepted wisdom in the field.*”<sup>160</sup> Given that the “then-accepted wisdom in the field” was that there was no particular risk to the Claimed Patient Population, and the prior art does not say otherwise, it is clear that arriving at the Examiner’s determination of obviousness required the use of impermissible hindsight reconstruction of Appellant’s invention,<sup>161</sup> despite the Examiner’s protest to the contrary.<sup>162</sup>

Appellants submit that the *prima facie* obviousness case is so fundamentally flawed that it must be reversed.

2. *The Final Office Action fails to address Appellant’s evidence and arguments of record, instead continuing to assert inappropriate interpretations of the cited references that are contrary to the evidence*

The Final Office Action states in conclusory fashion that “none of Applicants arguments or Declarations are persuasive,”<sup>163</sup> but provides not the slightest clue as to *why*. The Final Office Action does inform Appellant that “the position of the Examiner remains immutable”<sup>164</sup> (apparently a hint that it would be a waste of time to submit further evidence or

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<sup>160</sup> 217 F.3d 1365, 1369 (Fed. Cir. 2000) (internal citations omitted; emphasis added).

<sup>161</sup> Final Office Action at 12.

<sup>162</sup> *KSR*, 550 U.S. at 421 (“warning against a ‘temptation to read into the prior art the teachings of the invention in issue’ and instructing courts to guard against slipping into use of hindsight.” (quoting *Graham*, 383 U.S. at 36)); *Sensonics, Inc. v. Aerosonic Corp.*, 81 F.3d 1566, 1570 (Fed. Cir. 1996) (“To draw on hindsight knowledge of the patented invention, when the prior art does not contain or suggest knowledge, is to use the invention as a template for its own reconstruction—an illogical and inappropriate process by which to determine patentability” (internal citations omitted)).

<sup>163</sup> Final Office Action at 12.

<sup>164</sup> *Id.* Given the common dictionary definition of “immutable” as “fixed; not changeable,” this is a rather alarming admission by the Examiner. Appellant submits that it is the responsibility of all US Patent and Trademark Office Examiners to consider all evidence in an unbiased manner and to be open to a change of position.

arguments) and notes, **“Based on the preponderance of the evidence, the Examiner can only conclude based upon the facts and not impermissible hindsight reconstruction that the instant claims are not inventive.”**<sup>165</sup> Appellant’s evidence puts the presently claimed methods and the prior art into the context of real world facts showing how real physicians of skill in the art truly viewed the claimed subject matter prior to the invention date. This real-world evidence should compel a conclusion of nonobviousness.<sup>166</sup> Despite the Federal Circuit’s requirement that such evidence be given “great weight,”<sup>167</sup> the Examiner’s above assessment of the “preponderance of the evidence”<sup>168</sup> is made without a single word anywhere in the Final Office Action addressing the substance of Appellant’s evidence. Appellant submits that the evidence of nonobviousness in fact far outweighs the nonexistent evidence of obviousness in this case, and easily overcomes the weak *prima facie* rejection set out in the Final Office Action.

3. *The Examiner’s Rejection is Contrary to Common Sense*

As part of the “Response to Arguments” section, the Final Office Action constructs an obviousness analysis suggesting that the Examiner believes obviousness is based on what can be imagined, rather than on a real-world assessment of what sensible people of ordinary skill would have actually done.<sup>169</sup> This line of analysis begins with the assertion, “Certainly, Applicant and the panel of experts must be aware of the adverse events associated with iNO therapy as provided by INOmax® insert. Inhaled NO is not without inherent risk of adverse events.”<sup>170</sup> The Final Office Action then again relies on the Examiner’s novel “no stretch of the imagination” standard to posit that it is obvious to refrain from administering inhaled nitric oxide therapy to **any** neonate, regardless of the neonate’s condition (even “foot fungus” or “polydactyly”), because by not administering the therapy to anyone, one would necessarily reduce the risk of occurrence of all adverse events. According to the Examiner:

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<sup>165</sup> *Id.* (emphasis added).

<sup>166</sup> *Panduit Corp. v. Dennison Mfg. Co.*, 774 F.2d 1082, 1099 (Fed. Cir. 1985) (“The human, real world story in evidence...not only reflects the inadequacy of the prior art, but compels a conclusion of nonobviousness of the claimed inventions in suit.”).

<sup>167</sup> *Rosemount, Inc. v. Beckman Instruments, Inc.*, 727 F.2d 1540, 1546 (Fed. Cir. 1984) (“The objective evidence, again composed of real world facts, is worthy of great weight...”).

<sup>168</sup> Final Office Action at 12.

<sup>169</sup> *Id.* at 12-14.

<sup>170</sup> *Id.* at 12.



Consequently, the art as a whole paints a picture that patients, including neonates, are at risk of adverse events from iNO therapy even if the iNO therapy is beneficial in other aspects and it remains obvious to exclude patients, including neonates, from iNO therapy to reduce the risk of occurrence of such adverse events.<sup>171</sup>

That reasoning, which appears to be the fundamental basis for concluding that the present invention is obvious, is rather astonishing in that it suggests that real doctors treating real patients would consider it obvious to withhold all therapy from all patients, merely because the therapy was at some point reported to be associated with an adverse event—regardless of how beneficial the therapy is expected to be, regardless of how inconsequential the adverse event, and regardless of whether the adverse event was ever shown to be caused by the therapy or merely random chance. Since all drugs are associated with adverse events of some sort, this surprising view would effectively rule out all treatment of any patient with any drug, period. That the Examiner's purportedly "unwavering" position plainly does not reflect how real physicians behave hardly needs to be stated. One need only look to the fact that neonates in need of treatment for pulmonary hypertension were and are routinely treated with inhaled nitric oxide (despite the table reporting various adverse events with inhaled nitric oxide and with placebo in the 2007 INOmax® Insert on which the Examiner relies) to realize that physicians did not consider it "obvious" to exclude all patients from treatment with inhaled nitric oxide in order to avoid any chance that any of these adverse events might occur. A conclusion of obviousness should, at the very least, take into account the presumably rational behavior of those of ordinary skill in the art. The Examiner's "no stretch of the imagination" theory of obviousness plainly fails that test.

Appellant submits that whether or not it is "obvious" to exclude a given patient from a needed treatment depends on whether the risk of harm from an adverse event in that patient is believed to outweigh the potential benefit to the patient. One subset of neonates (the Shunt-Reliant Population) was well known in the art to be at high risk of serious adverse effects, and was explicitly identified as contraindicated in the prior art 2007 INOmax® Insert. It was certainly obvious to exclude that subset of neonates from treatment with inhaled nitric oxide, as

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<sup>171</sup> *Id.* at 14.

taught by the 2007 INOmax® Insert and by Atz & Wessel. The art disclosed no other subsets of neonates in whom inhaled nitric oxide treatment posed an increased risk of adverse events. Contrary to the assertions in the Final Office Action about what would have been “in the realm of common sense,”<sup>172</sup> it would not have been “common sense” for a physician to exclude any term or near-term neonate patient from a potentially life-saving treatment with inhaled nitric oxide without a legitimate medical justification for doing so.

Appellant was the first to discover that there is a second subset of neonates, separate and distinct from the Shunt-Reliant Population, who are also at increased risk of serious harm from inhaled nitric oxide treatment, although an entirely different type of harm than observed in the Shunt-Reliant Population. In the Shunt-Reliant Population, the potential harm is systemic circulatory collapse due to loss of the right-to-left shunt on which these patients rely to support their systemic circulation. In the Claimed Patient Population, the potential harm has nothing to do with systemic circulatory collapse, but rather stems primarily from pulmonary edema.

Until Appellant's discovery was publicized, there was no reason whatsoever to deprive the Claimed Patient Population of potentially lifesaving treatment with inhaled nitric oxide. Further, all of the evidence of record indicates that those of ordinary skill in the art did not consider it “obvious” to refrain from treating neonates of the Claimed Patient Population with inhaled nitric oxide, since if they had considered this obvious, they would have done it. As noted by the Examiner, physicians are by nature conservative about putting their patients at risk. Any “obvious” or “predictable” risk of serious harm in an identified subset of patients would be avoided, not ignored—to do otherwise would be tantamount to medical malpractice. If those in the art had indeed understood from the cited references (all published prior to 1999) that the Claimed Patient Population should not be treated with inhaled nitric oxide, such an understanding would of course have been explicitly memorialized in clinical trial protocols and prescribing information long before the present invention, and clearly before the INOT22 Study. Appellant has provided objective evidence proving that none —*not a single one*— of the at least 115 individuals from several institutions tasked with designing or reviewing and approving the

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<sup>172</sup> *Id.* at 11.

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original INOT22 Study protocol suggested there might be a particular risk to the Claimed Patient Population. The logical conclusion is that practitioners did not consider such an exclusion to be medically justified—i.e., not an “obvious” thing to do.

### **VIII. Conclusion**

Appellant has established that the obviousness rejection is founded on fundamental misinterpretations of each of the four cited references, on an improper legal analysis that is contrary to the statute and the case law, and on a failure to give due consideration to any of Appellant's highly pertinent objective evidence, including concrete evidence that at least 115 medical professionals of ordinary or even extraordinary skill in the art acted in a manner entirely inconsistent with what the Examiner (using his “no stretch of the imagination” standard) imagines to be “obvious.” The Examiner's obviousness rejection should be reversed.

The attached Claims Appendix (viii) shows the claims under appeal.

The attached Evidence Appendix (ix) includes Exhibits 1-11.

A Related Proceedings Appendix (x) is attached as required, but is empty.

The appeal brief fee of \$620 required by 37 C.F.R. § 41.20(b)(2) is being paid via the Electronic Filing System. Please apply any other necessary charges, or any credits, to Deposit Account No. 06-1050, referencing Attorney Docket No. 26047-0003002.

Respectfully submitted,

Date: October 4, 2011

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**(viii) Claims Appendix**

1.-27. (Canceled)

28. (New) A method of reducing the risk of occurrence, in a term or near-term neonate patient, of one or more adverse events or serious adverse events associated with a medical treatment comprising inhalation of nitric oxide gas, said method comprising:

- (a) identifying a term or near-term neonate patient in need of inhaled nitric oxide treatment, wherein the patient is not known to be dependent on right-to-left shunting of blood;
- (b) determining that the patient identified in (a) has pre-existing left ventricular dysfunction; and
- (c) excluding the patient from inhaled nitric oxide treatment based on the determination that the patient has pre-existing left ventricular dysfunction.

29. (New) The method of claim 28, wherein the patient has pulmonary hypertension.

30. (New) The method of claim 28, wherein the patient has a pulmonary capillary wedge pressure that is greater than or equal to 20 mm Hg.

31. (New) The method of claim 28, wherein the patient is a term neonate.

32. (New) A method of reducing the risk of occurrence, in a term or near-term neonate patient, of one or more adverse events or serious adverse events associated with a medical treatment comprising inhalation of nitric oxide gas, said method comprising:

- (a) identifying a term or near-term neonate patient in need of inhaled nitric oxide treatment, wherein the patient is not known to be dependent on right-to-left shunting of blood;
- (b) determining by diagnostic screening that the patient identified in (a) has pre-existing left ventricular dysfunction; and
- (c) excluding the patient from treatment with inhaled nitric oxide based on the determination that the patient has pre-existing left ventricular dysfunction.

33. (New) The method of claim 32, wherein the diagnostic screening comprises echocardiography.

34. (New) The method of claim 32, wherein the patient has pulmonary hypertension.
35. (New) The method of claim 32, wherein the patient has a pulmonary capillary wedge pressure that is greater than or equal to 20 mm Hg.
36. (New) The method of claim 32, wherein the patient is a term neonate.
37. (New) A method of reducing the risk of occurrence, in a plurality of term or near-term neonate patients, of one or more adverse events or serious adverse events associated with medical treatment comprising inhalation of nitric oxide gas, said method comprising:
- (a) identifying a plurality of term or near-term neonate patients who are in need of inhaled nitric oxide treatment, wherein the patients are not known to be dependent on right-to-left shunting of blood;
  - (b) determining that a first patient of the plurality has pre-existing left ventricular dysfunction and a second patient of the plurality does not;
  - (c) administering the inhaled nitric oxide treatment to the second patient; and
  - (d) excluding the first patient from treatment with inhaled nitric oxide, based on the determination that the first patient has pre-existing left ventricular dysfunction.
38. (New) The method of claim 37, wherein the first and second patients have pulmonary hypertension.
39. (New) The method of claim 37, wherein the second patient has congenital heart disease.
40. (New) The method of claim 37, wherein the first patient has a pulmonary capillary wedge pressure that is greater than or equal to 20 mm Hg.
41. (New) The method of claim 37, wherein the first and second patients are term neonates.

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42. (New) The method of claim 37, wherein determining that the first patient of the plurality has pre-existing left ventricular dysfunction and the second patient of the plurality does not have pre-existing left ventricular dysfunction comprises diagnostic screening.

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**(ix) Evidence Appendix**

Exhibit 1: 2007 prescribing information for INOmax® (“2007 INOmax® Insert”), submitted with the September 17, 2010 Reply filed by Appellant.

Exhibit 2: Atz & Wessel, *Seminars in Perinatology* 1997, 21(5), 441-455.

Exhibit 3: Kinsella et al., *The Lancet* 1999, 354, 1061-1065.

Exhibit 4: Loh et al., *Circulation* 1994, 90, 2780-2785.

Exhibit 5: Declaration of Douglas A. Greene, M.D. under 37 C.F.R. § 1.132, dated April 29, 2011 (“First Greene Dec.”), originally submitted with the May 2, 2011 Reply filed by Appellant.

Exhibit 6: Declaration of David L. Wessel, M.D. under 37 CFR § 1.132 (“Wessel Dec.”), made of record on July 27, 2011.

Exhibit 7: Declaration of Douglas A. Greene, M.D. under 37 C.F.R. § 1.132, dated July 7, 2011 (“Second Greene Dec.”), originally submitted with the July 8, 2011 Reply filed by Appellant.

Exhibit 8: Declaration of James S. Baldassarre, M.D. under 37 C.F.R. § 1.132, dated July 7, 2011 (“Second Baldassarre Dec.”), originally submitted with the July 8, 2011 Reply filed by Appellant.

Exhibit 9: Declaration of James S. Baldassarre, M.D. under 37 C.F.R. § 1.132, dated Sept. 29, 2010 (“First Baldassarre Dec.”), originally submitted with the October 1, 2010 Reply filed by Appellant.

Exhibit 10: 2009 prescribing information for INOmax® (“2009 INOmax® Insert”), submitted with the January 14, 2011 Reply filed by Appellant.

Exhibit 11: Fraise & Wessel, *Pediatric Critical Care Medicine* 2010, Vol. 11, No. 2 (Suppl.), pages S37-S40, originally made of record on July 8, 2011.

# EXHIBIT 1



# INOMax® (nitric oxide) for inhalation 100 and 800 ppm (parts per million)

## DESCRIPTION

INOMax (nitric oxide gas) is a drug administered by inhalation. Nitric oxide, the active substance in INOMax, is a pulmonary vasodilator. INOMax is a gaseous blend of nitric oxide and nitrogen (0.08% and 99.92%, respectively for 800 ppm; 0.01% and 99.99%, respectively for 100 ppm). INOMax is supplied in aluminum cylinders as a compressed gas under high pressure (2000 pounds per square inch gauge [psig]).

The structural formula of nitric oxide (NO) is shown below:



## CLINICAL PHARMACOLOGY

Nitric oxide is a compound produced by many cells of the body. It relaxes vascular smooth muscle by binding to the heme moiety of cytosolic guanylate cyclase, activating guanylate cyclase and increasing intracellular levels of cyclic guanosine 3',5'-monophosphate, which then leads to vasodilation. When inhaled, nitric oxide produces pulmonary vasodilation.

INOMax appears to increase the partial pressure of arterial oxygen (PaO<sub>2</sub>) by dilating pulmonary vessels in better ventilated areas of the lung, redistributing pulmonary blood flow away from lung regions with low ventilation/perfusion (V/Q) ratios toward regions with normal ratios.

### Effects on Pulmonary Vascular Tone in PPHN

Persistent pulmonary hypertension of the newborn (PPHN) occurs as a primary developmental defect or as a condition secondary to other diseases such as meconium aspiration syndrome (MAS), pneumonia, sepsis, hyaline membrane disease, congenital diaphragmatic hernia (CDH), and pulmonary hypoplasia. In these states, pulmonary vascular resistance (PVR) is high, which results in hypoxemia secondary to right-to-left shunting of blood through the patent ductus arteriosus and foramen ovale. In neonates with PPHN, INOMax improves oxygenation (as indicated by significant increases in PaO<sub>2</sub>).

## PHARMACOKINETICS

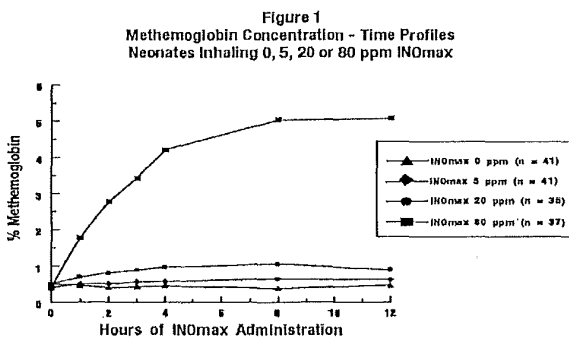
The pharmacokinetics of nitric oxide has been studied in adults.

### Uptake and Distribution

Nitric oxide is absorbed systemically after inhalation. Most of it traverses the pulmonary capillary bed where it combines with hemoglobin that is 60% to 100% oxygen-saturated. At this level of oxygen saturation, nitric oxide combines predominantly with oxyhemoglobin to produce methemoglobin and nitrate. At low oxygen saturation, nitric oxide can combine with deoxyhemoglobin to transiently form nitrosylhemoglobin, which is converted to nitrogen oxides and methemoglobin upon exposure to oxygen. Within the pulmonary system, nitric oxide can combine with oxygen and water to produce nitrogen dioxide and nitrite, respectively, which interact with oxyhemoglobin to produce methemoglobin and nitrate. Thus, the end products of nitric oxide that enter the systemic circulation are predominantly methemoglobin and nitrate.

### Metabolism

Methemoglobin disposition has been investigated as a function of time and nitric oxide exposure concentration in neonates with respiratory failure. The methemoglobin (MetHb) concentration-time profiles during the first 12 hours of exposure to 0, 5, 20, and 80 ppm INOMax are shown in Figure 1.



Methemoglobin concentrations increased during the first 8 hours of nitric oxide exposure. The mean methemoglobin level remained below 1% in the placebo group and in the 5 ppm and 20 ppm INOMax groups, but reached approximately 5% in the 80 ppm INOMax group. Methemoglobin levels >7% were attained only in patients receiving 80 ppm, where they comprised 35% of the group. The average time to reach peak methemoglobin was 10 ± 9 (SD) hours (median, 8 hours) in these 13 patients; but one patient did not exceed 7% until 40 hours.

### Elimination

Nitrate has been identified as the predominant nitric oxide metabolite excreted in the urine, accounting for >70% of the nitric oxide dose inhaled. Nitrate is cleared from the plasma by the kidney at rates approaching the rate of glomerular filtration.

## CLINICAL TRIALS

The efficacy of INOMax has been investigated in term and near-term newborns with hypoxic respiratory failure resulting from a variety of etiologies. Inhalation of INOMax reduces the oxygenation index (OI= mean airway pressure in cm H<sub>2</sub>O x fraction of inspired oxygen concentration [FIO<sub>2</sub>] x 100 divided by systemic arterial concentration in mm Hg [PaO<sub>2</sub>]) and increases PaO<sub>2</sub> (See CLINICAL PHARMACOLOGY).

## NINOS study

The Neonatal Inhaled Nitric Oxide Study (NINOS) group conducted a double-blind, randomized, placebo-controlled, multicenter trial in 235 neonates with hypoxic respiratory failure. The objective of the study was to determine whether inhaled nitric oxide would reduce the occurrence of death and/or initiation of extracorporeal membrane oxygenation (ECMO) in a prospectively defined cohort of term or near-term neonates with hypoxic respiratory failure unresponsive to conventional therapy. Hypoxic respiratory failure was caused by meconium aspiration syndrome (MAS; 49%), pneumonia/sepsis (21%), idiopathic primary pulmonary hypertension of the newborn (PPHN; 17%), or respiratory distress syndrome (RDS; 11%). Infants ≤14 days of age (mean, 1.7 days) with a mean PaO<sub>2</sub> of 46 mm Hg and a mean oxygenation index (OI) of 43 cm H<sub>2</sub>O / mm Hg were initially randomized to receive 100% O<sub>2</sub> with (n=114) or without (n=121) 20 ppm nitric oxide for up to 14 days. Response to study drug was defined as a change from baseline in PaO<sub>2</sub> 30 minutes after starting treatment (full response = >20 mm Hg, partial = 10–20 mm Hg, no response = <10 mm Hg). Neonates with a less than full response were evaluated for a response to 80 ppm nitric oxide or control gas. The primary results from the NINOS study are presented in Table 1.

Table 1  
Summary of Clinical Results from NINOS Study

	Control (n=121)	NO (n=114)	P value
Death or ECMO*,†	77 (64%)	52 (46%)	0.006
Death	20 (17%)	16 (14%)	0.60
ECMO	66 (55%)	44 (39%)	0.014

\* Extracorporeal membrane oxygenation

† Death or need for ECMO was the study's primary end point

Although the incidence of death by 120 days of age was similar in both groups (NO, 14%; control, 17%), significantly fewer infants in the nitric oxide group required ECMO compared with controls (39% vs. 55%, p = 0.014). The combined incidence of death and/or initiation of ECMO showed a significant advantage for the nitric oxide treated group (46% vs. 64%, p = 0.006). The nitric oxide group also had significantly greater increases in PaO<sub>2</sub> and greater decreases in the OI and the alveolar-arterial oxygen gradient than the control group (p<0.001 for all parameters). Significantly more patients had at least a partial response to the initial administration of study drug in the nitric oxide group (66%) than the control group (26%, p<0.001). Of the 125 infants who did not respond to 20 ppm nitric oxide or control, similar percentages of NO-treated (18%) and control (20%) patients had at least a partial response to 80 ppm nitric oxide for inhalation or control drug, suggesting a lack of additional benefit for the higher dose of nitric oxide. No infant had study drug discontinued for toxicity. Inhaled nitric oxide had no detectable effect on mortality. The adverse events collected in the NINOS trial occurred at similar incidence rates in both treatment groups (See ADVERSE REACTIONS). Follow-up exams were performed at 18–24 months for the infants enrolled in this trial. In the infants with available follow-up, the two treatment groups were similar with respect to their mental, motor, audiological, or neurologic evaluations.

## CINRGI study

This study was a double-blind, randomized, placebo-controlled, multicenter trial of 186 term and near-term neonates with pulmonary hypertension and hypoxic respiratory failure. The primary objective of the study was to determine whether INOMax would reduce the receipt of ECMO in these patients. Hypoxic respiratory failure was caused by MAS (35%), idiopathic PPHN (30%), pneumonia/sepsis (24%), or RDS (8%). Patients with a mean PaO<sub>2</sub> of 54 mm Hg and a mean OI of 44 cm H<sub>2</sub>O / mm Hg were randomly assigned to receive either 20 ppm INOMax (n=97) or nitrogen gas (placebo; n=89) in addition to their ventilatory support. Patients who exhibited a PaO<sub>2</sub> >60 mm Hg and a pH < 7.55 were weaned to 5 ppm INOMax or placebo. The primary results from the CINRGI study are presented in Table 2.

Table 2  
Summary of Clinical Results from CINRGI Study

	Placebo	INOMax	P value
ECMO*,†	51/89 (57%)	30/97 (31%)	<0.001
Death	5/89 (6%)	3/97 (3%)	0.48

\* Extracorporeal membrane oxygenation

† ECMO was the primary end point of this study

Significantly fewer neonates in the INOMax group required ECMO compared to the control group (31% vs. 57%, p<0.001). While the number of deaths were similar in both groups (INOMax, 3%; placebo, 6%), the combined incidence of death and/or receipt of ECMO was decreased in the INOMax group (33% vs. 58%, p<0.001).

In addition, the INOMax group had significantly improved oxygenation as measured by PaO<sub>2</sub>, OI, and alveolar-arterial gradient (p<0.001 for all parameters). Of the 97 patients treated with INOMax, 2 (2%) were withdrawn from study drug due to methemoglobin levels >4%. The frequency and number of adverse events reported were similar in the two study groups (See ADVERSE REACTIONS).

## ARDS study

In a randomized, double-blind, parallel, multicenter study, 385 patients with adult respiratory distress syndrome (ARDS) associated with pneumonia (46%), surgery (33%), multiple trauma (26%), aspiration (23%), pulmonary contusion (18%), and other causes, with PaO<sub>2</sub>/FIO<sub>2</sub> <250 mm Hg despite optimal oxygenation and ventilation, received placebo (n=193) or INOMax (n=192), 5 ppm, for 4 hours to 28 days or until weaned because of improvements in oxygenation. Despite acute improvements in oxygenation, there was no effect of INOMax on the primary endpoint of days alive and off ventilator support. These results were consistent with outcome data from a smaller dose ranging study of nitric oxide (1.25 to 80 ppm). INOMax is not indicated for use in ARDS.

## INDICATIONS

INOMax, in conjunction with ventilatory support and other appropriate agents, is indicated for the treatment of term and near-term (>34 weeks) neonates with hypoxic respiratory failure associated with clinical or echocardiographic evidence of pulmonary hypertension, where it improves oxygenation and reduces the need for extracorporeal membrane oxygenation.

## CONTRAINDICATIONS

INOMax should not be used in the treatment of neonates known to be dependent on right-to-left shunting of blood.

## PRECAUTIONS

### Rebound

Abrupt discontinuation of INOMax may lead to worsening oxygenation and increasing pulmonary artery pressure.

### Methemoglobinemia

Methemoglobinemia increases with the dose of nitric oxide. In the clinical trials, maximum methemoglobin levels usually were reached approximately 8 hours after initiation of inhalation, although methemoglobin levels have peaked as late as 40 hours following initiation of INOMax therapy. In one study, 13 of 37 (35%) of neonates treated with INOMax 80 ppm had methemoglobin levels exceeding 7%. Following discontinuation or reduction of nitric oxide the methemoglobin levels returned to baseline over a period of hours.

### Elevated NO<sub>2</sub> Levels

In one study, NO<sub>2</sub> levels were <0.5 ppm when neonates were treated with placebo, 5 ppm, and 20 ppm nitric oxide over the first 48 hours. The 80 ppm group had a mean peak NO<sub>2</sub> level of 2.6 ppm.

### Drug Interactions

No formal drug-interaction studies have been performed, and a clinically significant interaction with other medications used in the treatment of hypoxic respiratory failure cannot be excluded based on the available data. INOMax has been administered with tolazoline, dopamine, dobutamine, steroids, surfactant, and high-frequency ventilation. Although there are no study data to evaluate the possibility, nitric oxide donor compounds, including sodium nitroprusside and nitroglycerin, may have an additive effect with INOMax on the risk of developing methemoglobinemia. An association between prilocaline and an increased risk of methemoglobinemia, particularly in infants, has specifically been described in a literature case report. This risk is present whether the drugs are administered as oral, parenteral, or topical formulations.

### Carcinogenesis, Mutagenesis, Impairment of Fertility

No evidence of a carcinogenic effect was apparent, at inhalation exposures up to the recommended dose (20 ppm), in rats for 20 hr/day for up to two years. Higher exposures have not been investigated.

Nitric oxide has demonstrated genotoxicity in Salmonella (Ames Test), human lymphocytes, and after *in vivo* exposure in rats. There are no animal or human studies to evaluate nitric oxide for effects on fertility.

### Pregnancy: Category C

Animal reproduction studies have not been conducted with INOMax. It is not known if INOMax can cause fetal harm when administered to a pregnant woman or can affect reproductive capacity. INOMax is not intended for adults.

### Nursing Mothers

Nitric oxide is not indicated for use in the adult population, including nursing mothers. It is not known whether nitric oxide is excreted in human milk.

### Pediatric Use

Nitric oxide for inhalation has been studied in a neonatal population (up to 14 days of age). No information about its effectiveness in other age populations is available.

## ADVERSE REACTIONS

Controlled studies have included 325 patients on INOMax doses of 5 to 80 ppm and 251 patients on placebo. Total mortality in the pooled trials was 11% on placebo and 9% on INOMax, a result adequate to exclude INOMax mortality being more than 40% worse than placebo.

In both the NINOS and CINRGI studies, the duration of hospitalization was similar in INOMax and placebo-treated groups.

From all controlled studies, at least 6 months of follow-up is available for 278 patients who received INOMax and 212 patients who received placebo. Among these patients, there was no evidence of an adverse effect of treatment on the need for rehospitalization, special medical services, pulmonary disease, or neurological sequelae.

In the NINOS study, treatment groups were similar with respect to the incidence and severity of intracranial hemorrhage, Grade IV hemorrhage, periventricular leukomalacia, cerebral infarction, seizures requiring anticonvulsant therapy, pulmonary hemorrhage, or gastrointestinal hemorrhage.

The table below shows adverse events with an incidence of at least 5% on INOMax in the CINRGI study, and that were more common on INOMax than on placebo.

ADVERSE EVENTS IN THE CINRGI TRIAL

Adverse Event	Placebo (n=89)	Inhaled NO (n=97)
Hypotension	9 (10%)	13 (13%)
Withdrawal	9 (10%)	12 (12%)
Atelectasis	8 (9%)	9 (9%)
Hematuria	5 (6%)	8 (8%)
Hyperglycemia	6 (7%)	8 (8%)
Sepsis	2 (2%)	7 (7%)
Infection	3 (3%)	6 (6%)
Stridor	3 (3%)	5 (5%)
Cellulitis	0 (0%)	5 (5%)

## OVERDOSAGE

Overdosage with INOMax will be manifest by elevations in methemoglobin and NO<sub>2</sub>. Elevated NO<sub>2</sub> may cause acute lung injury. Elevations in methemoglobin reduce the oxygen delivery capacity of the circulation. In clinical studies, NO<sub>2</sub> levels >3 ppm or methemoglobin levels >7% were treated by reducing the dose of, or discontinuing, INOMax.

Methemoglobinemia that does not resolve after reduction or discontinuation of therapy can be treated with intravenous vitamin C, intravenous methylene blue, or blood transfusion, based upon the clinical situation.

## POST-MARKETING EXPERIENCE

The following adverse events have been reported as part of the post-marketing surveillance. These events have not been reported above. Given the nature of spontaneously reported post-marketing surveillance data, it is impossible to determine the actual incidence of the events or definitively establish their causal relationship to the drug. The listing is alphabetical; dose errors associated with the delivery system; headaches associated with environmental exposure of INOMax in hospital staff; hypotension associated with acute withdrawal of the drug; hypoxemia associated with acute withdrawal of the drug; pulmonary edema in patients with CREST syndrome.

## DOSAGE AND ADMINISTRATION

### Dosage

The recommended dose of INOMax is 20 ppm. Treatment should be maintained up to 14 days or until the underlying oxygen desaturation has resolved and the neonate is ready to be weaned from INOMax therapy.

An initial dose of 20 ppm was used in the NINOS and CINRGI trials. In CINRGI, patients whose oxygenation improved with 20 ppm were dose-reduced to 5 ppm as tolerated at the end of 4 hours of treatment. In the NINOS trial, patients whose oxygenation failed to improve on 20 ppm could be increased to 80 ppm, but those patients did not then improve on the higher dose. As the risk of methemoglobinemia and elevated NO<sub>2</sub> levels increases significantly when INOMax is administered at doses >20 ppm, doses above this level ordinarily should not be used.

### Administration

Additional therapies should be used to maximize oxygen delivery. In patients with collapsed alveoli, additional therapies might include surfactant and high-frequency oscillatory ventilation.

The safety and effectiveness of inhaled nitric oxide have been established in a population receiving other therapies for hypoxic respiratory failure, including vasodilators, intravenous fluids, bicarbonate therapy, and mechanical ventilation. Different dose regimens for nitric oxide were used in the clinical studies (see CLINICAL TRIALS).

INOMax should be administered with monitoring for PaO<sub>2</sub>, methemoglobin, and NO<sub>2</sub>.

The nitric oxide delivery systems used in the clinical trials provided operator-determined concentrations of nitric oxide in the breathing gas, and the concentration was constant throughout the respiratory cycle. INOMax must be delivered through a system with these characteristics and which does not cause generation of excessive inhaled nitrogen dioxide. The INOvent<sup>®</sup> system and other systems meeting these criteria were used in the clinical trials. In the ventilated neonate, precise monitoring of inspired nitric oxide and NO<sub>2</sub> should be instituted, using a properly calibrated analysis device with alarms. The system should be calibrated using a precisely defined calibration mixture of nitric oxide and nitrogen dioxide, such as INOcal<sup>®</sup>. Sample gas for analysis should be drawn before the Y-piece, proximal to the patient. Oxygen levels should also be measured.

In the event of a system failure or a wall-outlet power failure, a backup battery power supply and reserve nitric oxide delivery system should be available.

The INOMax dose should not be discontinued abruptly as it may result in an increase in pulmonary artery pressure (PAP) and/or worsening of blood oxygenation (PaO<sub>2</sub>). Deterioration in oxygenation and elevation in PAP may also occur in children with no apparent response to INOMax. Discontinue/wean cautiously.

## HOW SUPPLIED

INOMax (nitric oxide) is available in the following sizes:

Size D Portable aluminum cylinders containing 353 liters at STP of nitric oxide gas in 800 ppm concentration in nitrogen (delivered volume 344 liters) (NDC 64693-002-01)

Size D Portable aluminum cylinders containing 353 liters at STP of nitric oxide gas in 100 ppm concentration in nitrogen (delivered volume 344 liters) (NDC 64693-001-01)

Size 88 Aluminum cylinders containing 1963 liters at STP of nitric oxide gas in 800 ppm concentration in nitrogen (delivered volume 1918 liters) (NDC 64693-002-02)

Size 88 Aluminum cylinders containing 1963 liters at STP of nitric oxide gas in 100 ppm concentration in nitrogen (delivered volume 1918 liters) (NDC 64693-001-02)

Store at 25°C (77°F) with excursions permitted between 15–30°C (59–86°F) [see USP Controlled Room Temperature].

## Occupational Exposure

The exposure limit set by the Occupational Safety and Health Administration (OSHA) for nitric oxide is 25 ppm, and for NO<sub>2</sub> the limit is 5 ppm.

## CAUTION

Federal law prohibits dispensing without a prescription.

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SPC-0303 V:3.0

# EXHIBIT 2

## Inhaled Nitric Oxide in the Neonate With Cardiac Disease

*Andrew M. Atz and David L. Wessel*

As a selective pulmonary vasodilator, inhaled nitric oxide is an important diagnostic and therapeutic agent for the treatment of pulmonary hypertension in patients with congenital heart disease. Among 400 patients treated in our center with nitric oxide, 37% were newborns. Hemodynamic benefit was shown in newborns with total anomalous pulmonary venous connection, in those with congenital mitral stenosis, and in postoperative patients with preexisting left to right shunts and other lesions. It can be used to help discriminate anatomic obstruction to pulmonary blood flow from pulmonary vasoconstriction, and it may be used in the treatment or prevention of pulmonary hypertensive crises after cardiopulmonary bypass. However, none of the purported benefits of inhaled nitric oxide in children with congenital heart disease have been studied in a randomized, placebo-controlled manner. Copyright © 1997 by W.B. Saunders Company

### Pulmonary Hypertension and Congenital Heart Disease

#### Prevalence

Among causes of infant mortality in the United States, congenital anomalies account for the largest diagnostic category, and structural heart disease leads the list of congenital malformations.<sup>1</sup> Approximately one third of pediatric intensive care admissions are for children with cardiovascular disorders.<sup>2</sup> Compared with the number of adults with coronary and rheumatic heart disease, the number of Americans with congenital heart disease is relatively small, but one quarter of this number are sufficiently affected by the disease to require intervention within the first month of life.<sup>3</sup> The number of neonates with pulmonary hypertensive disorders further complicating their congenital heart disease is difficult to precisely quantify, but likely represents about 25% of those who require early intervention.<sup>4</sup> Their severity of illness, demand on resources, and the previously limited success of therapeutic options have focused attention on this population of patients.

#### Importance

Pulmonary hypertension is often a crucial factor in determining the timing or type of intervention, and has been invoked as the primary determinant of mortality in many lesions.<sup>5,6</sup> The assessment of pulmonary vascular reactivity forms an important part of the preoperative and postoperative management of patients with congeni-

tal heart disease. A fixed elevation in pulmonary vascular resistance may deny them the chance of corrective surgery with the subsequent development of progressive obliterative pulmonary vascular disease and severely reduced life-expectancy. Children with congenital heart disease are frequently cyanotic and have multiple intracardiac shunts, often coexisting with varying degrees of right or left ventricular outflow tract obstruction. Intravenous vasodilators with their attendant risks of hypotension and increased intrapulmonary shunt may be not only hazardous, but yield results that confound analysis of the reactivity of the pulmonary vascular bed.

### The Neonate With Congenital Heart Disease

#### Effects of Cardiopulmonary Bypass

Only a few years ago, it was considered heretical that a child with congenital heart disease should be electively repaired with a single primary pro-

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cedure during the first few days of life using cardiopulmonary bypass. Criticism of this approach focused not only on the technical capabilities of the surgeon, but on the adverse effects of cardiopulmonary bypass on the neonatal myocardium. Furthermore, concerns existed that severe pulmonary hypertension, activated by cardiopulmonary bypass, would compromise postoperative hemodynamic stability. Today, surgical correction of congenital heart disease, in contrast to palliation with shunts or pulmonary artery bands, has been extended to the neonate; surgical correction is emerging as the preferred approach to many defects in most major centers.<sup>7,8</sup> However, perioperative care of the newborn and infant does require an appreciation of the relative intolerance of the immature myocardium to increased afterload. The right ventricle must face the potential challenges of the transitional pulmonary circulation rendered ischemic and reactive by cardiopulmonary bypass, while simultaneously coping with impaired ventricular function caused by the adverse effects of bypass. Aside from the consequences of cardiopulmonary bypass, aortic cross-clamp time, routine use of deep hypothermia and cardioplegia solutions, many congenital heart defects (eg, tetralogy of Fallot, truncus arteriosus, pulmonary atresia) require a right ventriculotomy as part of the repair. Thus, it is imperative that one minimize right ventricular afterload during the early postoperative hours while the ischemic-reperfusion injury transiently depletes myocardial reserve and cardiac output normally declines.<sup>9</sup>

#### **Causes of Pulmonary Hypertension**

The neonatal pulmonary vasculature may be extremely labile. Remodeling of the vessel wall, functional maturation of the endothelial cell, differentiation of the smooth muscle cell, release of vasoactive mediators, and vessel recruitment all contribute to the successful transition from fetal to neonatal pulmonary circulation. The child with congenital heart disease and pulmonary hypertension has abnormal postnatal vessel remodeling.<sup>10</sup> Prolonged exposure to high pulmonary blood flow under conditions of high pressure will accelerate the pathological progression to less reversible states. Thus early surgical repair has been advocated to prevent later pulmonary vascular obstructive disease.<sup>11,12</sup> Neonatal cardiac surgical repair achieves earlier and

more normal pulmonary vascular maturation. It seems to reduce but not abolish the incidence of problematic postoperative pulmonary hypertension.<sup>12</sup>

Several factors attributable to cardiopulmonary bypass may raise pulmonary vascular resistance: microemboli, platelet aggregation, complement activation, pulmonary leukosequestration, excess thromboxane and endothelin production, atelectasis, and hypoxic pulmonary vasoconstriction among others. Furthermore, prior data would suggest that preoperative conditioning of the pulmonary vascular bed, perioperative vasospastic stimuli, increased postoperative adrenergic tone, along with damage to the pulmonary endothelium likely combine to increase pulmonary vascular resistance after cardiopulmonary bypass. The effect may be insidious, expressed over several hours as low cardiac output and right heart failure, or more acutely as pulmonary hypertensive crises. Pulmonary hypertensive crises are dramatic events that threaten the life of an infant despite a good surgical repair.<sup>13,14</sup> In such situations, the pulmonary artery pressure increases to systemic or suprasystemic levels, the systemic blood pressure falls and the arterial oxygen saturation decreases. In a report of a series from one large center, half of the postoperative cardiac children who had pulmonary hypertensive crises died during their hospitalization.<sup>4</sup>

#### **Inhaled NO: Measuring the Response**

The first investigations of pulmonary vasodilation with NO in adults were quickly followed by several clinical reports of inhaled NO aimed at the transitional circulation of the newborn and children with congenital heart disease. Successful clinical trials of inhaled NO have been conducted among patients with persistent pulmonary hypertension of the newborn (PPHN).<sup>15,16</sup> However, direct measurement of pulmonary artery pressure is rarely undertaken in patients with PPHN or in other forms of neonatal respiratory failure. Effects of NO treatment on pulmonary hypertension may be inferred from changes in systemic oxygenation only when hypoxia results from right to left shunting across the ductus arteriosus or foramen ovale. Even then, oxygenation is an indirect and ambiguous measure of the effect of treatment on pulmonary vascular resistance. The analysis is further confounded when severe pulmonary parenchymal disease

coexists with pulmonary hypertension. In this setting, systemic oxygenation may improve with inhaled vasodilators by enhancing ventilation-perfusion matching.<sup>17</sup> Pulmonary artery pressure is often monitored directly in the neonate and infant with congenital heart disease. This population affords us a unique opportunity to directly record the hemodynamic effects of initiation and withdrawal of inhaled NO.

### Clinical Studies

We will review the current literature regarding the use of inhaled NO in congenital heart disease, focusing on neonates. We first present studies that used nitric oxide as a means to identify endothelial dysfunction resulting from cardiopulmonary bypass and then suggest how NO may benefit cardiac patients with combined problems of pulmonary hypertension and acute respiratory failure. We will review its therapeutic utility in perioperative patients with pulmonary hypertension, and its use as a diagnostic tool to distinguish between neonates with reactive pulmonary vasoconstriction and those with right ventricular hypertension resulting from anatomic obstruction to pulmonary blood flow. We will also explore its use and limitations in patients with single ventricle physiology and discuss potential adverse effects as pertains to cardiac disease. Finally, we will consider the potential benefits of longer-term administration of NO to facilitate growth and remodeling of the abnormal pulmonary vasculature in unusual forms of idiopathic pulmonary hypertension identified in early infancy.

#### Age Distribution

By 1997, we had studied the clinical response to inhaled NO in more than 400 patients at a single center. Nearly two-thirds of these patients exhibited pulmonary hypertension associated with congenital heart disease. Thirty-seven percent were younger than 1 month of age and the majority were less than 1 year (Fig 1), reflecting the bias toward early surgical repair of congenital heart defects at Children's Hospital, Boston<sup>7</sup> and the perceived benefit of NO for PPHN.

#### Endothelial Dysfunction After Cardiopulmonary Bypass

Pulmonary vascular endothelial dysfunction contributes to post-cardiopulmonary bypass pulmo-

nary hypertension. The degree of pulmonary hypertension correlates with the extent of damage to the pulmonary endothelium after cardiopulmonary bypass. Reactivity of the pulmonary vascular bed is related to the presence and degree of preoperative pulmonary hypertension, magnitude of preoperative left to right shunts, and duration of bypass. On cardiopulmonary bypass, pulmonary blood flow is supplied only by the vasovasorum via the bronchial circulation, which may be inadequate to prevent ischemic damage to the endothelium and subsequently compromise endogenous production of nitric oxide. We hypothesized that transient pulmonary vascular endothelial cell dysfunction could be shown in neonates and older children by documenting the loss of endothelium dependent vasodilation during the immediate postoperative period.

We recorded hemodynamic variables after a 2-minute infusion of the endothelium dependent vasodilator, acetylcholine, at a concentration of  $10^{-6}$ M and after inhalation of the endothelium-independent smooth muscle relaxant, NO inhaled at 80 parts per million (ppm).<sup>18</sup> The two agents were compared in patients with pulmonary hypertensive congenital heart disease before and after surgical repair on cardiopulmonary bypass. Plasma levels of cyclic GMP were measured before and after acetylcholine and NO administration. Pulmonary vasodilation to acetylcholine was present preoperatively but attenuated postoperatively, while response to inhaled nitric oxide was present both preoperatively and postoperatively. Baseline mean pulmonary artery pressure decreased  $27\% \pm 4\%$  preoperatively but only  $9\% \pm 2\%$  postoperatively with acetylcholine. However, after the attenuated response to acetylcholine was shown, postoperative inhalation of NO immediately lowered mean pulmonary artery pressure by  $26\% \pm 3\%$  (Fig 2). Similarly, baseline pulmonary vascular resistance decreased  $46\% \pm 5\%$  in preoperative patients, but declined only  $11\% \pm 4\%$  in postoperative patients with acetylcholine. Inhalation of NO after acetylcholine infusion lowered pulmonary vascular resistance postoperatively by  $33\% \pm 4\%$ . This suggested that the functional integrity of the smooth muscle was intact in the presence of endothelial dysfunction resulting from cardiopulmonary bypass. Elevated pulmonary vascular resistance from atelectasis, microemboli, platelet plugging of vessels or other fixed obstructive

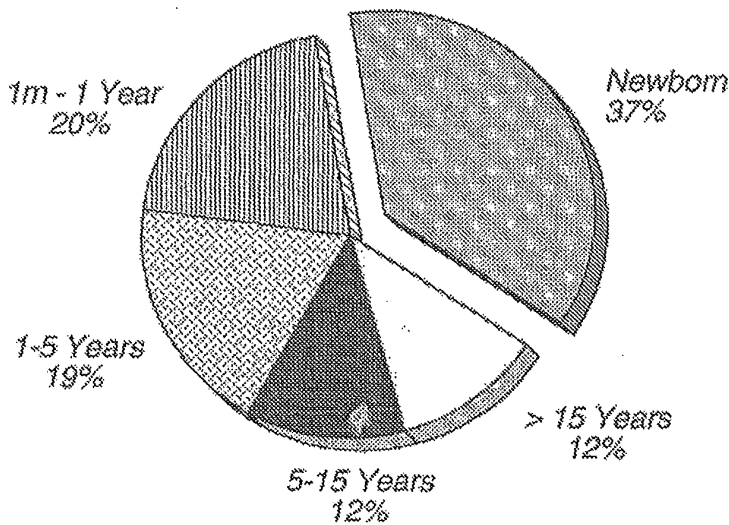
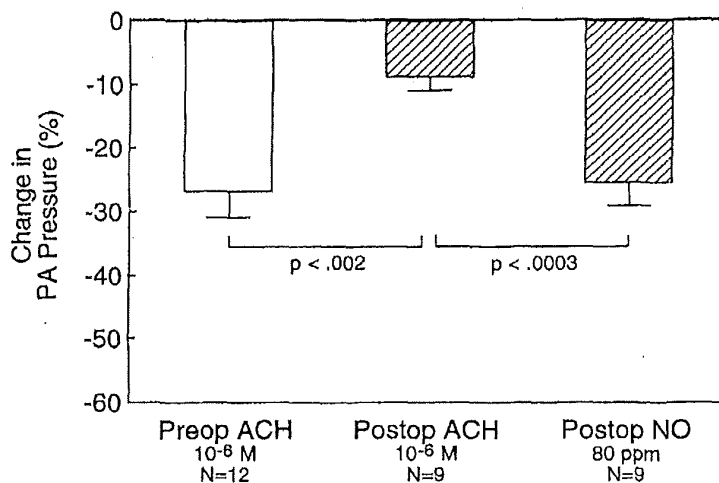


Figure 1. Age analysis of 405 consecutive patients who received inhaled NO at Children's Hospital, Boston.

processes could not be invoked as the cause of the blunted response to acetylcholine because resistance decreased so dramatically with NO. Plasma levels of cGMP in postoperative patients were unchanged after acetylcholine, but increased more than threefold during pulmonary vasodilation with NO. This finding was consistent with the purported role of cGMP as the second messenger effecting smooth muscle relaxation.

This study suggested that cardiopulmonary bypass is responsible for pulmonary endothelial dysfunction. This focused attention on the endothelium as an important organ to address in the management of pulmonary hypertension. It also highlighted the potential importance of maintaining at least some antegrade flow from right ventricle into pulmonary arteries during extracorporeal membrane oxygenation (ECMO).

Figure 2. The percentage change in mean pulmonary artery pressure (PA) with acetylcholine (ACH) in preoperative and postoperative patients. The vasodilator response is attenuated with ACH but retained with NO in the postoperative period. (Reprinted with permission from Wessel DL, et al: Use of inhaled nitric oxide and acetylcholine in the evaluation of pulmonary hypertension and endothelial function after cardiopulmonary bypass. *Circulation* 88:2128-2138, 1993.<sup>10</sup> Copyright 1993 American Heart Association.)



The heart should be permitted to eject some flow into the pulmonary arteries rather than allowing ECMO to provide total cardiopulmonary bypass for several hours or days. These early findings further suggested an important diagnostic and therapeutic role that inhaled nitric oxide might play as a result of its selective pulmonary vasodilation with minimal systemic side effects in children with congenital heart disease.

#### **Acute Respiratory Failure After Cardiopulmonary Bypass**

Pulmonary parenchymal disease may coexist with heart disease in the newborn. It complicates evaluation and treatment of the child. In some instances, structural abnormalities in the heart produce pulmonary venous hypertension, flood the alveoli with pulmonary edema fluid, and induce severe intrapulmonary and extrapulmonary right to left shunting of blood.

Examples of this phenomenon include the child born with transposition of the great arteries and intact ventricular and atrial septa. In this example, inadequate mixing of blood occurs simultaneously with extreme elevation in left atrial pressure. Pulmonary venous oxygen desaturation may critically lower the systemic oxygen levels further in this cyanotic heart disease. Immediate performance of a balloon atrial septostomy is essential, but may not instantly correct the pulmonary parenchymal abnormalities and alveolar hypoxia.<sup>19</sup> Treatment with inhaled NO may address ventilation-perfusion abnormalities in this circumstance as well as lower the still reactive pulmonary artery pressure. Reports have suggested that use of NO may obviate the need for ECMO in some such circumstances by accelerating improvements in gas exchange as well as hemodynamic recovery.<sup>20,21</sup>

Transient acute respiratory failure may occur in other instances after cardiopulmonary bypass, notably after lung transplantation in children. Here the ischemic injury to the endothelium is exaggerated after hours of cold ischemic preservation of the donor lung. The lung parenchyma is injured such that transient graft dysfunction characterized by lung consolidation, decreased lung compliance, hypoxia, and pulmonary hypertension may plague the patient postoperatively. Again in this clinical scenario, the injured lung vasculature is unresponsive to the endothelium-dependent vasodilators but highly respon-

sive to inhaled nitric oxide.<sup>22</sup> Pulmonary artery pressure decreased precipitously with treatment, but more importantly, PaO<sub>2</sub> increased dramatically (Fig 3).

In the presence of increased pulmonary vascular tone, patients with large intrapulmonary shunts respond to inhaled vasodilators with a reduction in intrapulmonary shunt fraction and improved systemic oxygenation. This contrasts with traditional intravenous vasodilators, which are prone to override hypoxic pulmonary vasoconstriction and worsen ventilation/perfusion abnormalities. Evidence now exists that NO can be administered to the donor lung to enhance preservation during storage and transport to the recipient.<sup>23,24</sup> Although neonatal lung transplantation is a rare procedure, other forms of respiratory failure in newborns after cardiopulmonary bypass are more commonly encountered. Overwhelming pneumonia is a devastating complication that may be exacerbated by cardiopulmonary bypass. Mild infectious pneumonitis or bronchiolitis in the young preoperative infant can turn to life-threatening respiratory failure during postoperative recovery. As an inhaled vasodilator, NO therapy addresses both aspects of the disease: pulmonary hypertension and hypoxia. Inhaled NO, by virtue of its antioxidant effects, inhibition of unwanted platelet aggregation and suppression of deleterious inflammatory responses during reperfusion injury, may even have a role in routine prophylactic use for all patients at risk of postbypass respiratory complications.

#### **NO or ECMO After Cardiopulmonary Bypass**

ECMO support for severe cardiopulmonary failure after cardiac surgery in newborns and children has been advocated in many centers.<sup>25,26</sup> Because postoperative pulmonary hypertension after reparative cardiac operations is believed to be life-threatening, yet reversible, NO treatment in this condition may diminish the need for ECMO. Certainly, Journois et al have shown the value of NO in the treatment of acute pulmonary hypertensive crises.<sup>27</sup> Goldman et al described 6 of 10 patients who met institutional ECMO criteria, but were managed with NO instead and survived to hospital discharge.<sup>21</sup> This compares favorably with published survival rates in postcardiotomy patients supported by ECMO.<sup>28</sup>



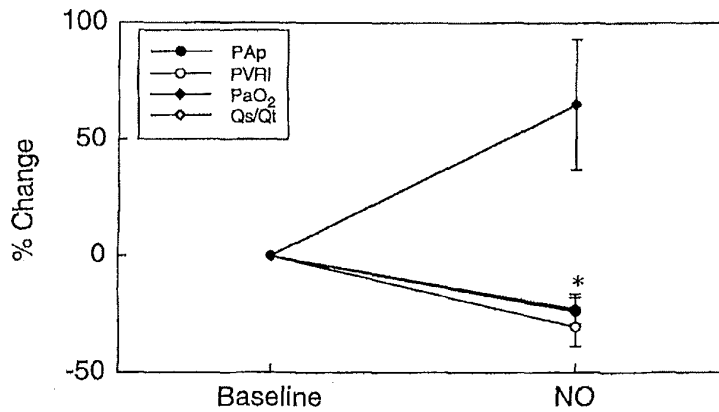


Figure 3. The effect of 80 ppm NO in six patients with transient graft dysfunction after lung transplantation. Pulmonary artery pressure (PAp), pulmonary vascular resistance (PVRI), and intrapulmonary shunt fraction (Qs/Qt) decreased significantly and PaO<sub>2</sub> increased. (Adapted and reprinted with permission from Adatia I, Wessel DL: Therapeutic use of inhaled nitric oxide. *Curr Op Pediatr* 6:583-590, 1994.)

Although there are no randomized trials examining the benefit of NO among cardiac patients, this information suggests that a trial of inhaled NO should be considered in these patients before cannulation for ECMO.

#### Total Anomalous Pulmonary Venous Connection

Infants with total anomalous pulmonary venous connection (TAPVC) frequently have obstruction of the pulmonary venous pathway as it connects anomalously to the systemic venous circulation. When pulmonary venous return is obstructed preoperatively, pulmonary hypertension is severe and demands urgent surgical relief. Increased neonatal pulmonary vasoreactivity, endothelial injury induced by cardiopulmonary bypass,<sup>18</sup> and intrauterine anatomic changes in the pulmonary vascular bed in this disease<sup>28</sup> contribute to postoperative pulmonary hypertension. We hypothesized that infants with anatomically obstructed TAPVC would have a high occurrence rate of postoperative pulmonary hypertension, and that their pulmonary vascular bed could be selectively dilated with inhaled NO. Our aim was to define the incidence of postoperative pulmonary hypertension in infants with TAPVC and to describe the hemodynamic effects of initiation and withdrawal of inhaled NO in those postoperative patients with pulmonary hypertension. Twenty infants presented with isolated TAPVC over a 3-year period and were monitored for pulmonary hypertension. Nine patients had postoperative pulmonary hyperten-

sion treated with a 15-minute trial of inhaled NO at 80 ppm. Five patients received prolonged treatment with NO at 20 ppm or less (median 28 hours, range 12 to 71 hours).

We showed a mean percentage decrease of 42% in pulmonary vascular resistance and 32% in mean pulmonary artery pressure.<sup>29</sup> There was no significant change in heart rate, systemic blood pressure, or vascular resistance. Although not statistically significant, cardiac index increased by 10% (Fig 4).

#### Congenital Mitral Stenosis

We examined the effect of inhaled NO at 80 ppm for 15 minutes in 15 children with pulmonary hypertension and congenital mitral stenosis to assess the extent of reversible pulmonary vasoconstriction.<sup>30</sup> Mean pulmonary artery pressure decreased from  $42 \pm 2$  to  $30 \pm 2$  ( $P < .05$ ) during NO inhalation. Pulmonary vascular resistance declined from  $5.8 \pm 0.7$  to  $2.9 \pm 0.4$  U · m<sup>2</sup> ( $P < .05$ ) (Fig 5). Cardiac index, left and right atrial pressure, mean systemic blood pressure, heart rate, systemic vascular resistance, PaO<sub>2</sub>, and calculated intrapulmonary shunt fraction were not changed. Selective pulmonary vasodilation occurred in all patients, proving the presence of a significant reactive component of pulmonary hypertension in this disease. Prolonged therapy with inhaled NO facilitated the management and recovery of 4 patients. It is particularly useful adjunctive therapy during awakening and extubation when pulmonary hypertension worsens and predisposes patients to pulmonary

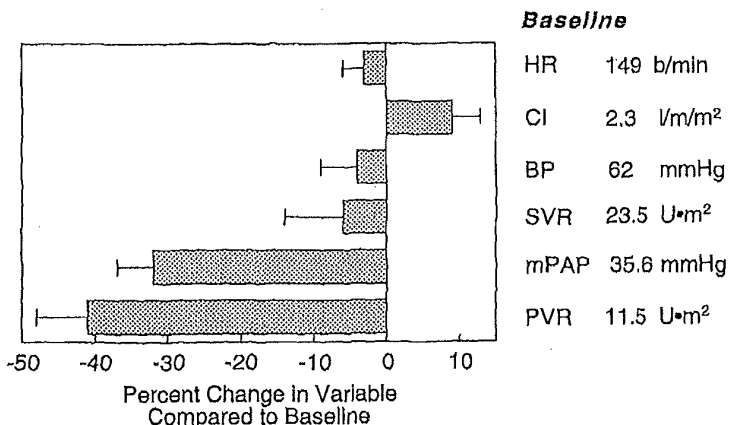


Figure 4. Percentage change in hemodynamic variables from baseline during 15 minutes of NO at 80 ppm in 9 patients with TAPVC. There is marked specificity for the pulmonary circulation.

edema. The vasoreactivity is greater than previously reported in adults with acquired mitral stenosis.<sup>31,32</sup> This may be due to the particular sensitivity of pulmonary veins to inhaled NO when pulmonary venous hypertension has been present since birth.

We have found patients with TAPVC, congenital mitral stenosis, and other pulmonary venous hypertensive disorders to be the most responsive to NO. These infants are born with significantly increased amounts of smooth muscle in their pulmonary veins.<sup>33,34</sup> Histological evidence of muscularized pulmonary veins as well as pulmonary arteries<sup>35</sup> suggest the presence of vascular

tone and capacity for change in resistance at both the arterial and venous sites. The increased responsiveness observed in younger patients with pulmonary venous hypertension to NO may result from pulmonary vasorelaxation at a combination of pre and postcapillary vessels.<sup>30,36</sup>

**Anatomic Obstruction Versus Pulmonary Vasoconstriction**

As we have discussed, even if a neonatal cardiac operation is successfully performed, endothelium-dependent pulmonary vascular relaxation is impaired after cardiopulmonary bypass and the postoperative course may be complicated by

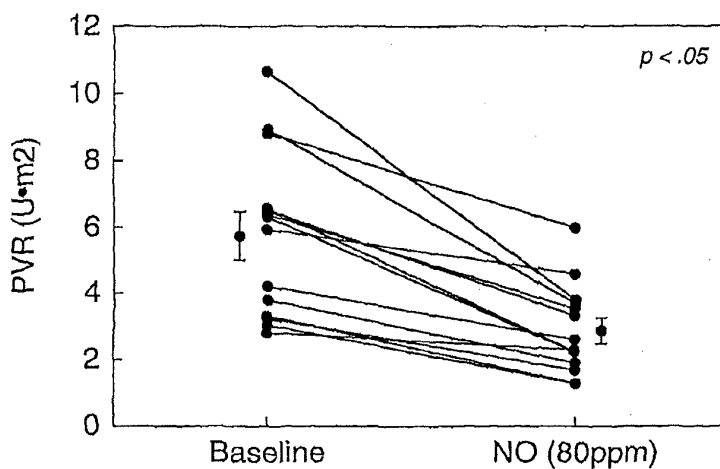
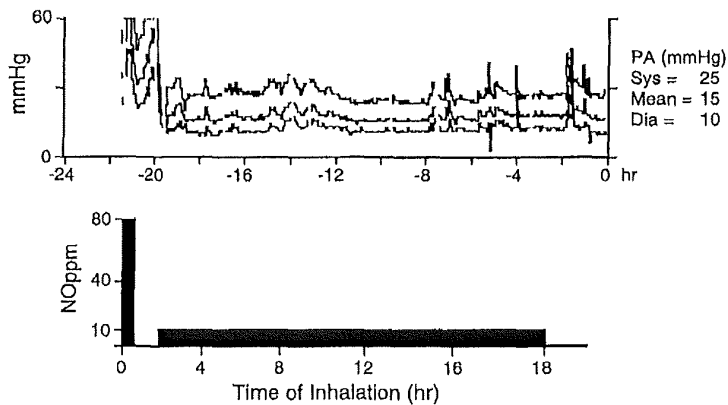


Figure 5. The effect of 80 ppm NO on pulmonary vascular resistance (PVR) in patients with congenital mitral stenosis. PVR decreased from baseline in all patients. (Reprinted with permission of the publisher from Atz AM, et al: Inhaled nitric oxide in children with pulmonary hypertension and congenital mitral stenosis. Am J Cardiol 77:316-319, 1996.<sup>30</sup> Copyright 1996 by Excerpta Medica Inc.)



**Figure 6.** Bedside tracing of pulmonary artery pressure (PA) (systolic, mean, diastolic) with NO dose and duration of therapy on bottom. PA pressure decreased during 80 ppm trial. Vasodilation was sustained with 10 ppm NO for 18 hours of therapy.

transient pulmonary hypertension. As shown previously, pulmonary vasoconstriction in the postoperative newborn is exquisitely responsive to inhaled NO. However, reactive pulmonary vasoconstriction may not be the only cause of elevated pulmonary artery and right ventricular pressures. Differentiation between pulmonary vasoconstriction and anatomic obstruction to pulmonary blood flow may be difficult, especially in neonates. Branch pulmonary artery stenosis, hypoplastic distal pulmonary arteries, or iatrogenic causes of obstruction to pulmonary blood flow may be reflected in elevated pressure in the main pulmonary artery. A definitive diagnosis may require invasive and potentially dangerous investigation of the circulation.

We therefore proposed to use inhaled NO diagnostically in neonates with pulmonary hypertension after cardiac surgery to discern those with reversible vasoconstriction. Nine of 15 patients responded to a 15-minute trial with a reduction in mean pulmonary artery pressure from  $35 \pm 4$  to  $26 \pm 4$  mm Hg and pulmonary vascular resistance from  $17 \pm 6$  to  $10 \pm 4$   $U \cdot m^2$ . There were insignificant changes in systemic hemodynamics. Two patients received prolonged therapy with inhaled NO after the initial trial. In both cases the use of continuous low dose (3 to 10 ppm) NO allowed management of the pulmonary artery pressure, without episodic increases, and optimization of the right ventricular afterload. It was also possible to wean ventilatory support and decrease sedation unpunctuated by increases in pulmonary artery pressure (Fig 6).

Six patients did not respond to inhaled NO

with either a decrease in proximal pulmonary artery pressure or an increase in systemic oxygen saturation. In each of these patients subsequent investigation, prompted by the failed response to inhaled NO, showed anatomic obstruction to pulmonary blood flow. Thus, failure of the postoperative newborn with pulmonary hypertension to respond to NO successfully discriminated anatomic obstruction to pulmonary blood flow from pulmonary vasoconstriction. Judicious use of a trial of inhaled NO may be of value to rule out pulmonary vasoconstriction and redirect investigation toward reassessment of the surgical result. Failure of the patient to show response to NO should be regarded as strong evidence of anatomic and possibly surgically remediable obstruction.

#### Other Lesions

Successful use of inhaled NO in a variety of congenital heart defects after cardiac surgery has been reported by several groups.<sup>20,27,37-41</sup> Selective pulmonary vasodilation has been documented after surgical repair of ventricular septal defects, atrioventricular septal defects, transposition of the great arteries, total anomalous pulmonary venous connection, and other structural heart defects. Some studies suggest that there is a correlation between the response to NO and the extent of preoperative pulmonary hypertension.<sup>38,39</sup> Synergistic use of NO with aerosolized or intravenous prostacyclin,<sup>42,43</sup> atrial natriuretic peptide,<sup>44</sup> dipyridamole,<sup>45,46</sup> or specific type V phosphodiesterase inhibitors holds considerable promise for more effective control of pulmonary

hypertension in infants with congenital heart disease.

#### Single Ventricle

Pulmonary blood flow in the newborn with a single ventricle and no anatomic obstruction of flow to the lungs may become excessive as pulmonary vascular resistance decreases after birth. A pulmonary artery band may be applied to limit pulmonary over circulation while the child grows and the lungs mature. More complex single ventricle anatomy with pulmonary or aortic valve atresia requires that reliable pulmonary blood flow be established surgically with a systemic to pulmonary artery shunt that is sufficiently restrictive to prevent congestive heart failure but adequate to permit oxygenation. Later during infancy, when pulmonary resistance has safely declined, a cavopulmonary anastomosis (ie, a bidirectional Glenn or later, a modified Fontan procedure) can be attempted as a more hemodynamically efficient method of providing pulmonary blood flow. If there is excessive cyanosis in the newborn after placement of a systemic to pulmonary artery shunt (eg, Blalock-Taussig), it is tempting to attribute the hypoxemia to pulmonary vasoconstriction. Indeed we have observed dramatic improvements in oxygenation in some of these newborns when NO is delivered. However, it is far more common for the reduction in pulmonary blood flow to result from a kinked or otherwise obstructed shunt that requires surgical revision<sup>47</sup> (Fig 7).

As a prelude to potential use of the cavopulmonary anastomosis in the newborn, we studied infants (2 to 8 months old) with refractory cyanosis after a bidirectional Glenn anastomosis.<sup>48</sup> Although median baseline oxygen saturation was only 65%, administration of inhaled NO provided minimal improvement in oxygenation. One child with respiratory syncytial virus bronchiolitis showed significant improvement in oxygenation, but NO did not substantially change systemic oxygenation or the transpulmonary pressure gradient in any other patient. Saturations and PaO<sub>2</sub> did not change despite the fact that there was a fivefold increase in plasma cyclic GMP production, suggesting that inadequate NO delivery or failure of guanylate cyclase activation could not explain the lack of therapeutic effect. We have extended these observations to nearly 30 patients. This suggests that the pulmo-

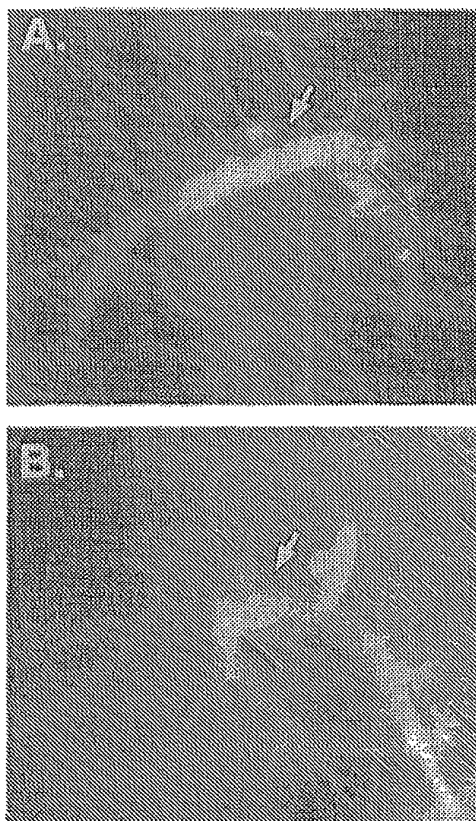


Figure 7. Anterior-posterior (A) and lateral (B) angiograms taken in a neonate with severe cyanosis and shunt-dependent pulmonary blood flow who failed to respond to inhaled NO. The arrow points to a discrete shunt narrowing that required surgical revision.

nary vascular bed in the newborn after a bidirectional Glenn will not be limited by pulmonary vasoconstriction, but rather by other regulatory mechanisms. Rather than refractory pulmonary vascular tone, it is likely that the limiting factor is pulmonary vascular cross-sectional area insufficient in the newborn to permit adequate passive blood flow through the lungs. Alternative treatment strategies may combine agents to accelerate postnatal growth of vessels for several days before a planned operation and then use NO postoperatively to avoid reactive pulmonary vasoconstriction.

Although not directly applicable to the newborn, the modified Fontan procedure is the ultimate reconstructive surgery for patients with a single ventricle. The Fontan physiology succeeds only with very low pulmonary vascular resistance, because flow through the lungs is conducted passively without a pumping chamber. NO has been used to considerable advantage by Macrae et al in the postoperative management of these patients.<sup>49</sup>

#### Chronic NO Use

Although outpatient use of inhaled NO has been reported in a small number of adults, its use in younger patients with heart disease or as a therapeutic bridge to lung or heart lung transplantation is largely unstudied. NO inhibits smooth muscle growth and matrix protein synthesis in the extracellular matrix. It also reduces hypoxic remodeling in the rat lung,<sup>50-53</sup> suggesting that it might have a salutary effect on scarring or pathological remodeling in the human lung. We hypothesized that the antioxidant and antiproliferative effects of NO combined with its antihypertensive action might provide a theoretical basis for prolonged treatment of idiopathic pulmonary hypertension. This might be particularly applicable to infants, who by virtue of their young age, have substantial capacity for smooth muscle regression, alveolar growth, and angiogenesis. We treated three infants younger than 3 months old who had severe unexplained pulmonary hypertension (biopsy-proven and presumed to be fatal) with a 25-day treatment regimen including inhaled NO. At the end of the treatment period, they had significantly lower (nearly normal) pulmonary artery pressures without recurrence of pulmonary hypertension during 3 to 22 months of follow-up. Although no conclusion can be drawn from such limited experience, it has prompted us to reevaluate our notion about presumed irreversibility of "primary" pulmonary hypertension early in life.

#### Adverse Effects

##### Rebound Pulmonary Hypertension

We observed in all patients with TAPVC after prolonged treatment with NO that a transient elevation in pulmonary artery pressure routinely

occurred when NO was successfully discontinued (Fig 8). Previous reports have described the abrupt return of pulmonary hypertension to systemic levels when NO was temporarily discontinued. When this phenomenon occurs very early in the postoperative course, and is accompanied by systemic hypotension and hypoxia, one is inclined to ascribe the changes to persistence of the underlying pulmonary hypertensive disorder. We described a somewhat different phenomenon. After several hours (12 to 72) of postoperative treatment and recovery NO could be discontinued, but a transient increase in pulmonary artery pressure was always observed. During the first minutes after successful NO withdrawal, pulmonary artery pressure increased moderately (peak effect  $7 \pm 3$  minutes after withdrawal) and then declined to very low levels without impact on systemic hemodynamics. These changes were complete within 1 hour of withdrawal and were not attributable to any change in ventilation or pharmacological support.<sup>29</sup>

Rebound pulmonary hypertension is not unique to inhaled vasodilators, but its causes are unclear. Negative feedback inhibition by exogenous NO has been postulated to account for this observation and shown to exist for inducible<sup>54</sup> and endothelial<sup>55</sup> NO synthase *in vitro*. NO donor agents inhibit endothelial NO biosynthesis in bovine arterial ring preparations by an apparent negative feedback on endothelial NO synthase. The arterial rings recovered responsiveness to endothelium-dependent relaxing agents within 30 to 40 minutes of withdrawing the NO donor agent, similar in timing to our witnessed rebound.<sup>56</sup> Decreased endogenous production of exhaled NO from smokers could also support a negative feedback theory.<sup>57</sup>

Alternatively inhaled NO may play an unknown role in the modulation of endogenous pulmonary vasoconstrictors. It is reported that after abrupt withdrawal of nitroprusside (an NO donor), a transient rebound phenomenon exists.<sup>58</sup> Accordingly, one could hypothesize that pulmonary vasodilation by NO provoked secondary production or activation of vasoconstrictors. With the short half-life of NO, abrupt discontinuation allowed a brief period of unopposed vasoconstriction until stimulation of endogenous vasodilators or change in the stimulus for vasoconstriction achieved a new balance of vasomotor tone. A third alternative is that exposure

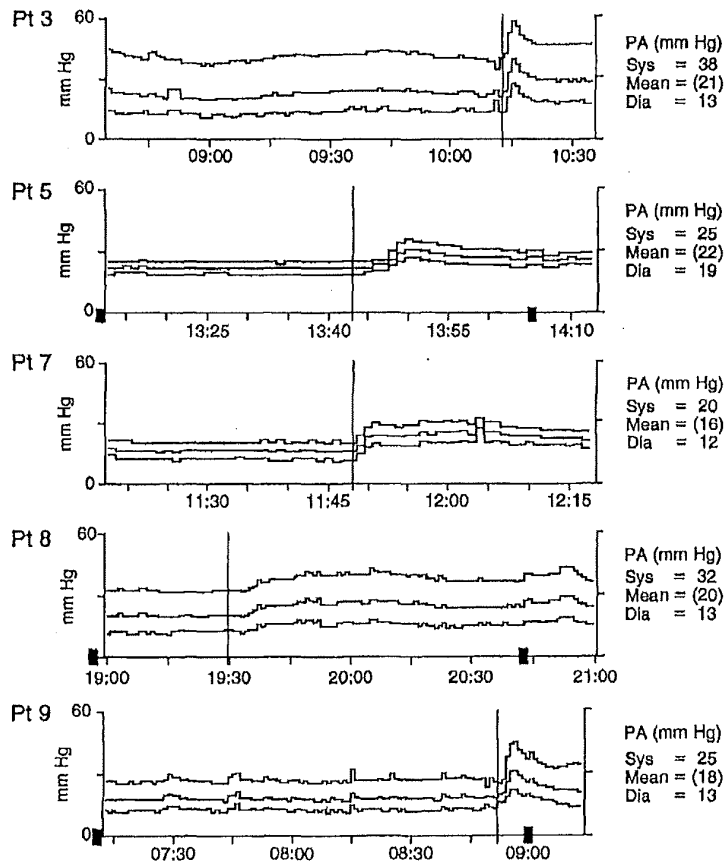


Figure 8. Bedside tracings of pulmonary artery (PA) pressure (systolic, mean, diastolic) for 5 patients (Pt) with TAPVC receiving prolonged NO plotted against time. Cursor represents time of withdrawal of NO; pulmonary artery pressures at time of withdrawal are displayed to the right of each tracing. In each patient a transient increase is observed, which dissipates without reinstatement of NO. (Reprinted with permission from the Society of Thoracic Surgeons [The Annals of Thoracic Surgery, 1996, Vol 62, pp 1759-1764].<sup>29</sup>)

to exogenous NO altered membrane receptor conformation in vascular smooth muscle which reconfigured within 30 to 60 minutes after NO was withdrawn.

Rebound hypertension confounds assessment of whether postoperative pulmonary hypertension has resolved. NO therapy may be prolonged unnecessarily if clinicians are unaware that a moderate increase in pulmonary artery pressure on withdrawal may be transient and well tolerated if the underlying pathological process has improved. During weaning of NO, if mild elevations in pulmonary artery pressure are observed, it seems prudent to continue careful observation if the effect is transient and systemic hemodynamic stability is not impaired. Dose response testing for inhaled NO should be undertaken

during the initial exposure to NO, because information obtained during weaning may reflect rebound effects and not the true dose-response relationship.

Appreciation of rebound pulmonary hypertension and its transient characteristic may facilitate weaning from NO and has important implications for patients with persistent pulmonary hypertensive disorders when interruption of NO is necessary. If the underlying pulmonary hypertensive process has not resolved, then the tendency for an abrupt increase in pulmonary artery pressure may be hazardous if NO therapy must be withdrawn or interrupted. For example, one should continue to provide a source of NO when suctioning or changing NO tanks because abrupt discontinuation can result in cardiovascular col-

lapse.<sup>59-61</sup> If withdrawal of NO is necessary before resolution of the pathological process, hemodynamic instability may be expected. If a labile patient with pulmonary hypertension is stabilized with NO before transfer to a specialized center for further management, NO should be available during patient transport.

#### Severe Left Ventricular Dysfunction

Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension. In adults with ischemic cardiomyopathy, sudden pulmonary vasodilation may occasionally unload the right ventricle sufficiently to increase pulmonary blood flow and harmfully augment preload in a compromised left ventricle. The attendant increase in left atrial pressure may produce pulmonary edema.<sup>62</sup> This is not likely to arise from any negative inotropic effect of NO<sup>63</sup> and may be ameliorated with vasodilators or diuretics. A different but related phenomenon may be operative in the newborn with severe left ventricular dysfunction and pulmonary hypertension. In these patients, the systemic circulation may depend in part on the ability of the right ventricle to sustain cardiac output through a right-to-left shunt across the patent ductus arteriosus. Selective pulmonary vasodilation may redirect the right ventricular output to the lungs and away from the systemic circulation. Therefore, in newborns with severe left ventricular dysfunction, predominantly left to right shunting at the foramen ovale and exclusively right to left shunting at the ductus arteriosus, NO should be used with extreme caution, if at all. We and others have reported adverse outcomes in this circumstance.<sup>64,65</sup>

#### NO Dosage and Toxicity

There has been concern over potential NO induced cellular injury during exogenous exposure to the drug, as well as the generation of nitrogen dioxide and methemoglobinemia during the delivery of NO (see article by Dr Darley-Usmar). If the dose of NO is maintained below 40 ppm, there have been few acute problems reported as the result of methemoglobinemia or excessive nitrogen dioxide concentrations. At a dose of 80 ppm, we have reported in a very few infants a transient elevation of methemoglo-

bin.<sup>66</sup> Optimal dosing of NO to maximize pulmonary vascular relaxation without incurring toxic side effects, systemic hypotension, or an increase venous admixture is unclear. Miller showed in 10 infants and children that low and potentially less toxic doses of NO were effective after cardiac surgery, with nearly identical response at 2 ppm compared with 10 and 20 ppm.<sup>39</sup> Day showed little additional value with 60 ppm over 12 ppm in patients with congenital heart disease.<sup>67</sup> However, Roberts et al have shown a dose-response relationship up to 80 ppm in a similar population.<sup>68</sup>

Maximal pulmonary vasodilator response to inhaled NO may occur at higher doses than that which produce optimal ventilation perfusion matching in patients with elevated pulmonary artery pressure and severe pulmonary parenchymal disease. By redistributing pulmonary blood flow away from underventilated alveoli toward normally ventilated areas of lung, inhaled NO in very low concentrations (<1 ppm) may improve intrapulmonary shunt fraction and raise PaO<sub>2</sub>. It has been suggested that this effect may be optimized at doses of inhaled NO that are low (1 to 10 ppm), even though maximal pulmonary vasodilation occurred in the same patients at higher NO doses (10 to 100 ppm) among 12 adult patients with ARDS.<sup>69</sup> Improved oxygenation was lost at the higher NO doses in these patients in whom pulmonary vasodilation was maximized. Presumably, this occurred from a "spillover" effect of NO into poorly ventilated lung with loss of preferential delivery to and vasodilation of better ventilated areas. Thus, the desirable dose may depend in part on the severity of the pulmonary artery hypertension versus the severity of intrapulmonary shunting from lung disease. It seems likely that the recommended starting dose of NO for newborns with congenital heart disease will lie between 5 and 40 ppm.

#### Delivery Considerations

The potential toxicity of NO underscores the importance of developing reliable delivery and monitoring systems. Newborns are typically ventilated with devices designed to operate with continuous fresh gas flows from which all tidal breaths are derived. Stable NO concentrations can be achieved by titrating NO directly from the source tank into the inspiratory side of the continuous gas flow of the ventilator.<sup>70</sup> The resi-

dent times of NO and oxygen are minimized in continuous flow delivery systems because the gases are continuously purged through the ventilator. This system is limited to use in small patients who never require peak inspiratory flow rates greater than 10 to 12 L/min. It uses substantial amounts of NO gas and can be complicated by scavenging systems that interfere with the exhalation valve of the ventilator. NO source tanks are balanced with nitrogen and are available in a variety of concentrations from 100 to 10,000 parts per million (ppm). As NO is titrated into a delivery circuit, nitrogen will dilute the set  $\text{FiO}_2$ . Using a ventilator gas flow rate of 9 L/min and a NO source tank of 800 ppm, 1 L/min flow of NO gas will be diluted to 80 ppm in inspiratory gas flow with a maximal  $\text{FiO}_2$  of .90. Because doses as low as 1 ppm may achieve therapeutic benefit, low-flow meters are needed to obtain a wide range of NO doses. Nitric oxide can be titrated into other continuous flow devices such as high frequency ventilators and continuous positive airway pressure systems.<sup>71</sup>

An ideal delivery system uses medical grade quality gas manufactured by a process approved by the Food and Drug Administration. It minimizes the duration of gas in the delivery circuit, can deliver a wide range of precise NO doses with uniform mixing despite variable flow rates, has on-line analysis of NO,  $\text{NO}_2$ , and oxygen, incorporates stringent controls for exhaled gases, and has alarms to protect against excessive dosing or inadvertent discontinuation. Because rebound pulmonary hypertension or respiratory collapse after prolonged inhalation of NO in some patients represents an additional hazard of abrupt interruption of NO delivery, an appropriate alarm and back-up supply of NO must be in place. The system should be adaptable to different clinical situations, oxygen and NO concentrations should be independently controlled, and when used in conjunction with mechanical ventilation should not interfere with ventilator functions. Commercial products are just now available that use mass flow-controller technology capable of rapid and precise regulation and mixing of NO, oxygen, and air gas flows.<sup>72</sup> When integrated into a microprocessor-governed, flow-sensing circuit, these devices promise to markedly improve the variability and precision of "homemade" systems, enabling the set NO concentration to remain constant during the dy-

namic flow of a single breath regardless of flow or ventilatory mode. They may be contained within standard ventilator housing with two separate control panels (oxygen and NO) directing output for the three relevant modules (air, oxygen, NO). Alternatively more flexible systems, similarly controlled, are now available to function in series with the most common mechanical ventilators.

### Summary

Inhaled NO has emerged as an important diagnostic and therapeutic agent in the treatment of pulmonary hypertension among newborns with congenital heart disease. It is a selective pulmonary vasodilator with minimal adverse hemodynamic effects when administered and monitored in a judicious fashion. It seems to be more effective in the newborn than the older patient and has a number of advantages compared with intravenous vasodilators. Its hemodynamic benefit has been shown in patients with pulmonary hypertension associated with total anomalous pulmonary venous connection, congenital mitral stenosis, postoperative patients with preexisting left to right shunts, and other lesions. It can be used in the newborn to help discriminate anatomic obstruction to pulmonary blood flow from pulmonary vasoconstriction, and it may be used effectively in the treatment or prevention of pulmonary hypertensive crises after cardiopulmonary bypass. As an inhaled vasodilator, it has special advantage in the treatment of acute respiratory failure that may arise in conjunction with pulmonary hypertension after bypass. There are also potential benefits of chronic, outpatient administration of NO to facilitate growth, and beneficial remodeling of the abnormal pulmonary vasculature in unusual forms of idiopathic pulmonary hypertension identified in early infancy. However, none of the purported benefits of inhaled NO in children with congenital heart disease have been studied in a randomized, placebo-controlled manner with convincing demonstration of improved outcomes. This must be kept in mind when evaluating the risks and potential benefits of this new therapy.

### References

1. Wegman ME: Annual Summary of Vital Statistics-1991. *Pediatrics* 90:835-845, 1992



2. Pollack MM, Yeh TS, Ruttimann UE, et al: Evaluation of pediatric intensive care. *Crit Care Med* 12:376-383, 1984
3. Moodie DS, Garson A, Freed MD, et al: 25th Bethesda Conference, Future Personnel Needs for Cardiovascular Health Care, Taskforce 6, Pediatric Cardiology. *J Am Coll Cardiol* 24:322-328, 1994
4. Hopkins RA, Bull C, Haworth SG, et al: Pulmonary hypertensive crises following surgery for congenital heart defects in young children. *Euro J Cardio-Thorac Surg* 5:628-634, 1991
5. Hoffman JIE, Rudolph AM, Heymann MA: Pulmonary vascular disease with congenital heart lesions: pathologic features and causes. *Circulation* 64:873-877, 1981
6. Rabinovitch M, Haworth SG, Castaneda AR, et al: Lung biopsy in congenital heart disease: A morphometric approach to pulmonary vascular disease. *Circulation* 58:1107-1122, 1978
7. Castaneda A, Mayer J, Jonas R, et al: The neonate with critical congenital heart disease: Repair—a surgical challenge. *J Thorac Cardiovasc Surg* 98:869-875, 1989
8. Wernovsky G, Chang AC, Wessel DL: Intensive care, in Emmanouilides GC, Riemenschneider TA, Allen HD, Gutgesell HP (eds): *Heart Disease in Infants, Children, and Adolescents—Including the Fetus and Young Adult*. Baltimore, MD, Williams and Wilkins, 1995, pp 398-439
9. Wernovsky G, Wypij D, Jonas RA, et al: Postoperative course and hemodynamic profile after the arterial switch operation in neonates and infants: A comparison of low-flow cardiopulmonary bypass versus circulatory arrest. *Circulation* 92:2226-2235, 1995
10. Hall SM, Haworth SG: Onset and evolution of pulmonary vascular disease in young children: Abnormal postnatal remodeling studied in lung biopsies. *J Pathol* 166:183-193, 1992
11. Yeager SB, Freed MD, Keane JF, et al: Primary surgical closure of ventricular septal defect in the first year of life: Results in 128 infants. *J Am Coll Cardiol* 3:1269-1276, 1984
12. Hanley FL, Heinemann MK, Jonas RA, et al: Repair of truncus arteriosus in the neonate. *J Thorac Cardiovasc Surg* 105:1047-1056, 1993
13. Wheller J, George BL, Mulder DG, Jarmakani JM: Diagnosis and management of postoperative pulmonary hypertensive crisis. *Circulation* 70:1640-1644, 1979
14. Del Nido PJ, Williams WG, Villamater J, et al: Changes in pericardial surface pressure during pulmonary hypertensive crises after cardiac surgery. *Circulation* 76:III-93-III-96, 1987
15. The Neonatal Nitric Oxide Study Group: Inhaled nitric oxide in full-term and nearly full-term infants with hypoxic respiratory failure. *N Engl J Med* 336:597-604, 1997
16. Roberts JD, Fineman JR, Morin FC, et al: Inhaled nitric oxide and persistent pulmonary hypertension of the newborn. *N Engl J Med* 336:605-610, 1997
17. Stark AR, Davidson D: Inhaled nitric oxide for persistent pulmonary hypertension of the newborn: Implications and strategy for future "high-tech" neonatal clinical trials. *Pediatrics* 96:1147-1151, 1995
18. Wessel DL, Adatia I, Giglia TM, et al: Use of inhaled nitric oxide and acetylcholine in the evaluation of pulmonary hypertension and endothelial function after cardiopulmonary bypass. *Circulation* 88(part 1):2128-2138, 1993
19. Chang AC, Wernovsky G, Kulik TJ, et al: Management of the neonate with transposition of the great arteries and persistent pulmonary hypertension. *Am J Cardiol* 68:1253-1255, 1991
20. Luciani G, Chang A, Stames V: Surgical repair of transposition of the great arteries in neonates with persistent pulmonary hypertension. *Ann Thorac Surg* 61:800-805, 1996
21. Goldman AP, Delius RE, Deanfield JE, et al: Nitric oxide might reduce the need for extracorporeal support in children with critical postoperative pulmonary hypertension. *Ann Thorac Surg* 62:750-755, 1996
22. Adatia I, Lillehei C, Arnold JH, et al: Inhaled nitric oxide in the treatment of postoperative graft dysfunction after lung transplantation. *Ann Thorac Surg* 57:1311-1318, 1994
23. Date H, Triantafyllou A, Trulock E, et al: Inhaled nitric oxide reduces human lung allograft dysfunction. *J Thorac Cardiovasc Surg* 111:913-919, 1996
24. Bacha E, Herve P, Murakami S, et al: Lasting beneficial effects of short-term inhaled nitric oxide on graft function after lung transplantation. *J Thorac Cardiovasc Surg* 112:590-598, 1996
25. Kulik TJ, Moler FW, Palmisano JM, et al: Outcome-associated factors in pediatric patients treated with extracorporeal membrane oxygenator after cardiac surgery. *Circulation* 94:1163-1168, 1996
26. Ziomek S, Harrell JE, Fasules JW, et al: Extracorporeal membrane oxygenation for cardiac failure after congenital heart operation. *Ann Thorac Surg* 54:861-867, 1992
27. Journois D, Pouard P, Mauriat P, et al: Inhaled nitric oxide as a therapy for pulmonary hypertension after operations for congenital heart defects. *J Thorac Cardiovasc Surg* 107:1129-1135, 1994
28. Haworth SG: Total anomalous pulmonary venous return. Prenatal damage to pulmonary vascular bed and extrapulmonary veins. *Br Heart J* 48:513-524, 1982
29. Atz AM, Adatia I, Wessel DL: Rebound pulmonary hypertension after inhalation of nitric oxide. *Ann Thorac Surg* 62:1759-1764, 1996
30. Atz AM, Adatia I, Jonas RA, Wessel DL: Inhaled nitric oxide in children with pulmonary hypertension and congenital mitral stenosis. *Am J Cardiol* 77:316-319, 1996
31. Snow DJ, Gray SJ, Ghosh S, et al: Inhaled nitric oxide in patients with normal and increased pulmonary vascular resistance after cardiac surgery. *Br J Anaesth* 72:185-189, 1994
32. Rich GF, Murphy GD, Roos CM, Johns RA: Inhaled nitric oxide. Selective pulmonary vasodilation in cardiac surgical patients. *Anesthesia* 78:1028-1035, 1993
33. Newfeld EA, Wilson A, Paul MH, Reisch JS: Pulmonary vascular disease in total anomalous pulmonary venous drainage. *Circulation* 61:103-109, 1980
34. Haworth SG, Reid L: Structural study of pulmonary circulation and of heart in total anomalous pulmonary venous return in early infancy. *Br Heart J* 39:80-92, 1977
35. Ferencz C, Dammann JF: Significance of the pulmonary vascular bed in congenital heart disease. *Circulation* 16:1046-1056, 1957
36. Adatia I, Perry S, Landzberg M, et al: Inhaled nitric oxide and hemodynamic evaluation of patients with pulmonary hypertension before transplantation. *J Am Coll Cardiol* 25:1656-1664, 1995

37. Curran R, Mavroudis C, Backer C, et al: Inhaled nitric oxide for children with congenital heart disease and pulmonary hypertension. *Ann Thorac Surg* 60:1765-1771, 1995
38. Beghetti M, Habre W, Friedli B, Berner M: Continuous low dose inhaled nitric oxide for treatment of severe pulmonary hypertension after cardiac surgery in paediatric patients. *Br Heart J* 73:65-68, 1995
39. Miller OI, Celermajer DS, Deanfield JE, Macrae DJ: Very low dose inhaled nitric oxide: A selective pulmonary vasodilator after operations for congenital heart disease. *J Thorac Cardiovasc Surg* 108:487-494, 1994
40. Yahagi N, Kumon K, Tanigami H: Inhaled nitric oxide for the postoperative management of Fontan-type operations. *Ann Thorac Surg* 57:1371-1372, 1994
41. Tibballs J: Clinical applications of gaseous nitric oxide. *Anaesth Intens Care* 21:866-871, 1993
42. Parker TA, Ivy DD, Kinsella JP, et al: Combined therapy with inhaled nitric oxide and intravenous prostacyclin in an infant with alveolar-capillary dysplasia. *Am J Respir Crit Care Med* 155:743-746, 1997
43. Schranz D, Huith R, Wippermann CF, et al: Nitric oxide and prostacyclin lower suprasystemic pulmonary hypertension after cardiopulmonary bypass. *Eur J Pediatr* 152:793-796, 1993
44. Ivy DD, Kinsella JP, Wolfe RR, Abman SH: Atrial natriuretic peptide and nitric oxide in children with pulmonary hypertension after surgical repair of congenital heart disease. *Am J Cardiol* 77:102-105, 1996
45. Kinsella JP, Torielli F, Ziegler JW, et al: Dipyrimadole augmentation of response to nitric oxide. *Lancet* 346:647-648, 1995
46. Fullerton DA, Jaggars J, Piedalue F, et al: Effective control of refractory pulmonary hypertension after cardiac operations. *J Thorac Cardiovasc Surg* 113:363-368, 1997
47. Atz AM, Adatia I, Wessel DL: Inhaled nitric oxide in shunted single ventricle patients. *Circulation* 92:I-53-I-54, 1995
48. Adatia I, Thompson J, Wessel DL: Inhaled nitric oxide and hypoxemia after bidirectional Glenn operation. *Circulation* 88:A1798, 1993
49. Goldman AP, Delius RE, Deanfield JE, et al: Pharmacologic control of pulmonary blood flow with inhaled nitric oxide after the fenestrated Fontan operation. *Circulation* 94:II-44-II-48, 1996(suppl 2)
50. Garg U, Hassid A: Nitric oxide-generating vasodilators and 8-bromo-cyclic guanosine monophosphate inhibit mitogenesis and proliferation of cultured rat vascular smooth muscle cells. *J Clin Invest* 83:1774-1777, 1989
51. Kouyoumdjian C, Adnot S, Levame M, et al: Continuous inhalation of nitric oxide protects against development of pulmonary hypertension in chronically hypoxic rats. *J Clin Invest* 94:578-584, 1994
52. Roberts J, Roberts C, Jones R, et al: Continuous nitric oxide inhalation reduces pulmonary arterial structural changes, right ventricular hypertrophy, and growth retardation in the hypoxic newborn rat. *Circ Res* 76:215-222, 1995
53. Kolpakov V, Gordon D, Kulik T: Nitric oxide-generating compounds inhibit total protein and collagen synthesis in cultured vascular smooth muscle cells. *Circ Res* 76:305-309, 1995
54. Assreuy J, Cunha FQ, Liew FY, Moncada S: Feedback inhibition of nitric oxide synthase activity by nitric oxide. *Eur J Pharmacol* 108:833-837, 1993
55. Ravichandran LV, Johns RA, Rengasamy A: Direct and reversible inhibition of endothelial nitric oxide synthase by nitric oxide. *Am J Physiol* 268:H2216-H2223, 1995
56. Buga GM, Griscavage JM, Rogers NE, Ignarro LJ: Negative feedback regulation of endothelial cell function by nitric oxide. *Circ Res* 73:808-812, 1993
57. Gerlach H, Rossaint K, Pappert D, et al: Autoinhalation of nitric oxide after endogenous synthesis in nasopharynx. *Lancet* 343:518-519, 1994
58. Packer M, Meller J, Medina N, et al: Rebound hemodynamic events after the abrupt withdrawal of nitroprusside in patients with severe chronic heart failure. *N Engl J Med* 301:1193-1197, 1979
59. Grover R, Murdoch I, Smithies M, et al: Nitric oxide during hand ventilation in patient with acute respiratory failure. *Lancet* 340:1038-1039, 1992 (letter)
60. Miller O, Tang S, Keech A, Celermajer D: Rebound pulmonary hypertension on withdrawal from inhaled nitric oxide. *Lancet* 346:51-52, 1995
61. Lavoie A, Hall JB, Olson DM, Wylam ME: Life-threatening effects of discontinuing inhaled nitric oxide in severe respiratory failure. *Am J Respir Crit Care Med* 153:1985-1987, 1996
62. Bocchi EA, Bacal F, Auler JOC, et al: Inhaled nitric oxide leading to pulmonary edema in stable severe heart failure. *Am J Cardiol* 74:70-74, 1994
63. Hare JM, Shernan SK, Body SC, et al: Influence of inhaled nitric oxide on systemic flow and ventricular filling pressure in patients receiving mechanical circulatory assistance. *Circulation* 95:2250-2253, 1997
64. Henrichsen T, Goldman AP, Macrae DJ: Inhaled nitric oxide can cause severe systemic hypotension. *J Pediatr* 129:183, 1996
65. Wessel DL, Adatia I, Van Marter LJ, et al: Improved oxygenation in a randomized trial of inhaled nitric oxide for persistent pulmonary hypertension of the newborn. *Pediatrics* 1997(in press)
66. Wessel DL, Adatia I, Thompson JE, Hickey PR: Delivery and monitoring of inhaled nitric oxide in patients with pulmonary hypertension. *Crit Care Med* 22:930-938, 1994
67. Day R, Lynch J, Shaddy R, Orsmond G: Pulmonary vasodilatory effects of 12 and 60 parts per million inhaled nitric oxide in children with ventricular septal defect. *Am J Cardiol* 75:196-198, 1995
68. Roberts JD, Lang P, Bigatello LM, et al: Inhaled nitric oxide in congenital heart disease. *Circulation* 87:447-453, 1993
69. Gerlach H, Rossaint D, Pappert D, Falke KJ: Time-course and dose-response of nitric oxide inhalation for systemic oxygenation and pulmonary hypertension in patients with adult respiratory distress syndrome. *Euro J Clin Invest* 23:499-502, 1993
70. Beüt P, Adatia I, Benjamin P, et al: Inhaled nitric oxide: Evaluation of a continuous titration delivery technique developed for infant mechanical ventilation and manual ventilation. *Respir Care* 40:706-715, 1995
71. Kinsella JP, Abman SH: Methaemoglobin during nitric oxide therapy with high-frequency ventilation. *Lancet* 342:615, 1993
72. Lindberg L, Rydgren G, Larsson A, et al: A delivery system for inhalation of nitric oxide evaluated with chemiluminescence, electrochemical fuel cells, and capnography. *Crit Care Med* 25:190-195, 1997

# EXHIBIT 3

## Inhaled nitric oxide in premature neonates with severe hypoxaemic respiratory failure: a randomised controlled trial

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### Summary

**Background** Inhaled nitric oxide improves oxygenation and lessens the need for extracorporeal-membrane oxygenation in full-term neonates with hypoxaemic respiratory failure and persistent pulmonary hypertension, but potential adverse effects are intracranial haemorrhage and chronic lung disease. We investigated whether low-dose inhaled nitric oxide would improve survival in premature neonates with unresponsive severe hypoxaemic respiratory failure, and would not increase the frequency or severity of intracranial haemorrhage or chronic lung disease.

**Methods** We did a double-blind, randomised controlled trial in 12 perinatal centres that provide tertiary care. 80 premature neonates (gestational age  $\leq 34$  weeks) with severe hypoxaemic respiratory failure were randomly assigned inhaled nitric oxide (n=48) or no nitric oxide (n=32, controls). Our primary outcome was survival to discharge. Analysis was by intention to treat. We studied also the rate and severity of intracranial haemorrhage, pulmonary haemorrhage, duration of ventilation, and chronic lung disease at 36 weeks' postconceptional age.

**Findings** The two groups did not differ for baseline characteristics or severity of disease. Inhaled nitric oxide improved oxygenation after 60 min ( $p=0.03$ ). Survival at discharge was 52% in the inhaled-nitric-oxide group and 47% in controls ( $p=0.65$ ). Causes of death were mainly related to extreme prematurity and were similar in the two groups. The two groups did not differ for adverse events or outcomes (intracranial haemorrhage grade 2-4, 28% inhaled nitric oxide and 33% control; pulmonary haemorrhage 13% and 9%; chronic lung disease 60% and 80%).

**Interpretation** Low-dose inhaled nitric oxide improved oxygenation but did not improve survival in severely hypoxaemic premature neonates. Low-dose nitric oxide in the most critically ill premature neonates does not increase the risk of intracranial haemorrhage, and may decrease risk of chronic lung injury.

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### Introduction

Early reports of inhaled nitric oxide in full-term neonates with persistent pulmonary hypertension showed sustained improvement in oxygenation.<sup>1,2</sup> Subsequently, randomised controlled trials of inhaled nitric oxide confirmed that this selective pulmonary vasodilator improves oxygenation and lessens the need for extracorporeal-membrane oxygenation in such neonates.<sup>3,5</sup> Inhaled nitric oxide did not, however, improve morbidity or survival.<sup>4</sup> In full-term neonates, survival is unlikely to be altered by innovative therapies for persistent pulmonary hypertension because extracorporeal-membrane oxygenation is widely available and can be started quickly when more conservative therapies fail. The role of inhaled nitric oxide in premature neonates with hypoxaemic respiratory failure is, however, more controversial in terms of efficacy and safety.<sup>6</sup> In addition, extracorporeal-membrane oxygenation is not generally offered to premature neonates because of the risks of intracranial haemorrhage associated with heparinisation, internal-jugular and common-carotid-vessel ligation, and mechanical cardiopulmonary bypass.<sup>7</sup>

Laboratory studies have shown that low-dose inhaled nitric oxide (5-20 parts per million [ppm]) leads to pulmonary vasodilation and improves gas exchange in premature lambs with respiratory-distress syndrome,<sup>8-10</sup> and previous clinical studies have suggested that inhaled nitric oxide acutely improves oxygenation in premature neonates.<sup>11-14</sup> Effects on morbidity and survival in premature neonates have not, however, been tested in a controlled trial. Premature neonates are uniquely susceptible to oxidant lung injury, which could increase the risk of chronic lung disease, but the effects of inhaled nitric oxide on chronic lung disease have not been studied. Laboratory and clinical studies suggest that high doses of inhaled nitric oxide can increase bleeding time,<sup>15-17</sup> and two case reports have suggested a high rate of intracranial haemorrhage in premature neonates treated with inhaled nitric oxide.<sup>18,19</sup> These case reports did not include control groups to find out the actual risk of intracranial haemorrhage, and there is no evidence from controlled trials that inhaled nitric oxide increases the risk of clinical bleeding complications in full-term neonates.

We tested the hypothesis in a double-blind, randomised, controlled trial that the use of low-dose inhaled nitric oxide (5 ppm) would improve survival in premature neonates with severe hypoxaemic respiratory failure unresponsive to conventional therapies, and would not increase the incidence or severity of bleeding complications. Because of the uncertainty about the safety of exposure to inhaled nitric oxide in premature neonates, we limited the study population to selected premature neonates with severe hypoxaemic respiratory failure despite maximum therapeutic intervention and a high predicted mortality rate.

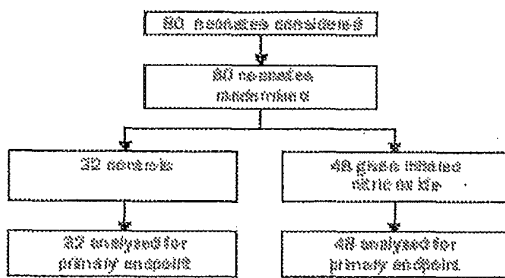


Figure 1: Trial profile

## Methods

### Patients

12 tertiary perinatal centres with clinical experience in inhaled-nitric-oxide therapy participated in the trial. The study was approved by the Institutional Review Board at each centre, and by the US Food and Drug Administration under an investigator-initiated investigational new drug exemption. Criteria for enrolment were: delivery at gestational age 34 weeks or less; age 7 days or younger; severe hypoxaemia (arterial/alveolar oxygen ratio <0.10 on two sequential arterial-blood-gas measurements) despite mechanical ventilation and surfactant treatment (Survanta, Abbott Laboratories, Columbus, OH, USA, 4 mL/kg) when indicated (based on a predicted mortality rate of 50%).<sup>20</sup> Exclusion criteria were fatal congenital anomalies or congenital heart disease (except atrial and ventricular septal defects). We enrolled neonates after informed consent was obtained from parents.

### Study design

Treatment assignment was designated by the central coordinating centre according to sequentially numbered randomisation cards, provided in sealed opaque envelopes with the order varied among hospitals. Randomisation was stratified by centre and gestational age ( $\leq 28$  weeks or  $> 28$  weeks), balanced in blocks of ten in each stratum, based on an expected total enrolment of 210 patients. Cranial ultrasound examinations were done before enrolment to find out the baseline incidence and severity of intracranial haemorrhage (Papile standards).<sup>21</sup>

After randomisation, the ventilator circuit was configured to allow delivery of nitric oxide at 5 ppm, as described previously.<sup>3</sup> In patients assigned nitric oxide ( $n=48$ ) the delivery system was activated. No supplemental gas was delivered to patients in the control group ( $n=32$ ). Caregivers were unaware of whether nitric oxide was delivered. Delivery systems were monitored routinely (sham monitoring in the control group). Delivered nitric oxide and nitrogen dioxide concentrations were monitored by chemiluminescence or electrochemical sensors.<sup>3</sup> After 7 days' administration, a period of no administration of study gas was tried. We limited the frequency of these periods to keep the risk of unmasking treatment assignment to a minimum. A threshold of 15% or more increase in oxygenation index (fraction of inspired oxygen  $[FIO_2] \times \text{mean airway pressure} \times 100 / \text{arterial partial pressure of oxygen } [PaO_2]$ ) was used to warrant restarting study gas. If study gas was restarted, periods without gas were kept to every 2 days for a maximum treatment duration of 14 days. We used oxygenation index for periods off gas because the calculation is straightforward for immediate bedside assessments, but after we had done analyses, we believed that  $PaO_2/FIO_2$  would be a more clinically useful comparison and present results in this way.

Patients were mechanically ventilated with standard neonatal, time-cycled, pressure-limited ventilators or with high-frequency devices (Sensormedics 3100A High Frequency Oscillator, Sensormedics Inc, Yorba Linda, CA, USA, or Infant Star HFV, Infracor Inc, San Diego, CA). The consensus among centres

Characteristic	Inhaled nitric oxide (n=48)	Control (n=32)
Mean (SD) weight (g)	1040 (461)	988 (387)
Mean (SD) gestational age (weeks)	27.1 (2.6)	26.8 (2.6)
Sex (female/male)	20/28	12/20
Median (range) 1 min Appur score	4 (1-8)	4 (1-9)
Median (range) 5 min Appur score	7 (2-9)	6 (1-9)
No intracranial haemorrhage	35 (73%)	19 (59%)
Intracranial haemorrhage (grade 2-4)	7 (15%)	6 (19%)
Mean (SD) age at enrolment (h)	30 (38)	27 (37)
Mean (SD) $PaO_2/FIO_2$ (kPa)	5.6 (2.4)	5.6 (2.1)
Mean (SD) pH	7.33 (0.12)	7.32 (0.10)
Mean (SD) $PiCO_2$ (kPa)	5.7 (1.9)	6.0 (2.1)

$PaCO_2$ =arterial partial pressure of carbon dioxide.

Table 1: Baseline characteristics

was that a high-volume strategy would be used during high-frequency oscillatory ventilation. The only ventilator prohibited was the Life Pulse High Frequency Ventilator (Bunnell Inc, Salt Lake City, UT, USA), because of limited information of the accurate measurement of delivered concentrations of inhaled nitric oxide. We did not allow changes in ventilator device or ventilator settings for the first 60 min of the trial to enable recording of acute responses to treatment.

### Statistical analysis

We based sample-size estimates on a predicted 50% mortality in the control group.<sup>21</sup> We estimated that 80% power to detect a 30% decrease in mortality with inhaled nitric oxide required 105 neonates in each treatment group. Safety analyses of mortality and rates of intracranial haemorrhage were done by an independent data, safety, and monitoring committee after enrolment of 20, 40, and 60 neonates, to find out whether the rate of adverse events warranted ending the trial. No such need was seen.

A planned interim analysis after enrolment of 80 neonates, based on a randomisation-date cut off (study duration 2.5 years) showed that no significant difference was detectable for the main outcome measure (survival to discharge) and that at the current enrolment rate, projections suggested detection of differences was unlikely in a reasonable time frame (based upon stochastic curtailment procedures). Interim analyses were done by the coordinating centre and the investigators were unaware of results. We did planned secondary analyses (eg, chronic lung disease and intracranial haemorrhage) of differences between treatment groups after the end of study.

For the primary and secondary outcome measures, we did analyses by intention to treat. For acute changes in respiratory variables, the results for seven neonates (four on inhaled nitric oxide, three controls) were censored because of protocol violations in the first 60 min of the trial (changes in ventilator devices or settings). Data from these neonates were, however, included for other study endpoints.

We analysed binomial data with  $\chi^2$  or Fisher's exact tests where appropriate. We compared normally distributed continuous data with Student's  $t$  test. Continuous data that were

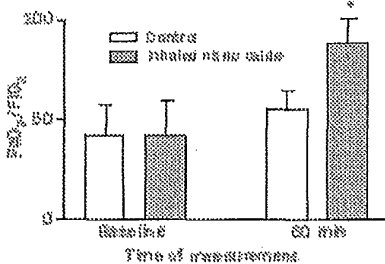


Figure 2:  $PaO_2/FIO_2$  results at baseline and 60 min after treatment

\*  $p < 0.05$  vs control.

not normally distributed were compared with the Mann-Whitney U test. We set the significance level at  $p < 0.05$ .

## Results

Complete data were available for 80 neonates during the planned interim analysis (figure 1). The unequal distribution of neonates was because of the stratification scheme, which was based on our anticipated enrolment of 20 neonates in each centre (ten of 12 centres enrolled fewer than ten neonates). Centres did not differ significantly in randomisation ( $p=0.92$ ). No randomisation violations were reported to the coordinating centre.

There were no differences between groups in baseline characteristics (table 1). 79 (99%) neonates were treated with surfactant. Distribution of ethnic origin, antenatal corticosteroid treatment or treatment, with high-frequency oscillatory ventilation at enrolment were similar in the inhaled-nitric-oxide and control groups.

In the inhaled-nitric-oxide group, there was an acute improvement in  $\text{PaO}_2$  after 60 min compared with the control group ( $p=0.03$ , figure 2). Arterial pH (7.32 [0.18] inhaled nitric oxide vs 7.32 [0.16] control) or arterial partial pressure of carbon dioxide (5.7 [2.9] vs 5.5 [2.4] kPa) did not differ between groups after 60 min. Methaemoglobin concentrations were also similar in the two groups (1.1% [0.72], inhaled nitric oxide 0.96 [0.60] control). Arterial-blood-gas measurements did not differ between groups after 60 min. In the first period off study gas after 7 days of treatment, treatment had to be restarted in three neonates (treatment was discontinued successfully on day 9 for one neonate and day 11 for two). Days on ventilators in survivors were significantly fewer in the inhaled-nitric-oxide group than in the control group ( $p=0.046$ ).

Survival to discharge or chronic lung disease (table 2) and days spent in hospital (median 86.5 [range 31-395] inhaled nitric oxide vs 79.0 [14-106] control) were similar in the two groups. Groups did not differ for incidence of pulmonary haemorrhage (13 vs 9%) or symptomatic patent ductus arteriosus (21 vs 19%). Periventricular leucomalacia occurred in two (8%) of 25 neonates receiving inhaled nitric oxide and in two (13%) of 15 controls ( $p=0.62$ ). Four neonates had retinopathy of prematurity that required treatment (one in the inhaled-nitric-oxide group, three in the control group,  $p=0.10$ ).

The rate and severity of intracranial haemorrhage at study entry was similar in the two groups (table 3). For intracranial-haemorrhage outcomes, the highest grade recorded (right or left) at age 7 days or 36 weeks postconceptional age was chosen to reflect intracranial-haemorrhage severity. The rate of intracranial haemorrhage for each group did not differ in survivors (table 2).

We did cranial ultrasound scans at study entry and at age 7 days, because most intracranial haemorrhages occur in this time.<sup>22</sup> Therefore, to find out whether intracranial haemorrhage occurred in neonates who died before age 7 days, we did a separate analysis that included results of cranial ultrasound scans done before 7 days as well as the results of necropsy. No intracranial-haemorrhage results were available for 11 of the 80 neonates who died suddenly before age 7 days and who did not undergo necropsy (five in the inhaled nitric oxide group, six in the control group). 13 neonates had cranial ultrasound scans

Outcome	Inhaled nitric oxide	Control	Relative risk (95% CI)	p
Survival	25/48 (52%)	16/32 (47%)	1.11 (0.70-1.8)	0.65
Chronic lung disease (oxygen at 36 weeks)	16/26 (60%)	12/15 (80%)	0.76 (0.6-1.18)	0.30
Death, chronic lung disease, or both	37/48 (77%)	29/32 (91%)	0.85 (0.7-1.08)	0.14
Discharged on oxygen	13/25 (54%)	12/15 (80%)	0.65 (0.41-1.02)	0.10
Median (range) ventilator days for survivors	26 (8-69)	37 (8-905)	..	0.046

Table 2: Relative risks of outcomes

after enrolment and before death before age 7 days, and additional intracranial-haemorrhage results were available from necropsies done in seven neonates. Therefore, results for intracranial haemorrhage were available for 43 (90%) of 48 neonates in the inhaled-nitric-oxide group and 26 (81%) of 32 controls (table 3). To find out whether inhaled nitric oxide increased the likelihood of new or worsened intracranial haemorrhage, we analysed the change in intracranial-haemorrhage grade from baseline between the two groups. A higher grade of intracranial haemorrhage after enrolment occurred in 19 (44%) of 43 neonates in the inhaled-nitric-oxide group and 11 (42%) of 26 controls ( $p=0.88$ ). The groups did not differ for the incidence of intracranial haemorrhage within the stratum 28 weeks or less estimated gestational age (ie, at highest risk for intracranial haemorrhage). The rate of intracranial haemorrhage (grades 1-4) was 56% (18 of 32) for the inhaled-nitric-oxide group and 59% (ten of 17) for the control group. The rate of the grade 4 intracranial haemorrhage was 19% for the inhaled-nitric-oxide group and 29% for the control group. 11 (46%) of the 24 neonates on inhaled nitric oxide and four (50%) of eight controls in this stratum who did not have intracranial haemorrhage at baseline subsequently developed intracranial haemorrhage.

Because the rate of intracranial haemorrhage in premature neonates is important to subsequent trials, we also did an analysis based on worst case scenario. We calculated the incidence of intracranial haemorrhage based on the premise that neonates in the inhaled-nitric-oxide group who died before age 7 days with unknown intracranial-haemorrhage status ( $n=5$ ) actually had grade 4 intracranial haemorrhage and all neonates in the control group who died before age 7 days with unknown intracranial-haemorrhage status ( $n=6$ ) actually had no intracranial haemorrhage. This analysis yielded a maximum potential rate for grade 4 intracranial haemorrhage of 29% for the inhaled-nitric-oxide group and 27% for the control group. With the prediction for the worst case scenario, a clinical trial designed to prove a significant increase in risk for grade 4 intracranial

	Inhaled nitric oxide (n=48)	Control (n=32)	p
Total unknown ICH status	6/48 (10%)	6/32 (19%)	0.29
Alive without ICH	16/26 (60%)	10/15 (67%)	0.67
Alive with ICH < grade 1	18/26 (72%)	10/15 (67%)	0.72
Alive with ICH grade 2-4	7/26 (28%)	5/15 (33%)	0.72
Died without ICH (< grade 1)	6/18 (33%)	3/11 (27%)	0.73
Died with ICH grade 2-4	12/18 (67%)	8/11 (73%)	0.73
Total known ICH incidence (survivors plus non-survivors)			
Grade 1-4	22/43 (51%)	13/26 (50%)	0.93
Grade 2-4	19/43 (44%)	13/26 (50%)	0.66
Grade 3-4	16/43 (37%)	10/26 (40%)	0.92
Grade 4	7/43 (16%)	7/26 (27%)	0.20

ICH=intracranial haemorrhage.

Table 3: Outcomes for intracranial haemorrhage

	Inhaled nitric oxide (n=23)	Control (n=17)	p
Support withdrawn for severe ICH	6 (26%)	4 (24%)	0.85
Extreme prematurity (<26 weeks) and MSOF	6 (26%)	4 (24%)	0.85
PIE/refractory respiratory failure	3 (13%)	3 (18%)	0.49
Bacterial sepsis	3 (13%)	2 (12%)	0.90
Renal failure	2 (9%)	2 (12%)	0.75
Pulmonary hypoplasia (non-CHD)	1 (4%)	2 (12%)	0.56
Congenital diaphragmatic hernia	2 (9%)	0	0.60

ICH=intracranial haemorrhage; MSOF=multisystem organ failure; PIE=pulmonary interstitial emphysema; CHD=coronary heart disease.

Table 4: Cause of death and associated disorders

haemorrhage in neonates treated with inhaled nitric oxide (80% power,  $\alpha=0.05$ ) would require a minimum of 15 000 neonates (with illness similar to those in this study). Causes of death and major associated disorders were similar in the two groups (table 4).

## Discussion

Low-dose inhaled nitric oxide did not affect survival, but this study population had a high rate of mortality associated with complications of prematurity such as multisystem organ failure and intracranial haemorrhage. Because the potential adverse effects of inhaled nitric oxide on platelet adhesion and the attendant risks of intracranial haemorrhage are severe consequences of prematurity, we included only neonates with the most severe respiratory failure.

One of our most important findings was that low-dose inhaled nitric oxide (5 ppm) did not affect the rate of severity of intracranial haemorrhage, in contrast to observational reports.<sup>18,19</sup> However, no increased incidence of intracranial haemorrhage was found in a small, unblinded trial that tested the effects of inhaled nitric oxide and dexamethasone.<sup>23</sup> In our trial, we found that intracranial haemorrhage occurred with similar frequency in the inhaled-nitric-oxide and control groups. By obtaining all available ultrasound and necropsy findings, it is unlikely that we missed any hidden morbidity of intracranial haemorrhage. This observation is important to future studies of inhaled nitric oxide in premature neonates. Less severely ill premature neonates may be safely treated with low-dose inhaled nitric oxide without the risk of a bleeding diathesis. We did, however, use a constant low dose of inhaled nitric oxide for a minimum of 7 days. We based the use of low-dose inhaled nitric oxide on the results of previous laboratory and clinical studies, which showed optimum beneficial vasoactive and anti-inflammatory effects and low potential adverse effects on platelet adhesion. There is little information about the safety and efficacy of higher doses of inhaled nitric oxide in premature neonates. We did not use laboratory-based assessments of bleeding tendency because, in premature neonates, such laboratory measurements are imprecise, variable, and would not replace the clinically relevant endpoints we reported.

Low-dose inhaled nitric oxide improved oxygenation and decreased the need for mechanical ventilation. Moreover, inhaled nitric oxide substantially lowered the frequency of chronic lung disease. We did not design this trial to test whether inhaled nitric oxide would have this effect on chronic lung disease. However, the possibility that inhaled nitric oxide may have preventive effects on lung injury is important, because, in addition to its effects on pulmonary haemodynamics and gas exchange during inhalation, this treatment may affect neutrophil adhesion

in the microcirculation.<sup>24</sup> In premature lambs at 78% of term, inhaled nitric oxide increased pulmonary blood flow and improved gas exchange without increasing pulmonary oedema<sup>14,15</sup> and decreased lung neutrophil accumulation.<sup>16</sup> The effects of low-dose inhaled nitric oxide on early neutrophil accumulation may have important clinical implications because neutrophils play an important part in the inflammatory cascade that contributes to lung injury and the evolution of the most important sequel of respiratory-distress syndrome, chronic lung disease.<sup>25-28</sup> Sequestration of neutrophils in the lung is an early step in a complex inflammatory response mediated through the elaboration of oxyradicals, proteases, phospholipases, and lipid compounds.<sup>29</sup> Therapies that lower neutrophil accumulation in the lung in respiratory-distress syndrome could potentially modify the early inflammatory process that amplifies acute lung injury and contribute to the development of chronic lung disease.<sup>30</sup>

We did not study long-term effects of inhaled nitric oxide in premature neonates. We are continuing follow-up studies on premature infants treated with inhaled nitric oxide and controls after 1 year, 2 years, and 6 years to assess neurodevelopmental outcomes.

Low-dose inhaled nitric oxide may be effective as a lung-specific anti-inflammatory therapy to lessen lung neutrophil accumulation and the attendant inflammatory injury that contributes to the evolution of chronic lung disease. Sufficient evidence may now be available to warrant a controlled trial of low-dose inhaled nitric oxide in premature neonates with less severe disease.

## Contributors

John Kinsella and Steven Abman designed the study. Gary Cutter and Monika Baier did the statistical analysis. John Kinsella, William Walsh, Carl Bose, Dale Gerstmann, J Labelle, Smeeta Sardesai, Michele Walsh-Sukys, Martin McCaffrey, David Cornfield, Vinod Bhutani, Gary Cutter, Monika Baier, and Steven Abman all contributed to the writing of the paper.

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## References

- 1 Roberts JD, Polaner DM, Lang P, et al. Inhaled nitric oxide in persistent pulmonary hypertension of the newborn. *Lancet* 1992; 340: 818-19.
- 2 Kinsella JP, Neish SR, Shaffer E, Abman SH. Low-dose inhalational nitric oxide in persistent pulmonary hypertension of the newborn. *Lancet* 1992; 340: 819-20.
- 3 Kinsella JP, Truong WE, Walsh WF, et al. Randomized, multicentre trial of inhaled nitric oxide and high frequency oscillatory ventilation in severe persistent pulmonary hypertension of the newborn. *J Pediatr* 1997; 131: 55-62.
- 4 The Neonatal Inhaled Nitric Oxide Study Group. Inhaled nitric oxide in full-term and nearly full-term infants with hypoxic respiratory failure. *N Engl J Med* 1997; 336: 597-604.
- 5 Roberts JD, Finegan JR, Morin FC, et al. Inhaled nitric oxide and persistent pulmonary hypertension of the newborn. *N Engl J Med* 1997; 336: 605-10.
- 6 Kinsella JP, Abman SH. Inhaled nitric oxide in the premature neonate: animal models and clinical experience. *Semin Perinatol* 1997; 21: 418-25.
- 7 Hardart GE, Faekler JC. Predictors of intracranial hemorrhage during neonatal extracorporeal membrane oxygenation. *J Pediatr* 1999; 134: 156-59.
- 8 Kinsella JP, Ivy DD, Abman SH. Ontogeny of NO activity and response to inhaled NO in the developing ovine pulmonary circulation. *Am J Physiol* 1994; 267: H1955-61.
- 9 Kinsella JP, Ivy DD, Abman SH. Inhaled nitric oxide lowers pulmonary vascular resistance and improves gas exchange in severe experimental hyaline membrane disease. *Pediatr Res* 1994; 36: 402-08.

- 10 Kinsella JP, Parker TA, Galan H, et al. Effects of inhaled nitric oxide on pulmonary edema and lung neutrophil accumulation in severe experimental hyaline membrane disease. *Pediatr Res* 1997; 41: 457-63.
- 11 Abman SH, Kinsella JP, Schaffer MS, Wilkening RB. Inhaled nitric oxide in the management of a premature newborn with severe respiratory distress and pulmonary hypertension. *Pediatrics* 1993; 92: 606-09.
- 12 Pellowski A, Finer NN, Etches PC, Tlorney AJ, Ryan CA. Inhaled nitric oxide for premature infants after prolonged rupture of the membranes. *J Pediatr* 1995; 126: 450-53.
- 13 Skimming JW, Bender KA, Hutchison AA, Drummond WH. Nitric oxide inhalation in infants with respiratory failure. *J Pediatr* 1997; 130: 225-30.
- 14 Subhedar NV, Shaw NJ. Changes in oxygenation and pulmonary haemodynamics in preterm infants treated with inhaled nitric oxide. *Arch Dis Child* 1997; 77: F191-97.
- 15 Hogman M, Frostell C, Arnberg H, Hedenstierna G. Bleeding time prolongation and NO inhalation. *Lancet* 1993; 341: 1664-65.
- 16 Simon DI, Stamler JS, Jaraki O, et al. Antiplatelet properties of protein S-nitrosothiols derived from nitric oxide and endothelium-derived relaxing factor. *Arterioscler Thromb* 1993; 13: 791-99.
- 17 George TN, Johnson KJ, Bates JN, Segar JL. The effect of inhaled nitric oxide therapy on bleeding time and platelet aggregation in neonates. *J Pediatr* 1998; 132: 731-34.
- 18 Van Meurs KP, Rhine WD, Asselin JM, Durand DJ. Response of premature infants with severe respiratory to inhaled nitric oxide. *Pediatr Pulmonol* 1997; 24: 319-23.
- 19 Cheung P, Pellowski A, Robertson CMT. The outcome of very low birth weight neonates ( $\leq 1500$  g) rescued by inhaled nitric oxide: neurodevelopment in early childhood. *J Pediatr* 1998; 133: 735-39.
- 20 The UAC Trial Study Group. The relationship of intraventricular hemorrhage or death with the level of umbilical artery catheter placement: a multicenter randomized clinical trial. *Pediatrics* 1992; 90: 881-87.
- 21 Papile L, Burstein J, Burstein R, Koffler H. Incidence and evaluation of subependymal and intraventricular hemorrhage: a study of infants with birth weights less than 1500 g. *J Pediatr* 1978; 92: 529-34.
- 22 Partridge JC, Babcock DS, Steichen JJ, et al. Optimal timing for diagnostic cranial ultrasound in low-birth-weight infants: detection of intracranial hemorrhage and ventricular dilation. *J Pediatr* 1983; 102: 281.
- 23 Subhedar NV, Ryan SW, Shaw NJ. Open randomised controlled trial of inhaled nitric oxide and early dexamethasone in high risk preterm infants. *Arch Dis Child* 1997; 77: F185-90.
- 24 Kanwar S, Kubes P. Nitric oxide is an antiadhesive molecule for leukocytes. *New Horiz* 1995; 3: 93-104.
- 25 Merritt TA, Cochrane CG, Holcomb K, bohl B, Hallman M, Strayer D, Edwards DK. Elastase and  $\alpha$ -1-proteinase inhibitor activity in tracheal aspirates during respiratory distress syndrome. *J Clin Invest* 1983; 72: 656-66.
- 26 Ogden BE, Murphy S, Saunders GC, Johnson JD. Lung lavage of newborns with respiratory distress syndrome: prolonged neutrophil influx is associated with bronchopulmonary dysplasia. *Chest* 1983; 83: 31-33.
- 27 Speer CP, Ruess D, Harms K, Herting E, Gefeller O. Neutrophil elastase and acute pulmonary damage in neonates with severe respiratory distress syndrome. *Pediatrics* 1993; 91: 794-99.
- 28 Brus F, Van Oeveren W, Heikamp A, Okken A, Oetomo SB. Leakage of protein into lungs of preterm ventilated rabbits is correlated with activation of clotting, complement, and polymorphonuclear leukocytes in plasma. *Pediatr Res* 1996; 39: 958-65.
- 29 Zimmerman JJ. Bronchoalveolar inflammatory pathophysiology of bronchopulmonary dysplasia. *Clin Perinatol* 1995; 22: 429-56.
- 30 Sugiyama M, McCulloch PR, Wren S, Dawson RH, Froese AB. Ventilator pattern influences neutrophil influx and activation in atelectasis-prone rabbit lung. *J Appl Physiol* 1994; 77: 1355-65.



# EXHIBIT 4

## Cardiovascular Effects of Inhaled Nitric Oxide in Patients With Left Ventricular Dysfunction

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**Background** Pulmonary vascular resistance (PVR) is frequently elevated in patients with advanced heart failure. Nitric oxide (NO), which contributes to the activity of endothelium-derived relaxing factor, causes relaxation of pulmonary arteries and veins *in vitro*. Inhalation of NO gas causes pulmonary vasodilation in patients with primary and secondary forms of pulmonary hypertension.

**Methods and Results** To test the hypothesis that inhalation of NO gas lowers PVR in patients with heart failure, we studied the hemodynamic effects of a 10-minute inhalation of NO (80 ppm) in 19 patients with New York Heart Association class III (n=5) and class IV (n=14) heart failure due to left ventricular (LV) dysfunction. Although inhalation of NO had no effect on pulmonary artery pressures, the PVR decreased by  $31 \pm 7\%$  ( $P < .001$ ) due to a  $23 \pm 7\%$  increase ( $P < .001$ ) in

pulmonary artery wedge pressure and despite a  $4 \pm 2\%$  ( $P < .05$ ) decrease in cardiac index. The magnitude of the decrease in PVR with inhaled NO was inversely related ( $r = -.713$ ;  $P < .001$ ) to the baseline PVR. Inhaled NO had no effect on heart rate, systemic arterial pressure, systemic vascular resistance, or LV peak  $+dP/dt$  or  $-dP/dt$ .

**Conclusions** In patients with heart failure due to LV dysfunction, inhalation of NO causes a decrease in the PVR associated with an increase in LV filling pressure. These findings predict that inhaled NO, if used alone at this dose (80 ppm), may have adverse effects in patients with LV failure. (*Circulation*. 1994;90:2780-2785.)

**Key words** • nitric oxide • lung • heart failure • endothelium-derived factors

The endothelium plays an essential role in the dynamic regulation of vascular tone by synthesizing and releasing a variety of substances, one of which, endothelium-derived relaxing factor (EDRF), has the physicochemical properties of nitric oxide (NO) or a closely related substance.<sup>1,2</sup> Endogenous NO produced by endothelial cells diffuses into neighboring vascular smooth muscle cells, where it binds to the heme component of guanylyl cyclase, thereby activating the enzyme, resulting in increased cyclic GMP production and relaxation.<sup>3,4</sup> Arterial and venous endothelial cells in the pulmonary vasculature produce NO constitutively and in response to a variety of stimuli.<sup>5-8</sup> NO appears to be involved both in the regulation of basal pulmonary vascular resistance (PVR)<sup>9,10</sup> and in counterregulating the effects of vasoconstrictor substances.<sup>11-15</sup>

PVR is frequently increased in patients with advanced heart failure. The underlying mechanism for increased PVR in heart failure is not known, but it almost certainly involves activation of vasoconstrictor pathways by the sympathetic nervous system, the renin-angiotensin system, and/or endothelin.<sup>16,17</sup> Although there is evidence that endothelium-dependent vasodilation is impaired in the systemic vasculature of both animal models<sup>18</sup> and patients with heart failure,<sup>19-22</sup> it is

not known whether this mechanism contributes to increased PVR.

Inhalation of NO gas causes pulmonary vasodilation in patients with primary pulmonary hypertension<sup>23</sup> and pulmonary hypertension secondary to congenital heart disease<sup>24</sup> and to adult respiratory distress syndrome.<sup>25</sup> These observations suggest that inhaled NO might ameliorate pulmonary vasoconstriction, and they led to our hypothesis that inhalation of NO would lower PVR in patients with heart failure. To test this hypothesis, we studied the hemodynamic effects of a 10-minute inhalation of NO (80 ppm) in 19 patients with moderate to severe heart failure secondary to LV dysfunction from idiopathic or ischemic dilated cardiomyopathy.

### Methods

#### Study Population

Nineteen patients with New York Heart Association functional class III (n=5) or IV (n=14) heart failure were studied. All patients were receiving digitalis, diuretics, and angiotensin-converting enzyme inhibitors. There were 15 men and 4 women, with a mean age of  $52 \pm 3$  years. The cause of heart failure was ischemic cardiomyopathy in 10 patients and idiopathic dilated cardiomyopathy in 9. The peak  $\dot{V}O_2$  averaged  $9.9 \pm 1.6$  mL  $\cdot$  kg<sup>-1</sup>  $\cdot$  min<sup>-1</sup>. The study protocol was approved by the Committee for the Protection of Human Subjects from Research Risks at the Brigham and Women's Hospital, and written informed consent was obtained in all cases.

#### Hemodynamic Measurements

Vasodilators, converting enzyme inhibitors, digitalis, and diuretics were withheld on the morning of the catheterization. A 7F Swan-Ganz catheter (Arrow International, Inc) was placed in the pulmonary artery. Femoral artery pressure was monitored via an 8F side-arm sheath (Cordis Laboratories). In 10 patients, a 7F micromanometer-tipped pigtail catheter

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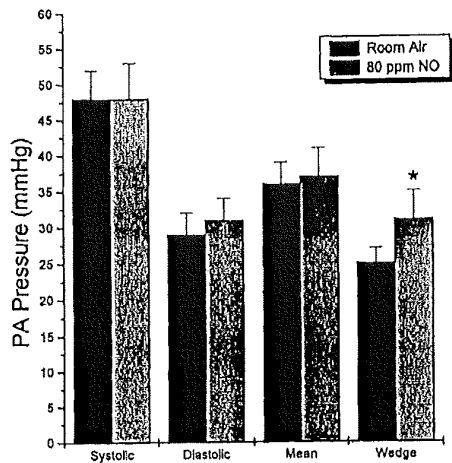
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**TABLE 1. Hemodynamic Effects of Inhaled NO in Patients With Congestive Heart Failure (n=19)**

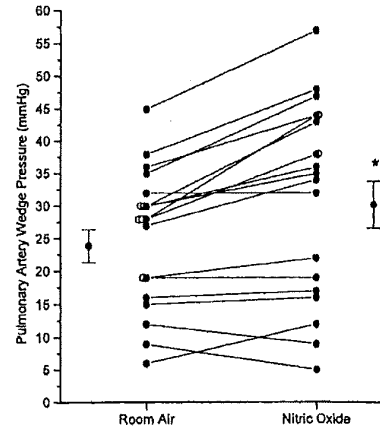
	Room Air	NO	P
HR, bpm	90±3	93±3	NS
MAP, mm Hg	79±3	81±3	NS
SVR, dyne · s · cm <sup>-5</sup>	1102±104	1041±97	NS
PA, mm Hg	35±4	37±4	NS
PAWP, mm Hg	25±3	31±4	<.001
LVEDP, mm Hg; n=10	28±4	34±5	.02
PVR, dyne · s · cm <sup>-5</sup>	226±30	119±13	<.001
PA-PAWP, mm Hg	11±1	6±0.5	<.001
SVI, mL/m <sup>2</sup>	26±2	24±2	.03
CI, L · min <sup>-1</sup> · m <sup>-2</sup>	2.3±0.2	2.1±0.2	.03

HR indicates heart rate; bpm, beats per minute; MAP, mean arterial pressure; SVR, systemic vascular resistance; PA, mean pulmonary artery pressure; PAWP, pulmonary artery wedge pressure; LVEDP, left ventricular end-diastolic pressure; PVR, pulmonary vascular resistance; SVI, stroke volume index; and CI, cardiac index.

(Millar Industries) was placed in the left ventricle (LV), allowing for simultaneous dP/dt and right heart pressure measurements. The ECG, femoral artery pressure, pulmonary artery pressure, and LV pressure were recorded on a strip chart recorder (Electronics for Medicine, PPG Biomedical Systems Division). Cardiac output was determined by the Fick method, based on the measured oxygen uptake (model MRM 2B, Waters Instruments, Inc) and oxygen content in the pulmonary and femoral arteries.<sup>26</sup> Oxygen content was calculated from the blood hemoglobin and oxygen saturation by standard methods.<sup>26</sup> Blood oxygen saturation was determined in duplicate samples on a Ciba-Corning model 270 Co-oximeter. LV peak +dP/dt (+dP/dt) and peak -dP/dt (-dP/dt) were computed on-line by an Electronics for Medicine amplifier (model 220A). Values for heart rate, arterial pressure, pulmonary arterial pressure, pulmonary artery wedge pressure, LV systolic pressure, LV end-diastolic pressure



**Fig 1.** Bar graph showing effect of inhalation of NO gas (80 ppm, 10 minutes) on pulmonary artery (PA) pressures in 19 patients with heart failure secondary to left ventricular dysfunction. Measurements were made after the patients inhaled room air (shaded bars) or NO (solid bars) from a face mask for 10 minutes. \*P<.001 vs room air.



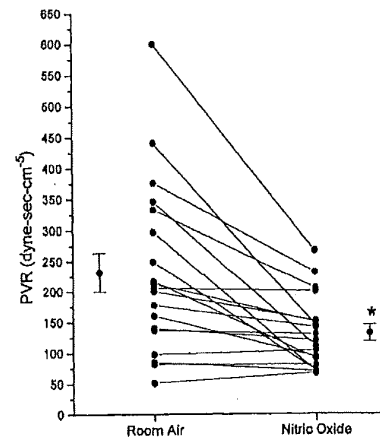
**Fig 2.** Graph showing pulmonary artery wedge pressure before and after a 10-minute inhalation of room air or NO. \*P<.001 vs room air.

(LVEDP), and LV +dP/dt and -dP/dt were calculated by averaging at least 50 consecutive beats under each experimental condition.

**Inhalation of Nitric Oxide**

NO gas (800 ppm) and N<sub>2</sub> (Airco) were mixed by use of a standard low-flow blender (Low Flow MicroBlender, Bird Products Corp) before introduction into the inspiratory limb of a closed breathing circuit attached to a face mask. The inhaled concentrations of NO and oxygen were regulated separately. The inhaled O<sub>2</sub> concentration was measured directly with an on-line oximeter (Ohmeda Oximeter). The inhaled concentrations of NO, nitrogen dioxide (NO<sub>2</sub>), and the higher oxides of nitrogen (NO<sub>x</sub>) were measured continuously by a chemiluminescence technique (Chemiluminescent NO<sub>x</sub>-NO<sub>2</sub> Analyzer, Thermo Environmental Instruments, Inc). The exhaled gases were scavenged by a vacuum system.

To establish baseline conditions, patients inhaled room air (FIO<sub>2</sub>, 21%; N<sub>2</sub>, 79%) via the closed face mask system for 10 minutes before the baseline hemodynamic measurements. Patients then inhaled NO at 80 ppm (FIO<sub>2</sub>, 21%; N<sub>2</sub>, 79%) via



**Fig 3.** Graph showing effect of NO inhalation on pulmonary vascular resistance (PVR). \*P<.001 vs room air.

face mask for 10 minutes, and hemodynamic measurements were repeated.

### Statistical Methods

All data are presented as the mean  $\pm$  SEM. Differences between two observations for one variable within the same group were determined by two-tailed paired *t* test. Differences between groups were determined by two-tailed unpaired *t* test. Differences were considered significant if the null hypothesis could be rejected at the .05 probability level.

### Results

#### Hemodynamic Effect of Inhaled NO

Baseline measurements during inhalation of room air revealed moderate LV failure with elevation of the LVEDP and mean pulmonary artery wedge pressure, and reduced stroke volume and cardiac indexes (Table 1). There was moderate reactive pulmonary hypertension, with an average PVR of  $226 \pm 30$  dyne  $\cdot$  sec  $\cdot$  cm $^{-5}$ .

Inhalation of NO caused no change in heart rate, mean systemic arterial pressure, systemic vascular resistance, or pulmonary artery pressure (systolic, diastolic, or mean) but caused a  $23 \pm 7\%$  increase in the mean pulmonary artery wedge pressure (Table 1, Figs 1 and 2) associated with  $4 \pm 2\%$  and  $7 \pm 2\%$  decreases in cardiac index and stroke volume index, respectively (Table 1). The mean transpulmonary pressure gradient decreased by  $35 \pm 7\%$  (Table 1), and the PVR decreased by  $31 \pm 7\%$  (Table 1 and Fig 3).

The decrease in PVR was due to the increase in pulmonary artery wedge pressure, as shown by the correlation ( $r = -.848$ ,  $P = .0001$ ) between the changes in PVR and pulmonary artery wedge pressure (Fig 4A) and lack of correlation with changes in pulmonary artery pressure (Fig 4B;  $r = .13$ ) or cardiac index (Fig 4C;  $r = .04$ ). The increase in mean pulmonary artery wedge pressure was due to an increase in LV filling pressure, as shown by the correlation ( $r = .939$ ,  $P < .0001$ ) between the changes in LV end-diastolic pressure and pulmonary artery wedge pressure with inhaled NO (Fig 5).

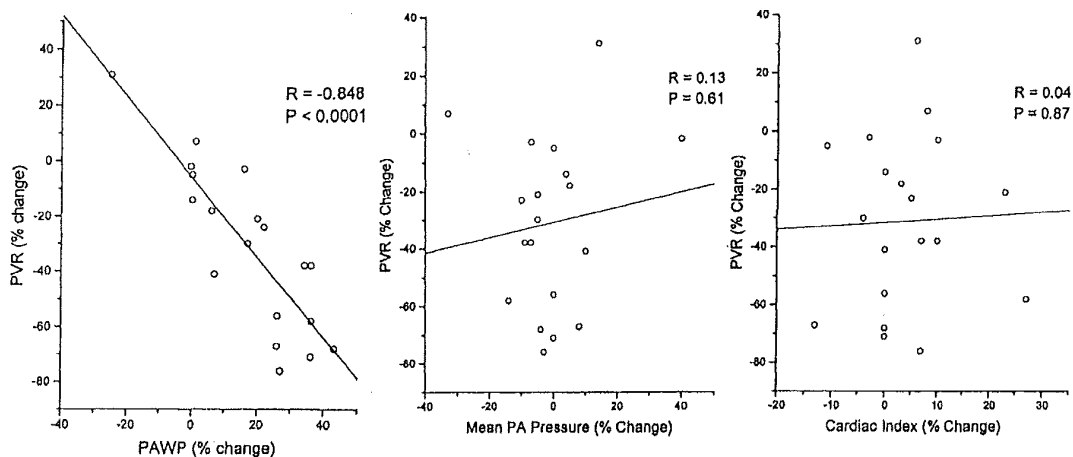
**TABLE 2. Hemodynamic Characteristics of Patients With a Change in Pulmonary Artery Wedge Pressure Above or Below the Median With Inhalation of NO**

	% PAWP <0.26 (n=9)	% PAWP >0.26 (n=10)	P
HR, bpm	87 $\pm$ 4	94 $\pm$ 3	NS
MAP, mm Hg	75 $\pm$ 3	84 $\pm$ 3	.02
SVR, dyne $\cdot$ s $\cdot$ cm $^{-5}$	987 $\pm$ 153	1218 $\pm$ 148	NS
PA, mm Hg	29 $\pm$ 5	42 $\pm$ 5	.02
PAWP, mm Hg	21 $\pm$ 4	28 $\pm$ 4	.02
SVI, mL/m $^2$	30 $\pm$ 2	21 $\pm$ 2	.004
CI, L $\cdot$ min $^{-1}$ $\cdot$ m $^{-2}$	2.6 $\pm$ 0.2	1.9 $\pm$ 0.2	.01
PVR, dyne $\cdot$ s $\cdot$ cm $^{-5}$	138 $\pm$ 23	295 $\pm$ 40	.002
LVEDD, cm	6.2 $\pm$ 0.4	7.1 $\pm$ 0.3	.04
$\dot{V}O_2$	9.6 $\pm$ 0.1	11.7 $\pm$ 0.8	NS

LVEDD indicates left ventricular end-diastolic dimension;  $\dot{V}O_2$ , peak oxygen consumption. Other abbreviations as in Table 1. n=19 for all parameters except EDD (n=16) and  $\dot{V}O_2$  (n=17).

#### Hemodynamic Determinants of an Increase in Pulmonary Artery Wedge Pressure With Inhaled NO

The most prominent hemodynamic effect of NO inhalation was the increase in pulmonary artery wedge pressure (median increase, 26%). In the 10 patients with an increase in pulmonary artery wedge pressure of  $\geq 26\%$  (mean increase,  $33 \pm 7\%$ ), the baseline pulmonary artery pressure, pulmonary vascular resistance, and LV end-diastolic dimension (by M-mode echocardiography; n=16) were higher and the cardiac index and stroke volume index were lower than in the 9 patients with an increase of  $< 26\%$  (Table 2). Thus, more severe LV dysfunction (as evidenced by higher left heart filling pressures, lower stroke volume, and larger LV cavity size) was present in the patients who had the largest increases in pulmonary artery wedge pressure with inhaled NO.



**FIG 4.** Scatterplots of regression analyses depicting the relation between the change in pulmonary vascular resistance (PVR) with NO (vs room air) and the change in pulmonary artery wedge pressure (PAWP) (left), mean PA pressure (middle), or cardiac index (right) in 19 patients.

The baseline PVR was more than twofold higher in the group that had the largest increases in pulmonary artery wedge pressure with inhaled NO (Table 2), suggesting that resting PVR might be a determinant or predictor of the response to inhaled NO. Consistent with this view, there was a strong correlation ( $r = -.713$ ,  $P < .001$ ) between the baseline PVR and the decrease in PVR with inhaled NO (Fig 6).

As an alternative approach to this issue, we identified a subgroup of 5 patients who had "compensated" LV failure, as defined by a pulmonary artery wedge pressure  $\leq 18$  mm Hg (mean,  $12 \pm 2$  mm Hg) and a cardiac index  $\geq 2.5$   $L \cdot \text{min}^{-1} \cdot \text{m}^{-2}$  (mean,  $2.8 \pm 0.3$   $L \cdot \text{min}^{-1} \cdot \text{m}^{-2}$ ). In these patients, inhalation of NO has no effect on pulmonary artery wedge pressure ( $+7 \pm 3\%$ ) or PVR ( $+5 \pm 13\%$ ). In the remaining 14 patients with "decompensated" LV failure (mean pulmonary artery wedge pressure,  $30 \pm 2$  mm Hg; mean cardiac index,  $1.9 \pm 0.1$   $L \cdot \text{min}^{-1} \cdot \text{m}^{-2}$ ), inhalation of NO increased the pulmonary artery wedge pressure by  $27 \pm 3\%$  ( $P < .001$ ) and decreased the PVR by  $43 \pm 7\%$  ( $P < .001$ ).

#### Effects of Inhaled NO on LV Function

Since it has been suggested that NO can depress the contractile function of isolated cardiac myocytes,<sup>27</sup> we considered the possibility that inhaled NO exerted a negative inotropic effect on the LV. A negative inotropic effect of inhaled NO was suggested by a decrease in stroke volume index despite an increase in pulmonary artery wedge pressure (Fig 7A). However, in the 10 patients in whom it was measured, inhaled NO had no effect on LV peak  $+dP/dt$ , despite increasing LVEDP by  $8 \pm 1$  mm Hg (Fig 7B). LV peak  $-dP/dt$ , which reflects isovolumic relaxation in the absence of changes in loading conditions or heart rate,<sup>28,29</sup> was also not affected by inhaled NO (baseline,  $807 \pm 140$  mm Hg/s; NO,  $800 \pm 139$  mm Hg/s;  $P = \text{NS}$ ;  $n = 10$ ).

#### Discussion

The major finding of this study is that in patients with reactive pulmonary arterial hypertension secondary to LV failure, inhalation of NO causes reciprocal changes in the PVR (decrease) and LV filling pressure (increase). In patients with primary pulmonary hypertension, inhalation of NO causes a decrease in pulmonary artery pressure.<sup>23</sup> In contrast, in patients with LV failure, we found that inhalation of NO is associated not with a decrease in pulmonary artery pressure, but rather, with an increase in LV filling pressure that accounts for the decrease in PVR. Preliminary reports from two other groups<sup>30,31</sup> also indicate a similar effect of inhaled NO on LV filling pressure in patients with LV failure.

The observed decrease in transpulmonary artery pressure gradient, particularly in the setting of no change or a small decrease in cardiac output, indicates that inhaled NO caused pulmonary vasodilation. NO diffuses readily through tissues, and therefore inhalation of NO may increase the concentration of NO in the vicinity of vascular smooth muscle cells in pulmonary resistance vessels, thereby exerting a direct vasodilator effect.

We believe that the NO-induced increase in LV filling pressure is due to a small increase in LV volume that

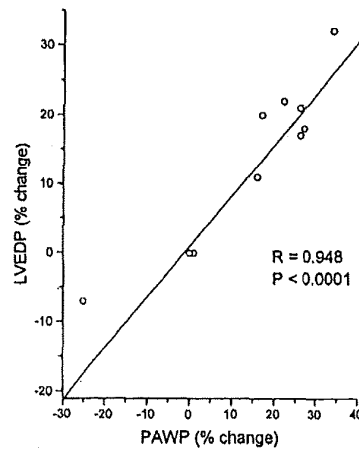


Fig 5. Scatterplot showing relation between the percent changes in pulmonary artery wedge pressure (PAWP) and left ventricular end-diastolic pressure (LVEDP) with inhaled NO in 10 patients.

occurred secondary to an increase in pulmonary venous return to the LV. For a given pulmonary artery pressure, a decrease in PVR will result in an increase in the net driving force for LV filling. Although an increase in LV volume would result in increases in ejection fraction and stroke volume in a normal LV, in our patients LV function was severely depressed and may have been on the flat portion of the Starling relation. In addition, an NO-induced increase in LV volume may have increased the magnitude of functional mitral regurgitation that is present in the majority of such hearts.<sup>32,33</sup> Thus, an NO-induced redistribution of blood from the right ventricle to the LV may occur with no increase, or even a small decrease, in stroke volume. Since the failing LV often operates on the steep portion of the diastolic pressure/volume relation, a substantial increase in LV filling pressure might reflect only a small NO-induced increase in LV volume.

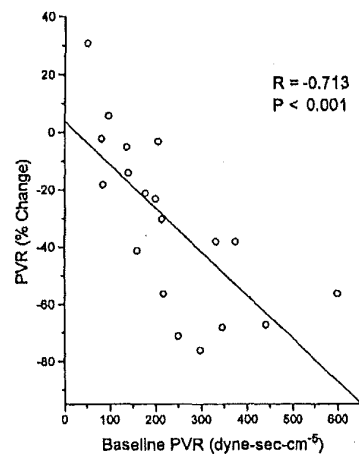


Fig 6. Scatterplot showing relation between the baseline pulmonary vascular resistance (PVR) and the percent change in PVR after inhalation of NO in 19 patients.

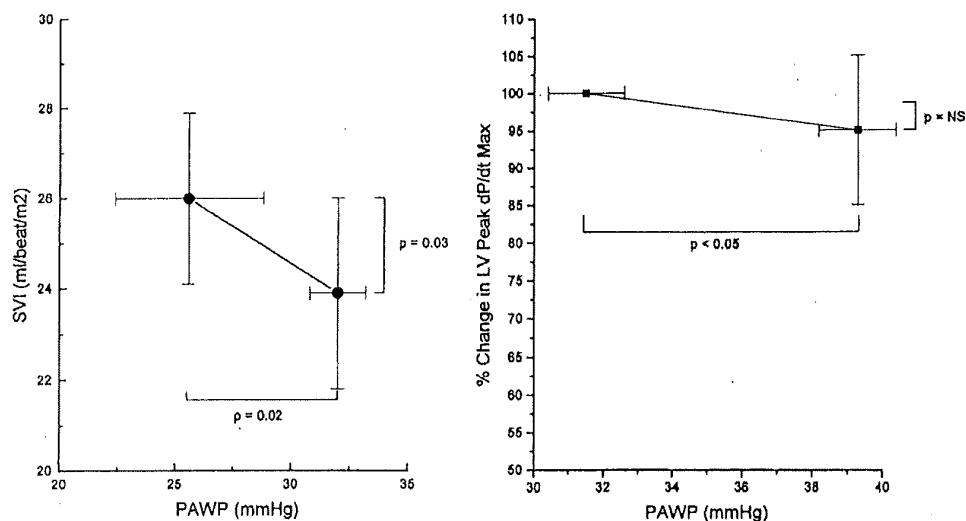


FIG 7. Graphs showing (left) effect of inhaled NO on the relation between stroke volume index (SVI) and mean pulmonary artery wedge pressure (PAWP) and (right) effect of inhaled NO on the relation between left ventricular (LV) peak +dP/dt and PAWP.

The NO-induced changes in LV filling pressure and PVR correlated with both the baseline PVR (see Fig 6) and the severity of hemodynamic compromise (see Table 2). It was previously observed that inhaled NO has no hemodynamic effects in control subjects who have a normal PVR.<sup>34</sup> Since the degree of reactive pulmonary hypertension is generally related to the severity of hemodynamic compromise in patients with LV failure, it might be anticipated that patients with more severe heart failure will have a more marked hemodynamic response to inhaled NO. To examine this prediction further, we compared the effects of inhaled NO in a subset of 5 patients with relatively compensated hemodynamics ("compensated group," defined by a pulmonary artery wedge pressure  $\leq 18$  mm Hg and a cardiac index  $\geq 2.5$  L  $\cdot$  m<sup>-1</sup>  $\cdot$  m<sup>-2</sup>) and those of the remaining 14 patients ("decompensated group," defined by a pulmonary artery wedge pressure  $\geq 18$  mm Hg and/or a cardiac index  $< 2.5$  L  $\cdot$  m<sup>-1</sup>  $\cdot$  m<sup>-2</sup>). Although the LV ejection fractions were comparable in the two groups, the baseline PVR was higher in the decompensated group (Table 2). As predicted by our hypothesis, the NO-induced fall in PVR (43% versus 7%) and increase in LV filling pressure (27% versus 0%) were larger in the decompensated group. Taken together, these observations suggest that the greater effect of inhaled NO in patients with decompensated LV failure is due to the greater degree of reactive pulmonary hypertension present in such patients.

A second potential explanation for the decrease in transpulmonary gradient is that inhaled NO exerts a direct negative inotropic effect on the LV, resulting in a primary increase in LV filling pressure. In this scenario, passive pulmonary vasodilation might occur because of recruitment of precapillary vessels, an effect that has been demonstrated in animals.<sup>35</sup> However, we feel that a direct negative inotropic effect of inhaled NO is less likely, for several reasons. First, NO is rapidly inactivated by hemoglobin<sup>1</sup> and might not be expected to reach the coronary circulation under these conditions.

Second, we observed no decrease in LV +dP/dt, a highly sensitive measure of changes in contractile state. Third, it has been shown that in humans, the intracoronary infusion of nitroprusside, to donate NO to the myocardium, has no effect on +dP/dt and, contrary to our findings with inhaled NO, caused a decrease in LV filling pressure apparently due to an increase in ventricular distensibility.<sup>36</sup>

An interesting corollary of these observations is that selective pulmonary vasodilation, in the absence of systemic vasodilation, may not be desirable in patients with severe LV failure. Clearly, inhaled NO, administered alone at the dose used in this study (80 ppm), may have adverse effects in such patients. Nevertheless, the ability of inhaled NO to reduce PVR selectively (ie, without causing systemic vasodilation), resulted in a unique physiological situation and thus provided the basis for these novel observations. Finally, on the basis of these observations, it is intriguing to speculate that an elevation in PVR may play an important adaptive role in patients with LV failure by limiting LV filling and thereby "protecting" the LV from excessive dilation, albeit at the expense of increased right ventricular work.

#### Acknowledgments

This study was supported in part by grants MOI-RR0088, HL-42539, HL-43344, and HL-48763 from the National Institutes of Health (NIH). Dr Loh is the recipient of Physician-Scientist Award KL-HL-02514 from the National Heart, Lung, and Blood Institute. Dr Colucci was a Sandoz Established Investigator of the American Heart Association. Dr Loscalzo is the recipient of a Research Career Development Award (HL-02273) from the NIH. We would like to thank Dr Eugene Braunwald for his insightful comments, Erin Graydon for technical assistance with NO gas administration, Dr Jeffrey Drazen for his generous support, the staff of the Cardiac Catheterization Laboratory for their help and patience, and Paula McColgan for expert typing.

#### References

- Palmer RMJ, Ashton DS, Moncada S. Vascular endothelial cells synthesize nitric oxide from L-arginine. *Nature*. 1988;333:664-666.

2. Ignarro LJ, Buga GM, Wood KS, Byrns RE, Chaudhuri G. Endothelium-derived relaxing factor produced and released from artery and vein is nitric oxide. *Proc Natl Acad Sci U S A*. 1987;84:9265-9269.
3. Ignarro LJ. Nitric oxide: a novel signal transduction mechanism for transcellular communication. *Hypertension*. 1990;16:477-483.
4. Ignarro LJ. Biological actions and properties of endothelium-derived nitric oxide formed and released from artery and vein. *Circ Res*. 1989;65:1-21.
5. Ignarro LJ, Byrns RE, Wood KS. Endothelium-dependent modulation of cGMP levels and intrinsic smooth muscle tone in isolated bovine intrapulmonary artery and vein. *Circ Res*. 1987;60:82-92.
6. Ignarro LJ, Byrns RE, Buga GM, Wood KS. Endothelium-derived relaxing factor from pulmonary artery and vein possesses pharmacologic and chemical properties identical to those of nitric oxide radical. *Circ Res*. 1987;61:866-879.
7. Cremona G, Dinh Xuan AT, Higenbottam TW. Endothelium-derived relaxing factor and the pulmonary circulation. *Lung*. 1991;169:185-202.
8. Dinh-Xuan AT. Endothelial modulation of pulmonary vascular tone. *Eur Respir J*. 1992;5:757-762.
9. Cremona G, Higenbottam T, Dinh Xuan AT, Wells F, Large S, Stewart S, Wallwork J. Influence of endothelium derived relaxing factor (EDRF) on basal vascular resistance in isolated perfused human lungs. *Thorax*. 1991;46:283. Abstract.
10. Fineman JR, Crowley MR, Heymann MA, Soifer SJ. In vivo attenuation of endothelium-dependent pulmonary vasodilation by methylene blue. *J Appl Physiol*. 1991;71:735-741.
11. Nishiwaki K, Nyhan DP, Rock P, Desai PM, Peterson WP, Pribble CG, Murray PA. N<sup>o</sup>-Nitro-L-arginine and pulmonary vascular pressure-flow relationship in conscious dogs. *Am J Physiol*. 1992;262:H1331-H1337.
12. Fanburg BL. Relationship of the pulmonary vascular endothelium to altered pulmonary vascular resistance: state of the art. *Chest*. 1988;93:101S-105S.
13. Chand N, Altura BM. Acetylcholine and bradykinin relax intrapulmonary arteries by acting on endothelial cells: role in lung vascular diseases. *Science*. 1981;213:1376-1379.
14. Fineman JR, Chang R, Soifer SJ. EDRF inhibition augments pulmonary hypertension in intact newborn lambs. *Am J Physiol*. 1992;262:H1365-H1371.
15. Fineman JR, Heymann MA, Soifer SJ. N<sup>o</sup>-nitro-L-arginine attenuates endothelium-dependent pulmonary vasodilation in lambs. *Am J Physiol*. 1991;260:H1299-H1306.
16. Cody RJ, Haas GJ, Binkley PF, Capers O, Kelley R. Plasma endothelin correlates with the extent of pulmonary hypertension in patients with chronic congestive heart failure. *Circulation*. 1992;85:504-509.
17. Francis GS, Goldsmith SR, Levine TB, Olivari MT, Cohn JN. The neurohumoral axis in congestive heart failure. *Ann Intern Med*. 1984;101:370-377.
18. Kaiser L, Spickard RC, Olivier NB. Heart failure depresses endothelium-dependent responses in canine femoral artery. *Am J Physiol*. 1989;256:H962-H967.
19. Drexler H, Hayoz D, Münzel T, Hornig B, Just H, Brunner HR, Zelis R. Endothelial function in chronic congestive heart failure. *Am J Cardiol*. 1992;69:1596-1601.
20. Kubo SH, Rector RS, Bank AJ, Williams RE, Heifetz SM. Endothelium-dependent vasodilation is attenuated in patients with heart failure. *Circulation*. 1991;84:1589-1596.
21. Katz SD, Biasucci L, Sabba C, Strom JA, Jondeau G, Galvo M, Solomon S, Nikolic S, Forman R, LeJemtel TH. Impaired endothelium-mediated vasodilation in the peripheral vasculature of patients with congestive heart failure. *J Am Coll Cardiol*. 1992;19:918-925.
22. Treasure CB, Vita JA, Cox DA, Fish RD, Gordon JB, Mudge GH, Colucci WS, St John Sutton MG, Selwyn AP, Alexander RW, Ganz P. Endothelium-dependent dilation of the coronary microvasculature is impaired in dilated cardiomyopathy. *Circulation*. 1990;81:772-779.
23. Pepke-Zaba J, Higenbottam TW, Dinh Xuan AT, Stone D, Wallwork J. Inhaled nitric oxide as a cause of selective pulmonary vasodilation in pulmonary hypertension. *Lancet*. 1991;338:1173-1174.
24. Roberts JD Jr, Lang P, Bigatello LM, Vlahakes GJ, Zapol WM. Inhaled nitric oxide in congenital heart disease. *Circulation*. 1993;87:447-453.
25. Rossaint R, Falke KJ, López F, Slama K, Plson U, Zapol WM. Inhaled nitric oxide for the adult respiratory distress syndrome. *N Engl J Med*. 1993;328:399-405.
26. Grossman W. In: Grossman W, Baim DS, eds. *Cardiac Catheterization, Angiocardiology and Intervention*. 4th ed. Philadelphia, Pa: Lea & Febiger; 1991:105-122.
27. Brady AJB, Warren JB, Poole-Wilson PA, Williams TJ, Harding SE. Nitric oxide attenuates cardiac myocyte contraction. *Am J Physiol*. 1993;H176-H182.
28. McLaurin LP, Rolett EL, Grossman W. Impaired left ventricular relaxation during pacing-induced ischemia. *Am J Cardiol*. 1973;32:751-757.
29. Hirota Y. A clinical study of left ventricular relaxation. *Circulation*. 1980;62:756-763.
30. Lundin S, Kieler-Jensen N, Waagstein F, Wennmalm A. Hemodynamic effects and metabolic fate of inhaled nitric oxide in patients with severe congestive heart failure. *Circulation*. 1992;86(suppl 1):I-770. Abstract.
31. Semigran MJ, Cockrill BA, Kacmarek R, Thompson BT, Zapol WA, Dec GW, Fifer MA. Nitric oxide is an effective pulmonary vasodilator in cardiac transplant candidates with pulmonary hypertension. *J Am Coll Cardiol*. 1993;21:428A. Abstract.
32. Keren G, Katz S, Strom J, Sonnenblick EH, LeJemtel TH. Non-invasive quantification of mitral regurgitation in dilated cardiomyopathy: correlation of two Doppler echocardiographic methods. *Am Heart J*. 1988;116:758-764.
33. Keren G, Katz S, Strom J, Sonnenblick EH, LeJemtel TH. Dynamic response to load alterations and inotropic therapy in severe heart failure. *Circulation*. 1989;80:3066-313.
34. Frostell CG, Blomquist H, Hedenstierna G, Lundberg J, Zapol WM. Inhaled nitric oxide reverses human hypoxic pulmonary vasoconstriction without causing systemic vasodilation. *Anesthesiology*. 1993;78:427-435.
35. Hakim TS, Michel RP, Chang HK. Partitioning of pulmonary vascular resistance in dogs by arterial and venous occlusion. *Am J Physiol*. 1982;52:710-715.
36. Paulus WJ, Vantrimpont PJ, Shah AM. Acute effects of nitric oxide on left ventricular relaxation and diastolic distensibility in humans: assessment by bicoronary sodium nitroprusside infusion. *Circulation*. 1994;89:2070-2078.

# EXHIBIT 5



UNITED STATES PATENT AND TRADEMARK OFFICE	
Application Serial Number	12/820,866
Confirmation Number	2913
Filing Date	22-JUN-2010
Title of Application	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
First Named Inventor	JAMES S. BALDASSARRE
Assignee	IKARIA, INC.
Group Art Unit	1616
Examiner	ARNOLD, ERNST V.
Attorney Docket Number	I001-0002USC1

Mail Stop Amendment  
 Commissioner for Patents  
 P.O. Box 1450  
 Alexandria, VA 22313-1450

DECLARATION OF DOUGLAS A. GREENE, M.D.  
UNDER 37 C.F.R. § 1.132

I, Douglas A. Greene, do hereby declare the following:

1. I currently hold the position of Executive Vice President and Head, Research and Development at INO Therapeutics LLC ("INO"). A copy of my *curriculum vitae* is attached as **Exhibit 1**.
2. I received an undergraduate degree in biology (*cum laude*) from Princeton University in 1966 and a doctoral degree in medicine (M.D.) from Johns Hopkins School of Medicine in 1970.
3. I spent the next thirty years of my medical career (1970-2000) practicing and teaching medicine at some of America's foremost academic medical centers, including Johns Hopkins, Penn, Pitt, and the University of Michigan. At Michigan, I was a full professor of internal medicine, director of the Michigan Diabetes Research and Training Center, and chief of the Division of Endocrinology and Metabolism.

4. In 2000, I left Michigan to join Merck as Executive Vice President in charge of clinical sciences and product development. In this role, I supervised and directly managed all clinical research at Merck Research Laboratories, among other duties.

5. In 2003, I left Merck for Sanofi-Aventis, where I became a Senior Vice President and Chief Medical Officer. My duties at Sanofi-Aventis included overseeing all aspects of pre-clinical and clinical regulatory development of the company's products and overseeing all medical aspects of the company's US business.

6. In 2010, I joined INO, where – as noted above – I am presently Executive Vice President and Head of Research and Development.

7. INO markets pharmaceutical grade nitric oxide (NO) gas under the brand name INOmax<sup>®</sup>. INOmax<sup>®</sup> is administered to patients using INO's proprietary INOvent<sup>®</sup> and INOmax<sup>®</sup> DS devices.

8. INOmax<sup>®</sup> was approved for sale in the United States by the U.S. Food and Drug Administration ("FDA") in 1999 for the treatment of term and near-term ( $\geq 34$  weeks gestational age) neonates with hypoxic respiratory failure ("HRF") associated with clinical or echocardiographic evidence of pulmonary hypertension, a condition also known as persistent pulmonary hypertension in the newborn ("PPHN"). From 2000 to the present, INO has been selling INOmax<sup>®</sup> throughout the United States, Canada and certain other overseas markets.

9. In addition to the approved indication, physicians employ INOmax<sup>®</sup> to treat or prevent pulmonary hypertension and improve blood oxygen levels in a variety of other clinical settings, including in both pediatric and adult patients suffering from acute respiratory distress syndrome ("ARDS"), pediatric and adult patients undergoing cardiac or transplant surgeries, pediatric and adult patients for testing to diagnose reversible pulmonary hypertension, and in pediatric patients with congenital diaphragmatic hernia. In most, if not all, of these applications, INOmax<sup>®</sup> acts by preventing or treating reversible pulmonary vasoconstriction, and improves pulmonary gas exchange.

10. The mechanism of action of INOmax<sup>®</sup> - the selective relaxation of pulmonary blood vessels - is particularly relevant to the transition of the newborn from the fetal to the neonatal environment. During *in utero* development, the fetal lungs are not filled with air. Accordingly, the fetus obtains oxygen from the mother across the placenta into the systemic circulation, whereas the circulation through the lungs is largely shut down because the pulmonary vessels are tightly constricted. Instead of the blood being pumped from the right side of the heart through the fetal lungs and then returning to the left side of the heart to be pumped to the rest of the body, as it is normally after birth, blood from the right side of the fetal heart bypasses the fetal lungs through a patent ductus arteriosus, a blood vessel connecting the outflow of the right heart directly to the systemic circulation.

11. In addition to the patent ductus arteriosus, the fetal heart contains a second anatomical distinction from the neonatal heart - the foramen ovale - as a means for fetal blood to circumvent the nonfunctional fetal lungs while the fetus obtains its oxygen from the placenta. The foramen ovale is a "hole" located in the wall that separates the right and left atria of the heart. The foramen ovale is usually covered by a flap of tissue known as the septum primum, which is located on the inner wall of the left atrium. The septum primum and the foramen ovale together act as a one-way valve that permits blood to be shunted from the right atrium, where blood pressure is usually high due to the high vascular resistance present in the non-functional fetal lungs, into the left atrium for distribution to the body via the left ventricle. As discussed below, nonclosure of a patent foramen ovale after birth, as well as other forms of congenital heart disease, are often associated with a large persistently patent ductus arteriosus.

12. After birth, the pressure in the pulmonary circulatory system drops, reducing the right atrial pressure below that of the left atrium. This shift in pressure causes the septum primum to close off the foramen ovale, and this flap of tissue eventually becomes incorporated into the intra-atrial wall. In certain instances, however, the foramen ovale may remain open or "patent" after birth. In one such case, elevation of pressure in the pulmonary circulatory system (i.e.: pulmonary hypertension due to various causes) can prevent the pressure shift that leads to the closure of the foramen ovale. This condition is known as patent foramen ovale, and the use

of inhaled nitric oxide to decrease pulmonary hypertension is known to be a successful treatment for right-to-left shunting through a patent foramen ovale.<sup>1</sup>

13. At birth, the ductus arteriosus closes and pulmonary vessels relax, thereby redirecting the outflow of the right heart to the now oxygenated lungs, with oxygenated blood then returning to the left side of the heart to be pumped to the rest of the body from the left ventricle. However, in some instances, neonates are born with severe congenital heart disease involving the left ventricle, wherein the left side of the heart lacks the ability to pump blood to the rest of the body. In these instances, a ductus arteriosus that remains open or "patent" is actually beneficial, and in fact is life-saving when combined with pulmonary hypertension, because the reverse pressure created by the pulmonary hypertension creates a right-to-left shunt through the patent ductus arteriosus, thereby permitting the right ventricle to pump oxygenated blood directly to the systemic circulation to maintain organ function; simply put, the patent ductus arteriosus permits the right ventricle to subsume the role of nonfunctional left ventricle in circulating blood to the body. In these circumstances, stealing blood circulation away from the ductus arteriosus would be potentially fatal, and significantly, pulmonary vasoconstriction is also absolutely essential for survival in order to divert sufficient blood from the right heart through the patent ductus arteriosus to the systemic circulation, thus bypassing the non-functional left side of the heart to maintain life. The terminology to describe this situation is "neonates dependent upon right-to-left shunting of blood" for survival.

14. Administration of inhaled nitric oxide (iNO) in the context of such right-to-left shunting would be catastrophic, because reducing or eliminating the pulmonary vasoconstriction would permit blood to be diverted to the lungs and away from the patent ductus arteriosus.<sup>2</sup> Accordingly, an absolute contraindication for the use of iNO in babies dependent upon right-to-

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<sup>1</sup> See Fessler MB et al., *Right-to-left shunting through a patent foramen ovale in right ventricular infarction: improvement of hypoxemic and hemodynamics with inhaled nitric oxide*. J. Clin. Anesth. 15: 371-4, 1993, at 371.

<sup>2</sup> See, e.g., Atz AM, Wessel DL. *Inhaled nitric oxide in the neonate with cardiac disease*. Sem. Perinatol. 21:441-455, 1997, at 452.

left shunting of blood has been contained in the INOmax<sup>®</sup> prescribing information since the original approval of INOmax<sup>®</sup> by the FDA in December, 1999.<sup>3</sup>

15. Pulmonary engorgement also occurs in adults with serious left-sided heart disease due to coronary artery disease (“ischemic cardiomyopathy”), hypertensive heart disease (“hypertensive cardiomyopathy”) or obstructive valvular disease or other conditions that similarly restrict the inflow of blood to the left side of the heart such that engorgement of the pulmonary blood vessels ensues. It is important to note that restriction of left-sided inflow is particularly prominent in the above cardiomyopathies, and is described as diastolic dysfunction.<sup>4</sup> Diastolic dysfunction is extremely common in adult heart disease, especially in the elderly, but is extremely rare in childhood heart disease, which is generally caused by either congenital malformations or viral infections.<sup>5</sup>

16. To summarize, in adults, left-sided ventricular dysfunction is generally ischemic or hypertensive in origin, and is associated with a stiff, non-compliant left ventricle that cannot

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<sup>3</sup> See, Exhibit 2, section 4, Prescribing Information, INOMAX.

<sup>4</sup> See “Diastolic Dysfunction” American Heart Association “Learn and Live” website visited April 13, 2011: “The heart contracts and relaxes with each heartbeat. The contraction part of this cycle is called **systole** (SIS'-to-le). The relaxation portion is called **diastole** (di-AS'-to-le). In some people with heart failure, the contraction function is normal but there's impaired relaxation of the heart. This affects the heart's lower, pumping chambers (the ventricles) specifically. If the relaxation part of the cycle is abnormal, it's called diastolic (di"as-TOL'-ik) dysfunction. Because the ventricle doesn't relax normally, the pressure in it increases and exceeds what's normal as blood for the next heartbeat. (It's harder for all of the blood to go into the ventricle.) This can cause increased pressure and fluid in the blood vessels of the lungs. (This is called pulmonary congestion.) It can also cause increased pressure and fluid in the blood vessels coming back to the heart. (This is called systemic congestion.) People with certain types of cardiomyopathy (kar"-de-o-my-OP'-ah-the) may also have diastolic dysfunction.”

<sup>5</sup> Diastolic dysfunction in children has been described in rare genetic diseases such as Marfan's syndrome [that directly affects the elasticity of connective tissue of the heart and elsewhere], Kawasaki's disease [that creates cardiac ischemia similar to that in adult ischemic cardiomyopathy] or sickle cell disease [that produces fibrotic scars in the myocardium].

fill properly ("diastolic dysfunction"). In contrast, in children, left-sided ventricular dysfunction is generally not of ischemic or hypertensive in origin and is not associated with impaired filling, but rather is associated with a soft, overly elastic heart that cannot push blood out, resulting in impaired emptying ("systolic dysfunction"). Thus, adult left ventricular diastolic dysfunction, but not childhood left ventricular systolic dysfunction, would lead to pulmonary vascular engorgement, requiring caution in the use of iNO.

17. Since the approval of iNO in December 1999, INO has from time-to-time sponsored, supported or otherwise facilitated - under its own FDA Investigational New Drug (IND) application or IND applications filed by other investigators - clinical research exploring the efficacy and safety of iNO in clinical contexts outside the approved indication for PPHN. The results of these investigations are submitted to the FDA and are often published in the medical literature. In May 2004, following detailed consultations with an expert steering committee composed of leading world authorities in pediatric heart and lung disease,<sup>6</sup> INO initiated a multinational randomized controlled 150-patient study entitled "Comparison of Supplemental Oxygen and Nitric Oxide for Inhalation Plus Oxygen in the Evaluation of the Reactivity of the Pulmonary Vasculature During Acute Pulmonary Vasodilator Testing" ("INOT22"). Prior to its initiation, the INOT22 study was reviewed and approved by the Institutional Review Board (IRB) and/or Independent Ethics Committee (IEC) at each of the 18 participating study institutions, and by two independent National Health Authorities (the U.S. FDA and the European Medicines Agency (EMA)). At no time did any of the members of these boards, committees or agencies counsel against giving inhaled nitric oxide to the proposed patient population because of the risk of severe adverse events in pediatric patients (i.e., children) with left ventricular dysfunction.

18. INOT22 was designed and purposed to compare the diagnostic utility of short-term (10 minute) inhalation of iNO alone, iNO plus oxygen ("O<sub>2</sub>") or O<sub>2</sub> alone to children between the ages of 4 weeks and eighteen years with either idiopathic pulmonary arterial

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<sup>6</sup> The steering committee included Dr. David Wessel of the Department of Cardiology, Children's Hospital and the Department of Pediatrics, Harvard Medical School.

hypertension, congenital heart disease with pulmonary arterial hypertension, or childhood forms of cardiomyopathy undergoing diagnostic right heart catheterization and acute pulmonary vasodilatation testing to assess pulmonary vasoreactivity. The rationale for INOT22 were: (1) that in patients with right ventricular failure and lung disorders, the prognosis and course of treatment are determined by acute pulmonary vasodilatation testing (APVT); (2) a reduction in the mean pulmonary artery pressure and pulmonary vascular resistance with acute vasodilator treatment may be used to predict therapeutic efficacy of long-term vasodilator medication; and (3) APVT is also used to evaluate patients being considered for heart or heart/lung transplantation; elevated pulmonary artery pressures and pulmonary vascular resistance place a strain on the right ventricle leading to an increased risk of perioperative morbidity and mortality due to right heart failure post heart transplant. Accordingly, the primary objective of INOT22 was to compare the number of patients who exhibited reversible pulmonary hypertension (vasoreactivity) in response to iNO or iNO plus and oxygen as compared to 100% oxygen alone.

19. Under the direction of the expert steering committee, inclusion and exclusion criteria were established that were intended to ensure the safe use of iNO during the conduct of the study. For example, patients dependent on right-to-left shunting and thereby contraindicated for iNO treatment were not included. Patients also were excluded if they had focal pulmonary infiltrates on chest radiograph, a diagnosis of severe obstructive or restrictive pulmonary disease that significantly contributed to the patient's pulmonary hypertension, had received treatment with iNO within 30 days prior to study initiation or were on other investigational medications, nitroglycerin, sodium nitroprusside, sildenafil, other PDE-5 inhibitors, or prostacyclin, or were pregnant.

20. However, since the inclusion criteria included congenital heart disease or cardiomyopathy, many of the patients had, by design, significant childhood heart disease. This was not considered to pose a significant risk by the experts on the steering committee (1) based on the exclusion of right-to-left shunt-dependent patients, (2) based on prior extensive safe experience with iNO in pediatric patients with congenital heart disease or cardiomyopathy by the

investigators and published in the medical literature,<sup>7</sup> and (3) the very different nature of non-ischemic non-hypertensive childhood heart disease from the ischemic or hypertensive adult form marked by diastolic dysfunction.

21. Surprisingly and unexpectedly, severe adverse events including pulmonary edema and death were noted during the early phase of the study, and the study was stopped. Analysis of the cases revealed that the patients suffering severe adverse events had severe left ventricular dysfunction, largely due to viral cardiomyopathy, and exhibited during their right-sided cardiac catheterizations an increased pulmonary capillary wedge pressure ("PCWP") of greater than 20 mm Hg, indicative of elevated pressures in the upper chamber of the left side of the heart (the left atrium).

22. To determine if there was a correlation between the severe adverse events and the left ventricular dysfunction of the patients that had suffered them, a protocol amendment was submitted to FDA to exclude – on an ongoing basis - patients with severe left ventricular dysfunction with a PCWP greater than 20 mm Hg from further enrollment in the study. The study was then completed. On analyzing the data from the study, the inventors concluded that a correlation did, in fact, exist between the severe adverse events that had occurred during the study and the left ventricular dysfunction of the patients that had suffered them. Accordingly, INO subsequently requested that the FDA add an additional warning to the product labeling for INOmax concerning use of the drug within patients with left ventricular dysfunction. The FDA agreed and included an additional warning in section 5.4 and the Warnings and Precautions section of the INOmax prescribing information (in the US and worldwide).<sup>8</sup>

23. Competent practitioners would understand that the warnings included in section 5.4 and the Warnings and Precautions section of the INOmax prescribing information are intended as a separate warning generally applicable to all patients with left ventricular dysfunction and not limited to those patients having left ventricular dysfunction that also rely on

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<sup>7</sup> See Atz AM et al. *Combined effects of nitric oxide and oxygen during acute pulmonary vasodilator testing*. J. Amer. Coll. Cardio. 33:813-819, 1999, at 814, 818.

<sup>8</sup> See EXHIBIT 2.



right to left shunting of blood. This second category of patients is the subject of a separate section of the US Package Insert which expressly provides that INOmax is contraindicated for patients with this condition. The fact that administration of INOmax would be harmful to patients dependent on right to left shunting of blood has been well known for many years as demonstrated by several of the references that are of record in the present case including [e.g., Atz AM, Wessel DL. *Inhaled nitric oxide in the neonate with cardiac disease*. Sem. Perinatol. 21:441-455, 1997].

24. Furthermore, no competent practitioner would understand the separate warnings in section 5.4 and the Warnings and Precautions section of the INOmax prescribing information, or the disclosure in the present application of the potential for severe adverse events in patients with left ventricular dysfunction as referring to patients dependent on right to left shunting of blood, since it has long been known that the use of INOmax is contraindicated in such patients. Rather, the competent practitioner would understand the additional warnings added at section 5.4 and within the Warnings and Precautions section of the INOmax prescribing information, and the disclosure in the present application of the potential for severe adverse events in patients with left ventricular dysfunction, as a distinct and separate warning and disclosure that administration of INOmax to patients with left ventricular dysfunction generally (even those not dependent on right to left shunting of blood) may result in serious adverse events.

Applicant : Baldassarre et al  
Serial No. : 12/820,866  
Filed : 22JUN10  
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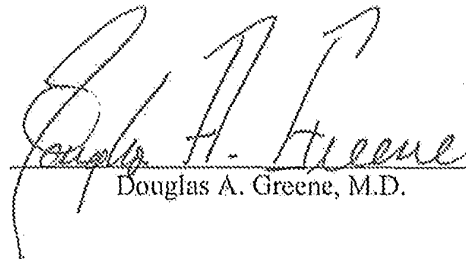
Attorney's Docket No.: 1001-0002USC1

25. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the '359 patent.

26.

Dated

*April 29, 2011*

  
\_\_\_\_\_  
Douglas A. Greene, M.D.

Applicant : Baldassarre et al  
Serial No. : 12/820,866  
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Attorney's Docket No.: I001-0002USC1

# EXHIBIT 1

8112727.1

## CURRICULUM VITAE

### PERSONAL DATA

Name: Douglas Alan Greene, M.D.

### EDUCATION

High School Columbia High School, South Orange, NJ, 1962  
Undergraduate Princeton University, Princeton, NJ, BA Biology(cum laude), 1962-1966  
Graduate/Professional Johns Hopkins School of Medicine, Baltimore, MD, M.D., 1966-1970

### POSTDOCTORAL TRAINING

Medical Internship: Department of Medicine, Johns Hopkins, Baltimore, MD, 1970-1971  
Medical Residency: Department of Medicine, Johns Hopkins, Baltimore, MD, 1971-1972  
Fellowship: Medical Fellowship, Department of Medicine, Johns Hopkins University, School of Medicine, Baltimore, MD, 1970-1972  
  
Post-doctoral Research Fellow, Diabetes, George S. Cox Medical Research Institute; Hospital of the University of Pennsylvania, Philadelphia, PA (Dr. Albert I. Winegrad, preceptor), 1972-1975  
  
Medical Fellowship, Department of Medicine, University of Pennsylvania, School of Medicine, Philadelphia, PA, 1972-1975

### NON-ACADEMIC EMPLOYMENT

2000-2003 Executive Vice President, Clinical Sciences and Product Development (CSPD), Merck Research Laboratories, Rahway, New Jersey, and Corporate Officer, Merck, Inc. Supervised and directly managed all clinical research, regulatory affairs, clinical and non-clinical quality assurance and pharmaco-vigilance at Merck Research Laboratories.

2003-2006 Vice President, Head Corporate Regulatory Development, Sanofi-Aventis, Bridgewater, NJ. Overseeing all aspects of corporate regulatory development of all pre-clinical and clinical development projects/life-cycle products in Research & Development.

2006-2009 Senior Vice President, Chief Medical Officer, Sanofi-Aventis, Bridgewater, NJ. Overseeing medical, regulatory, pharmacovigilance, risk management, education and medical communications for US region, Member US Executive Committee, Member Committee Operational de Development, International Clinical Development.

2009-present Senior Vice President, Senior Scientific Advisor, Sanofi-Aventis, Bridgewater, New Jersey. Member Corporate Portfolio Valuation Process and Drug Development Committees. The position at the interface between the Research and Development and Pharmaceutical Operations is responsible for providing key scientific and medical guidance for sanofi-aventis' scientific strategy within U.S. and global contexts to enhance the quality and effectiveness of the company's research and product portfolio, including assessment and guidance of internal R&D product pipeline and franchise portfolio and external commercial and academic innovation opportunities.

#### ACADEMIC APPOINTMENTS

- |              |  |
|--------------|--|
| 1975-1980    | Assistant Professor of Medicine, University of Pennsylvania, School of Medicine, Philadelphia, Pennsylvania  |
| 1980-1986    | Associate Professor of Medicine, Director, General Clinical Research Center and Diabetes Research Laboratories, University of Pittsburgh, School of Medicine |
| 1986-2000    | Professor of Internal Medicine, Director, Michigan Diabetes Research and Training Center, University of Michigan School of Medicine                          |
| 1991-2000    | Chief, Division of Endocrinology & Metabolism, University of Michigan School of Medicine   |
| 2000-Present | Adjunct Professor, Internal Medicine, Division of Endocrinology & Metabolism, University of Michigan, School of Medicine                                     |

#### SELECTED SCIENTIFIC ACTIVITIES

- |           |   |
|-----------|---|
| 1988-1994 | Chairman, Endocrinologic and Metabolic Drug Advisory Board, Food and Drug Administration, Washington D.C (Chair, 1990-1994) |
| 1994-2000 | Chairman, Merck Scientific Board of Advisors  |

#### SELECTED SCIENTIFIC PRIZES AND AWARDS

- |      |   |
|------|---|
| 1986 | First Annual Raymond A. and Robert L. Kroc Lecturer, Eisenhower Medical Center, Palm Springs, California              |
| 1987 | Moore Award, The American Association of Neuropathologists, Seattle, Washington                                       |
| 1987 | Carol Sinicki Manuscript Award (The Diabetes Educator), American Association of Diabetes Educators, Chicago, Illinois |
| 1988 | Kellion Lecture, International Diabetes Federation, Sydney, Australia   |
| 1989 | Banting and Best Lecture, Toronto General Hospital, Toronto, Canada   |
| 1994 | Charles H. Best Lecturer, Toronto Diabetes Association, Toronto, Canada   |
| 1996 | Invited Speaker, Seventy-fifth Anniversary Celebrating the Discovery of Insulin, Toronto, Canada                      |
| 1996 | First Alan Robinson Lecturer, University of Pittsburgh  |
| 1998 | Outstanding Foreign Investigator Award, Japan Society of Diabetic Complications                                       |

## SELECTED BIBLIOGRAPHY

### *Peer-Reviewed Publications (Selected from over 170 peer-reviewed articles):*

1. Greene DA, DeJesus PV, Winegrad AI: Effect of insulin and dietary Myo-Inositol on impaired peripheral motor nerve conduction velocity in acute streptozotocin diabetes. *J. Clin. Invest.* 55:1326-1336, 1975.
2. Winegrad AI, Greene DA: Diabetic polyneuropathy: The importance of insulin deficiency, hyperglycemia and alterations in myoinositol metabolism in its pathogenesis. *N. Engl. J. Med.* 295:1416-1420, 1976.
3. Greene DA, Lattimer SA: Sodium- and energy dependent uptake of myo-inositol by rabbit peripheral nerve. Competitive inhibition by glucose and lack of an insulin effect. *J. Clin. Invest.* 70:1009-1018, 1982.
4. Greene DA, Lattimer SA: Impaired rat sciatic nerve sodium-potassium ATPase in acute streptozotocin diabetes and its correlation by dietary myo-inositol supplementation. *J. Clin. Invest.* 72:1058-1063, 1983.
5. Greene DA, Lattimer SA: Impaired energy utilization and Na-K-ATPase in diabetic peripheral nerve. *Am. J. Physiol.* 246:E311-E318, 1984.
6. Greene DA, Yagihashi S, Lattimer SA, Sima AAF: Nerve Na<sup>+</sup>+K<sup>+</sup>-ATPase, conduction and myo-inositol in the insulin deficient BB rat. *Am J Physiol* 247:E534-E539, 1984.
7. Greene DA, Lattimer SA: Protein kinase C agonists acutely normalize decreased ouabain-inhibitable respiration in diabetic rabbit nerve: Implications for [Na,K]-ATPase regulation and diabetic complications. *Diabetes* 35:242-245, 1986.
8. Sima AAF, Lattimer SA, Yagihashi S, Greene DA: 'Axo-glial dysjunction' a novel structural lesion that accounts for poorly-reversible slowing of nerve conduction in the spontaneously diabetic BB-rat. *J. Clin. Invest.* 77:474-484, 1986.
9. Greene DA: A sodium-pump defect in diabetic peripheral nerve corrected by sorbinil administration: Relationship to myo-inositol metabolism and nerve conduction slowing. *Metabolism* 35:60-66, 1986.
10. Greene DA, Mackway AM: Decreased myo-inositol content and Na<sup>+</sup>-K<sup>+</sup>-ATPase activity in superior cervical ganglion of STZ-diabetic rat and prevention by aldose reductase inhibition. *Diabetes* 35:1106-1108, 1986.
11. Carroll PB, Thornton BM, Greene DA: Glutathione redox state is not the link between polyol pathway activity and diminished (Na,K)-ATPase activity in experimental diabetic neuropathy. *Diabetes* 35:1282-1285, 1986.
12. Greene DA, Lattimer SA, Sima AAF: Sorbitol, phosphoinositides and the sodium-potassium ATPase in the pathogenesis of diabetic complications. *N. Engl. J. Med.* 316:599-606, 1987.
13. Greene DA, Chakrabarti S, Lattimer SA, Sima AAF: Role of sorbitol accumulation and myo-inositol depletion in paranodal swelling of large myelinated nerve fibers in the insulin-deficient spontaneously diabetic bio-breeding rat: Reversal by insulin replacement, an aldose reductase inhibitor, and myo-inositol. *J. Clin. Invest.* 79:1479-1485, 1987.

14. Sima AAF, Nathaniel V, Bril V, McEwen TAJ, Greene DA: Histopathological heterogeneity of neuropathy in insulin-dependent and non-insulin-dependent diabetes, and demonstration of axo-glial dysjunction in human diabetic neuropathy. *J. Clin. Invest.* 81:349-364, 1988.
15. Greene DA, Lattimer SA, Sima AAF: Perspectives in diabetes: Are disturbances of sorbitol, phosphoinositide, and  $\text{Na}^+\text{-K}^+\text{-ATPase}$  regulation involved in pathogenesis of diabetic neuropathy? *Diabetes* 37:688-693, 1988.
16. Greene DA, Lattimer SA, Sima AA: Pathogenesis and prevention of diabetic neuropathy. *Diabetes Metab Rev* 4:201-221, 1988.
17. Lattimer SA, Sima AAF, Greene DA: In Vitro correction of impaired  $\text{Na}^+\text{-K}^+\text{-ATPase}$  in diabetic nerve by protein kinase C agonists. *Am. J. Physiol.* 256 (Endocrinol. Metab. 19):E264-E269, 1989.
18. Greene DA, Lattimer SA, Sima AAF: Pathogenesis of diabetic neuropathy: Role of altered phosphoinositide metabolism. *CRC Critical Reviews in Neurobiology* (J. Nelson, ed., CRC Press, Inc.), pp. 143-219, 1989.
19. Greene DA, Lattimer SA, Carroll PB, Fernstrom JD, Finogold DN: A defect in sodium-dependent amino acid uptake in diabetic rabbit peripheral nerve: Correction by an aldose reductase inhibitor or myo-inositol administration. *J. Clin. Invest.* 85:1657-1665, 1990.
20. Greene DA, Sima AF, Pfeifer MA, Albers JW. Diabetic Neuropathy. *Annu Rev Med* 41:303-317, 1990.
21. Sima AAF, Prashar A, Zhang W-X, Chakrabarti S, Greene DA: Preventive effect of long-term aldose reductase inhibition (Ponalrestat) on nerve conduction and sural nerve structure in the spontaneously diabetic bio-breeding rat. *J. Clin. Invest.* 85:1410-1420, 1990.
22. Kim J, Kyriazi H, Greene DA: Normalization of (Na,K)-ATPase activity in an isolated membrane fraction from sciatic nerves of streptozotocin-diabetic rats by dietary myo-inositol supplementation in vivo or protein kinase C agonists in vitro. *Diabetes* 40:558-567, 1991.
23. Stevens MJ, Lattimer SA, Kamijo M, Van Huysen C, Sima AAF, Greene DA: Osmotically induced nerve taurine depletion in experimental diabetes: An hypothetical mediator of painful neuropathy. *Diabetologia* 36:608-614, 1993.
24. Henry DN, Del Monte M, Greene DA, Killen PD: Altered aldose reductase gene regulation in cultured human retinal pigment epithelial cells. *J. Clin. Invest.* 92:617-623, 1993.
25. The DCCT Research Group: The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N. Eng. J. Med.* 329:977-986, 1993.
26. Thomas TP, Feldman EL, Nakamura J, Kato K, Lion M, Stevens MJ, Greene DA: Ambient glucose and aldose reductase-induced myo-inositol depletion modulate basal and carbachol-stimulated inositol phospholipid metabolism and diacylglycerol accumulation in human retinal pigment epithelial cells in culture. *Proc. Natl. Acad. Sci. USA* 90:9712-9716, 1993.
27. Thomas TP, Porcellati F, Kato K, Stevens MJ, Sherman WR, Greene DA: Effects of glucose on sorbitol pathway activation, cellular redox, and metabolism of myo-inositol, phosphoinositide and

- diacylglycerol in cultured human retinal pigment epithelial cells. *J. Clin. Invest.* 93:2718-2724, 1994.
28. Stevens MJ, Dananberg J, Feldman EL, Lattimer SA, Kamijo M, Thomas TP, Shindo H, Sima AAF, Greene, DA: The linked roles of nitric oxide, aldose reductase and (NA<sup>+</sup>,K<sup>+</sup>)-ATPase in the slowing of nerve conduction in the streptozotocin diabetic rat. *J. Clin. Invest.* 94:853-859, 1994.
  29. Feldman EL, Stevens MJ, Thomas PK, Brown MB, Canal N, Greene DA: A practical two-step quantitative clinical and electrophysiological assessment for the diagnosis and staging of diabetic neuropathy. *Diabetes Care* 17:1281-1289, 1994.
  30. The DCCT Research Group: The effect of intensive treatment of diabetes on nerve conduction measures in the DCCT. *Annals of Neuro.* 38:869-880, 1995.
  31. Stevens MJ, Feldman EL, Greene DA: The aetiology of diabetic neuropathy: The combined roles of metabolic and vascular defects. *Diabetic Medicine* 12:566-579, 1995.
  32. Shindo H, Thomas TP, Larkin DD, Karihaloo AK, Inada H, Onaya T, Stevens MJ, Greene DA: Modulation of basal nitric oxide-dependent cyclic-GMP production by ambient glucose, myo-inositol, and protein kinase C in SH-SY5Y human neuroblastoma cells. *J Clin Invest* 97:736-745, 1996.
  33. Sima AAF, Ristic H, Merry A, Kamijo M, Lattimer SA, Stevens MJ, Greene DA: Primary preventive and secondary interventional effects of acetyl-L-carnitine on diabetic neuropathy in the bio-breeding Worcester rat. *J Clin Invest* 97:1900-1907, 1996.
  34. Karihaloo A, Kato K, Greene DA, Thomas TP: Protein kinase and cytosolic calcium modulation of myo-inositol transport in cultured retinal pigment epithelial cells. *Am J Physiol* 273:C671-678, 1997.
  35. The DCCT Research Group: Effect of intensive therapy on residual  $\beta$ -cell function in patients with Type I diabetes in the DCCT: A randomized, controlled trial. *Ann Int Med* 128:517-523, 1998.
  36. The DCCT Research Group: The effect of intensive diabetes therapy on measures of autonomic nervous system function in the DCCT. *Diabetologia* 41:416-423, 1998.
  37. Porcellati F, Hlaing T, Togawa M, Stevens MJ, Larkin DD, Hosaka Y, Glover TW, Henry DN, Greene DA, Killen PD: Human Na<sup>+</sup>-myo-inositol cotransporter gene: alternate splicing generates diverse transcripts. *Am J Physio.* 274: C1215-C1225, 1998.
  38. Porcellati F, Hosaka Y Hlaing T, Togawa M, Larkin DD, Karihaloo A, Stevens MJ, Killen PD, Greene DA: alternate splicing in human Na<sup>+</sup>-MI cotransporter gene yields differentially regulated transport isoforms. *Am J Physiol* 276:1325-1337, 1999.
  39. Greene DA, Stevens MJ, Obrosova I, Feldman EL. Glucose-induced oxidative stress and programmed cell death in diabetic neuropathy. *European Journal of Pharmacology* 375:217-223, 1999.
  40. Greene DA, Arczzo JC, Brown MB: Effect of aldose reductase inhibition on nerve conduction and morphometry in diabetic neuropathy. *Neurology* 53:580-591, 1999.



41. Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group: Retinopathy and nephropathy in patients with type 1 diabetes four years after a trial of intensive therapy. *N Engl J Med* 342:381-389, 2000.
42. Sundkvist G, Dahlin LB, Nilsson H, Eriksson KF, Lingarde F, Rosen I, Lattimer SA, Sima AAF, Sullivan KA, Greene DA: Sorbitol and myo-inositol levels and morphology of sural nerve in relation to peripheral nerve function and clinical neuropathy in men with diabetic, impaired, and normal glucose tolerance. *Diabetic Medicine* 17:259-268, 2000.
43. Stevens MJ, Obrosova I, Cao X, Van Huysen C, Greene DA: Effects of DL-alpha-lipoic acid on peripheral nerve conduction, blood flow, energy metabolism and oxidative stress in experimental diabetic neuropathy. *Diabetes* 49:1006-1015, 2000.
44. Obrosova IG, Fathallah L, Greene DA: Early changes in lipid peroxidation and antioxidative defense in diabetic rat retina: effect of DL-alpha-lipoic acid. *Eur J Pharmacol* 398:139-146, 2000.
45. White NH, Cleary PA, Dahms W, Goldstein D, Malone J, Tamborlane WV; Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) Research Group: Beneficial effects of intensive therapy of diabetes during adolescence: outcomes after the conclusion of the Diabetes Control and Complications Trial (DCCT). *J Pediatr* 139:804-812, 2001.
46. Perkins BA, Greene DA, Bril V: Glycemic control is related to the morphological severity of diabetic sensorimotor polyneuropathy. *Diabetes Care* 24: 748-752, 2001.
47. Moller DE, Greene DA: Peroxisome proliferators-activated receptor (PPAR) gamma agonists for diabetes. *Adv Protein Chem* 56:181-212, 2001.
48. Obrosova IG, Van Huysen C, Fathallah L, Cao XC, Greene DA, Stevens MJ: An aldose reductase inhibitor reverses early diabetes-induced changes in peripheral nerve function, metabolism, and antioxidative defense. *FASEB J* 16:123-125, 2002.
49. Pop-Busui R, Marinescu V, Van Huysen C, Li F, Sullivan K, Greene DA, Larkin D, Stevens MJ: Dissection of metabolic, vascular, and nerve conduction interrelationships in experimental diabetic neuropathy by cyclooxygenase inhibition and acetyl-L-carnitine administration. *Diabetes* 51: 2619-2628, 2002.
50. Viberti G, Kahn SE, Greene DA, Herman WH, Zinman B, Holman RR, Haffner SM, Levy D, Lachin JM, Berry RA, Heise MA, Jones NP, Freed MI: A diabetes outcome progression trial (ADOPT): an international multicenter study of the comparative efficacy of rosiglitazone, glyburide, and metformin in recently diagnosed type 2 diabetes. *Diabetes* 25:1737-1743, 2002.
51. The Writing Team for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group: Effect of intensive therapy on the microvascular complications of type 1 diabetes mellitus. *JAMA* 287:2563-2569, 2002.

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## EXHIBIT 2

# INOMax® (nitric oxide) for inhalation

## HIGHLIGHTS OF PRESCRIBING INFORMATION

These highlights do not include all the information needed to use INOMax safely and effectively. See full prescribing information for INOMax.

INOMax (nitric oxide) for inhalation  
Initial U.S. Approval: 1999

### RECENT MAJOR CHANGES

Warnings and Precautions, Heart Failure (5.4) 8/2009

### INDICATIONS AND USAGE

INOMax is a vasodilator, which, in conjunction with ventilatory support and other appropriate agents, is indicated for the treatment of term and near-term (>34 weeks gestation) neonates with hypoxic respiratory failure associated with clinical or echocardiographic evidence of pulmonary hypertension, where it improves oxygenation and reduces the need for extracorporeal membrane oxygenation (1.1).

Monitor for  $P_{50}$ , methemoglobin, and inspired  $NO_2$  during INOMax administration (1.1).

Utilize additional therapies to maximize oxygen delivery (1.1).

### DOSE AND ADMINISTRATION

**Dosage:** The recommended dose of INOMax is 20 ppm, maintained for up to 14 days or until the underlying oxygen desaturation has resolved (2.1).

#### Administration:

- INOMax must be delivered via a system which does not cause generation of excessive inhaled nitrogen dioxide (2.2).
- Do not discontinue INOMax abruptly (2.2).

### DOSE FORMS AND STRENGTHS

INOMax (nitric oxide) is a gas available in 100 ppm and 800 ppm concentrations.

### CONTRAINDICATIONS

Neonates known to be dependent on right-to-left shunting of blood (4).

### WARNINGS AND PRECAUTIONS

**Rebound:** Abrupt discontinuation of INOMax may lead to worsening oxygenation and increasing pulmonary artery pressure (5.1).

**Methemoglobinemia:** Methemoglobin increases with the dose of nitric oxide; following discontinuation or reduction of nitric oxide, methemoglobin levels return to baseline over a period of hours (5.2).

**Elevated  $NO_2$  Levels:**  $NO_2$  levels should be monitored (5.3).

**Heart Failure in neonates with pre-existing left ventricular dysfunction:** Inhaled nitric oxide may increase pulmonary capillary wedge pressure leading to pulmonary edema (5.4).

### ADVERSE REACTIONS

Methemoglobinemia and elevated  $NO_2$  levels are dose dependent adverse events. Worsening oxygenation and increasing pulmonary artery pressure occur if INOMax is discontinued abruptly. Other adverse reactions that occurred in more than 5% of patients receiving INOMax in the CIRRI study were: thrombocytopenia, hypokalemia, bilirubinemia, atelectasis, and hypotension (6).

To report SUSPECTED ADVERSE REACTIONS, contact INO Therapeutics at 1-877-666-8466 and <http://www.inomax.com/> or FDA at 1-800-FDA-1088 or [www.fda.gov/medwatch](http://www.fda.gov/medwatch).

### DRUG INTERACTIONS

**Nitric oxide donor agents:** Nitric oxide donor compounds, such as pilocaine, sodium nitroprusside, and nitroglycerin, when administered as oral, parenteral, or topical formulations, may have an additive effect with INOMax on the risk of developing methemoglobinemia (7).

Revised: August 2009

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2.2 Administration

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\*Sections or subsections omitted from the full prescribing information are not listed.

## FULL PRESCRIBING INFORMATION

### 1 INDICATIONS AND USAGE

#### 1.1 Treatment of Hypoxic Respiratory Failure

INOmax® is a vasodilator, which, in conjunction with ventilatory support and other appropriate agents, is indicated for the treatment of term and near-term (>24 weeks) neonates with hypoxic respiratory failure associated with clinical or echocardiographic evidence of pulmonary hypertension, where it improves oxygenation and reduces the need for extracorporeal membrane oxygenation.

Utilize additional therapies to maximize oxygen delivery. In patients with collapsed alveoli, additional therapies might include surfactant and high-frequency oscillatory ventilation.

The safety and effectiveness of inhaled nitric oxide have been established in a population receiving other therapies for hypoxic respiratory failure, including vasodilators, intravenous fluids, bicarbonate therapy, and mechanical ventilation. Different dose regimens for nitric oxide were used in the clinical studies (see Clinical Studies [14]).

Monitor for PaO<sub>2</sub>, methemoglobin, and inspired NO<sub>2</sub> during INOmax administration.

### 2 DOSAGE AND ADMINISTRATION

#### 2.1 Dosage

##### Term and near-term neonates with hypoxic respiratory failure

The recommended dose of INOmax is 20 ppm. Treatment should be maintained up to 14 days or until the underlying oxygen desaturation has resolved and the neonate is ready to be weaned from INOmax therapy.

An initial dose of 20 ppm was used in the NINOS and CIRNFI trials. In CIRNFI, patients whose oxygenation improved with 20 ppm were dose-reduced to 5 ppm as tolerated at the end of 4 hours of treatment. In the NINOS trial, patients whose oxygenation failed to improve on 20 ppm could be increased to 80 ppm, but those patients did not then improve on the higher dose. As the risk of methemoglobinemia and elevated NO<sub>2</sub> levels increases significantly when INOmax is administered at doses >20 ppm, doses above this level ordinarily should not be used.

#### 2.2 Administration

The nitric oxide delivery systems used in the clinical trials provided operator-determined concentrations of nitric oxide in the breathing gas, and the concentration was constant throughout the respiratory cycle. INOmax must be delivered through a system with these characteristics and which does not cause generation of excessive inhaled nitrogen dioxide. The INOvent® system and other systems meeting these criteria were used in the clinical trials. In the ventilated neonate, precise monitoring of inspired nitric oxide and NO<sub>2</sub> should be instituted, using a properly calibrated analysis device with alarms. The system should be calibrated using a precisely defined calibration mixture of nitric oxide and nitrogen dioxide, such as INOcal®. Sample gas for analysis should be drawn before the Y-piece, proximal to the patient. Oxygen levels should also be measured.

In the event of a system failure or a wall-outlet power failure, a backup battery power supply and reserve nitric oxide delivery system should be available.

Do not discontinue INOmax abruptly, as it may result in an increase in pulmonary artery pressure (PAP) and/or worsening of blood oxygenation (PaO<sub>2</sub>). Deterioration in oxygenation and elevation in PAP may also occur in children with no apparent response to INOmax. Discontinue/wean cautiously.

### 3 DOSAGE FORMS AND STRENGTHS

Nitric oxide is a gas available in 100 ppm and 800 ppm concentrations.

### 4 CONTRAINDICATIONS

INOmax is contraindicated in the treatment of neonates known to be dependent on right-to-left shunt of blood.

### 5 WARNINGS AND PRECAUTIONS

#### 5.1 Rebound

Abrupt discontinuation of INOmax may lead to worsening oxygenation and increasing pulmonary artery pressure.

#### 5.2 Methemoglobinemia

Methemoglobinemia increases with the dose of nitric oxide. In clinical trials, maximum methemoglobin levels usually were reached

approximately 6 hours after initiation of inhalation, although methemoglobin levels have peaked as late as 40 hours following initiation of INOmax therapy. In one study, 13 of 37 (35%) of neonates treated with INOmax 80 ppm had methemoglobin levels exceeding 7%. Following discontinuation or reduction of nitric oxide, the methemoglobin levels returned to baseline over a period of hours.

#### 5.3 Elevated NO<sub>2</sub> Levels

In one study, NO<sub>2</sub> levels were <0.5 ppm when neonates were treated with placebo, 5 ppm, and 20 ppm nitric oxide over the first 48 hours. The 80 ppm group had a mean peak NO<sub>2</sub> level of 2.6 ppm.

#### 5.4 Heart Failure

Patients who had pre-existing left ventricular dysfunction treated with inhaled nitric oxide, even for short durations, experienced serious adverse events from pulmonary edema.

### 6 ADVERSE REACTIONS

Because clinical trials are conducted under widely varying conditions, adverse reaction rates observed in the clinical trials of a drug cannot be directly compared in rates in the clinical trials of another drug and may not reflect the rates observed in practice. The adverse reaction information from the clinical studies does, however, provide a basis for identifying the adverse events that appear to be related to drug use and for approximating rates.

#### 6.1 Clinical Trials Experience

Controlled studies have included 325 patients on INOmax doses of 5 to 80 ppm and 251 patients on placebo. Total mortality in the pooled trials was 11% on placebo and 9% on INOmax, a result adequate to exclude INOmax mortality being more than 40% worse than placebo.

In both the NINOS and CIRNFI studies, the duration of hospitalization was similar in INOmax and placebo-treated groups.

From all controlled studies, at least 6 months of follow-up is available for 278 patients who received INOmax and 212 patients who received placebo. Among these patients, there was no evidence of an adverse effect of treatment on the need for rehospitalization, special medical services, pulmonary disease, or neurological sequelae.

In the NINOS study, treatment groups were similar with respect to the incidence and severity of intracranial hemorrhage, Grade IV hemorrhage, periventricular leukomalacia, cerebral infarction, seizures requiring anticonvulsant therapy, pulmonary hemorrhage, or gastrointestinal hemorrhage.

The table below shows adverse reactions that occurred in at least 5% of patients receiving INOmax in the CIRNFI study with event rates >5% and greater than placebo event rates. None of the differences in these adverse reactions were statistically significant when inhaled nitric oxide patients were compared to patients receiving placebo.

Table 1:  
Adverse Reactions in the CIRNFI Study

Adverse Event	Placebo (n=89)	Inhaled NO (n=97)
Hypochromia	9 (10%)	13 (13%)
Withdrawal	9 (10%)	12 (12%)
Atelectasis	8 (9%)	9 (9%)
Hematuria	5 (6%)	5 (5%)
Hypoglycemia	5 (7%)	8 (8%)
Sepsis	2 (2%)	7 (7%)
Infection	2 (2%)	6 (6%)
Stridor	3 (3%)	5 (5%)
Cellulitis	0 (0%)	5 (5%)

#### 6.2 Post-Marketing Experience

The following adverse reactions have been identified during post-approval use of INOmax. Because these reactions are reported voluntarily from a population of uncertain size, it is not always possible to estimate their frequency reliably or to establish a causal relationship to drug exposure. The listing is alphabetical; dose errors associated with the delivery system; headaches associated with environmental exposure of INOmax; in hospital staff; hypotension associated with acute withdrawal of the drug; hypoxemia associated with acute withdrawal of the drug; pulmonary edema in patients with CHEST syndrome.

## 7 DRUG INTERACTIONS

No formal drug-interaction studies have been performed, and a clinically significant interaction with other medications used in the treatment of hypoxic respiratory failure cannot be excluded based on the available data. INOmax has been administered with ketazoline, dopamine, dobutamine, steroids, surfactant, and high-frequency ventilation. Although there are no study data to evaluate the possibility, nitric oxide donor compounds, including sodium nitroprusside and nitroglycerin, may have an additive effect with INOmax on the risk of developing methemoglobinemia. An association between propofol and an increased risk of methemoglobinemia, particularly in infants, has specifically been described in a literature case report. This risk is present whether the drugs are administered as oral, parenteral, or topical formulations.

## 8 USE IN SPECIFIC POPULATIONS

### 8.1 Pregnancy

Pregnancy Category C

Animal reproduction studies have not been conducted with INOmax. It is not known if INOmax can cause fetal harm when administered to a pregnant woman or can affect reproductive capacity. INOmax is not intended for adults.

### 8.2 Labor and Delivery

The effect of INOmax on labor and delivery in humans is unknown.

### 8.3 Nursing Mothers

Nitric oxide is not indicated for use in the adult population, including nursing mothers. It is not known whether nitric oxide is excreted in human milk.

### 8.4 Pediatric Use

Nitric oxide for inhalation has been studied in a neonatal population (up to 14 days of age). No information about its effectiveness in other age populations is available.

### 8.5 Geriatric Use

Nitric oxide is not indicated for use in the adult population.

## 10 OVERDOSAGE

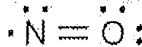
Overdosage with INOmax will be manifest by elevations in methemoglobin and pulmonary toxicities associated with inspired  $\text{NO}_2$ . Elevated  $\text{NO}_2$  may cause acute lung injury. Elevations in methemoglobinemia reduce the oxygen delivery capacity of the circulation. In clinical studies,  $\text{NO}_2$  levels  $>3$  ppm or methemoglobin levels  $>7\%$  were treated by reducing the dose of, or discontinuing, INOmax.

Methemoglobinemia that does not resolve after reduction or discontinuation of therapy can be treated with intravenous vitamin C, intravenous methylene blue, or blood transfusion, based upon the clinical situation.

## 11 DESCRIPTION

INOmax (nitric oxide gas) is a drug administered by inhalation. Nitric oxide, the active substance in INOmax, is a pulmonary vasodilator. INOmax is a gaseous blend of nitric oxide and nitrogen (0.08% and 99.92%, respectively for 800 ppm; 0.01% and 99.99%, respectively for 100 ppm). INOmax is supplied in aluminum cylinders as a compressed gas under high pressure (2000 pounds per square inch gauge [psig]).

The structural formula of nitric oxide (NO) is shown below:



## 12 CLINICAL PHARMACOLOGY

### 12.1 Mechanism of Action

Nitric oxide is a compound produced by many cells of the body. It relaxes vascular smooth muscle by binding to the heme moiety of cytosolic guanylate cyclase, activating guanylate cyclase and increasing intracellular levels of cyclic guanosine 3',5'-monophosphate, which then leads to vasodilation. When inhaled, nitric oxide selectively dilates the pulmonary vasculature, and because of efficient scavenging by hemoglobin, has minimal effect on the systemic vasculature.

INOmax appears to increase the partial pressure of arterial oxygen ( $\text{PaO}_2$ ) by dilating pulmonary vessels in better ventilated areas of the lung, redistributing pulmonary blood flow away from lung regions with low ventilation/perfusion (V/Q) ratios toward regions with normal ratios.

### 12.2 Pharmacodynamics

#### Effects on Pulmonary Vascular Tone in PPHN

Persistent pulmonary hypertension of the newborn (PPHN) occurs as a primary developmental defect or as a condition secondary to other diseases such as meconium aspiration syndrome (MAS), pneumonia, sepsis, hyaline membrane disease, congenital diaphragmatic hernia (CDH), and pulmonary hypoplasia. In these states, pulmonary vascular resistance (PVR) is high, which results in hypoxemia secondary to right-to-left shunting of blood through the patent ductus arteriosus and foramen ovale. In neonates with PPHN, INOmax improves oxygenation (as indicated by significant increases in  $\text{PaO}_2$ ).

### 12.3 Pharmacokinetics

The pharmacokinetics of nitric oxide has been studied in adults.

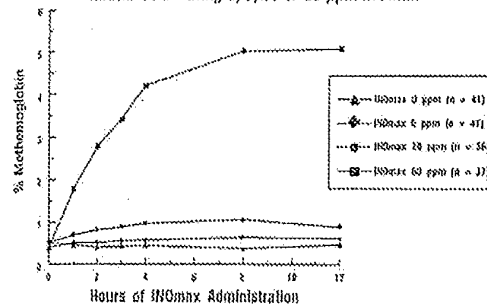
### 12.4 Pharmacokinetics: Uptake and Distribution

Nitric oxide is absorbed systemically after inhalation. Most of it traverses the pulmonary capillary bed where it combines with hemoglobin that is 60% to 100% oxygen-saturated. At this level of oxygen saturation, nitric oxide combines predominantly with oxyhemoglobin to produce methemoglobin and nitrate. At low oxygen saturation, nitric oxide can combine with deoxyhemoglobin to transiently form nitrosylhemoglobin, which is converted to nitrogen oxides and methemoglobin upon exposure to oxygen. Within the pulmonary system, nitric oxide can combine with oxygen and water to produce nitrogen dioxide and nitrite, respectively, which interact with oxyhemoglobin to produce methemoglobin and nitrate. Thus, the end products of nitric oxide that enter the systemic circulation are predominantly methemoglobin and nitrate.

### 12.5 Pharmacokinetics: Metabolism

Methemoglobin disposition has been investigated as a function of time and nitric oxide exposure concentration in neonates with respiratory failure. The methemoglobin (MetHb) concentration-time profiles during the first 12 hours of exposure to 0, 5, 20, and 80 ppm INOmax are shown in Figure 1.

Figure 1:  
Methemoglobin Concentration - Time Profiles  
Neonates Inhaling 0, 5, 20 or 80 ppm INOmax



Methemoglobin concentrations increased during the first 8 hours of nitric oxide exposure. The mean methemoglobin level remained below 1% in the placebo group and in the 5 ppm and 20 ppm INOmax groups, but reached approximately 5% in the 80 ppm INOmax group. Methemoglobin levels  $>7\%$  were attained only in patients receiving 80 ppm, where they comprised 35% of the group. The average time to reach peak methemoglobin was  $10 \pm 9$  (SD) hours (median, 8 hours) in these 13 patients, but one patient did not exceed 7% until 40 hours.

### 12.6 Pharmacokinetics: Elimination

Nitrate has been identified as the predominant nitric oxide metabolite excreted in the urine, accounting for  $>70\%$  of the nitric oxide dose inhaled. Nitrate is cleared from the plasma by the kidney at rates approaching the rate of glomerular filtration.

## 13 NONCLINICAL TOXICOLOGY

### 13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility

No evidence of a carcinogenic effect was apparent, at inhalation exposures up to the recommended dose (20 ppm), in rats for 20 hr/day for up to two years. Higher exposures have not been investigated.

Nitric oxide has demonstrated genotoxicity in Salmonella (Ames Test), human lymphocytes, and after *in vivo* exposure in rats. There are no animal or human studies to evaluate nitric oxide for effects on fertility.

#### 14 CLINICAL STUDIES

##### 14.1 Treatment of Hypoxic Respiratory Failure (HRF)

The efficacy of INOmax has been investigated in term and near-term newborns with hypoxic respiratory failure resulting from a variety of etiologies. Inhalation of INOmax reduces the oxygenation index (OI= mean airway pressure in cm H<sub>2</sub>O × fraction of inspired oxygen concentration [FIO<sub>2</sub>] × 100 divided by systemic arterial concentration in mm Hg [PaO<sub>2</sub>]) and increases PaO<sub>2</sub> [see *Clinical Pharmacology* (12.1)].

##### NINOS Study

The Neonatal Inhaled Nitric Oxide Study (NINOS) group conducted a double-blind, randomized, placebo-controlled, multicenter trial in 235 neonates with hypoxic respiratory failure. The objective of the study was to determine whether inhaled nitric oxide would reduce the occurrence of death and/or initiation of extracorporeal membrane oxygenation (ECMO) in a prospectively defined cohort of term or near-term neonates with hypoxic respiratory failure unresponsive to conventional therapy. Hypoxic respiratory failure was caused by meconium aspiration syndrome (MAS; 49%), pneumonia/sepsis (21%), idiopathic primary pulmonary hypertension of the newborn (PPHN; 17%), or respiratory distress syndrome (RDS; 11%). Infants ≤14 days of age (mean, 1.7 days) with a mean PaO<sub>2</sub> of 46 mm Hg and a mean oxygenation index (OI) of 43 cm H<sub>2</sub>O / mm Hg were initially randomized to receive 100% O<sub>2</sub> with (n=114) or without (n=121) 20 ppm nitric oxide for up to 14 days. Response to study drug was defined as a change from baseline in PaO<sub>2</sub> 30 minutes after starting treatment (full response = >20 mm Hg, partial = 10–20 mm Hg, no response = <10 mm Hg). Neonates with a less than full response were evaluated for a response to 80 ppm nitric oxide or control gas. The primary results from the NINOS study are presented in Table 2.

Table 2:  
Summary of Clinical Results from NINOS Study

	Control (n=121)	NO (n=114)	P value
Death or ECMO*†	77 (64%)	52 (46%)	0.006
Death	20 (17%)	16 (14%)	0.60
ECMO	66 (55%)	44 (39%)	0.014

\* Extracorporeal membrane oxygenation

† Death or need for ECMO was the study's primary end point

Although the incidence of death by 120 days of age was similar in both groups (NO, 14%; control, 17%), significantly fewer infants in the nitric oxide group required ECMO compared with controls (39% vs. 55%, p = 0.014). The combined incidence of death and/or initiation of ECMO showed a significant advantage for the nitric oxide treated group (46% vs. 64%, p = 0.006). The nitric oxide group also had significantly greater increases in PaO<sub>2</sub> and greater decreases in the OI and the alveolar-arterial oxygen gradient than the control group (p<0.001 for all parameters). Significantly more patients had at least a partial response to the initial administration of study drug in the nitric oxide group (66%) than the control group (26%, p<0.001). Of the 125 infants who did not respond to 20 ppm nitric oxide or control, similar percentages of NO-treated (18%) and control (20%) patients had at least a partial response to 80 ppm nitric oxide for inhalation or control drug, suggesting a lack of additional benefit for the higher dose of nitric oxide. No infant had study drug discontinued for toxicity. Inhaled nitric oxide had no detectable effect on mortality. The adverse events collected in the NINOS trial occurred at similar incidence rates in both treatment groups [see *Adverse Reactions* (6.1)]. Follow-up exams were performed at 18–24 months for the infants enrolled in this trial. In the infants with available follow-up, the two treatment groups were similar with respect to their mental, motor, audiologic, or neurologic evaluations.

##### CINRGI Study

This study was a double-blind, randomized, placebo-controlled, multicenter trial of 186 term and near-term neonates with pulmonary hypertension and hypoxic respiratory failure. The primary objective of the study was to determine whether INOmax would reduce the receipt

of ECMO in these patients. Hypoxic respiratory failure was caused by MAS (35%), idiopathic PPHN (30%), pneumonia/sepsis (24%), or RDS (8%). Patients with a mean PaO<sub>2</sub> of 54 mm Hg and a mean OI of 44 cm H<sub>2</sub>O / mm Hg were randomly assigned to receive either 20 ppm INOmax (n=97) or nitrogen gas (placebo; n=89) in addition to their ventilatory support. Patients who exhibited a PaO<sub>2</sub> >60 mm Hg and a pH < 7.55 were weaned to 5 ppm INOmax or placebo. The primary results from the CINRGI study are presented in Table 3.

Table 3:  
Summary of Clinical Results from CINRGI Study

	Placebo	INOmax	P value
ECMO*†	51/89 (57%)	30/97 (31%)	<0.001
Death	5/89 (6%)	3/97 (3%)	0.48

\* Extracorporeal membrane oxygenation

† ECMO was the primary end point of this study

Significantly fewer neonates in the INOmax group required ECMO compared to the control group (31% vs. 57%, p<0.001). While the number of deaths were similar in both groups (INOmax, 3%; placebo, 6%), the combined incidence of death and/or receipt of ECMO was decreased in the INOmax group (33% vs. 58%, p<0.001).

In addition, the INOmax group had significantly improved oxygenation as measured by PaO<sub>2</sub>, OI, and alveolar-arterial gradient (p<0.001 for all parameters). Of the 97 patients treated with INOmax, 2 (2%) were withdrawn from study drug due to methemoglobin levels >4%. The frequency and number of adverse events reported were similar in the two study groups [see *Adverse Reactions* (6.1)].

##### 14.2 Ineffective in Adult Respiratory Distress Syndrome (ARDS) ARDS Study

In a randomized, double-blind, parallel, multicenter study, 385 patients with adult respiratory distress syndrome (ARDS) associated with pneumonia (46%), surgery (33%), multiple trauma (26%), aspiration (23%), pulmonary contusion (18%), and other causes, with PaO<sub>2</sub>/FIO<sub>2</sub> <250 mm Hg despite optimal oxygenation and ventilation, received placebo (n=193) or INOmax (n=192), 5 ppm, for 4 hours to 28 days or until weaned because of improvements in oxygenation. Despite acute improvements in oxygenation, there was no effect of INOmax on the primary endpoint of days alive and off ventilator support. These results were consistent with outcome data from a smaller dose ranging study of nitric oxide (1.25 to 80 ppm). INOmax is not indicated for use in ARDS.

#### 16 HOW SUPPLIED/STORAGE AND HANDLING

INOmax (nitric oxide) is available in the following sizes:

Size D	Portable aluminum cylinders containing 353 liters at STP of nitric oxide gas in 800 ppm concentration in nitrogen (delivered volume 344 liters) (NDC 64693-002-01)
Size D	Portable aluminum cylinders containing 353 liters at STP of nitric oxide gas in 100 ppm concentration in nitrogen (delivered volume 344 liters) (NDC 64693-001-01)
Size 88	Aluminum cylinders containing 1963 liters at STP of nitric oxide gas in 800 ppm concentration in nitrogen (delivered volume 1918 liters) (NDC 64693-002-02)
Size 88	Aluminum cylinders containing 1963 liters at STP of nitric oxide gas in 100 ppm concentration in nitrogen (delivered volume 1918 liters) (NDC 64693-001-02)

Store at 25°C (77°F) with excursions permitted between 15–30°C (59–86°F) [see USP Controlled Room Temperature].

##### Occupational Exposure

The exposure limit set by the Occupational Safety and Health Administration (OSHA) for nitric oxide is 25 ppm, and for NO<sub>2</sub> the limit is 5 ppm.

INO Therapeutics  
6 Route 173 West  
Clinton, NJ 08809  
USA

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SPC-0303 V:4.0

# EXHIBIT 6

USSN: 12/820,866

UNITED STATES PATENT AND TRADEMARK OFFICE	
Application Serial Number	12/820,866
Confirmation Number	2913
Filing Date	22-JUN-2010
Title of Application	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
First Named Inventor	JAMES S. BALDASSARRE
Assignee	IKARIA, INC.
Group Art Unit	1616
Examiner	ARNOLD, ERNST V.
Attorney Docket Number	1001-0002USC1

Mail Stop Amendment  
 Commissioner for Patents  
 P.O. Box 1450  
 Alexandria, VA 22313-1450

DECLARATION OF DAVID L. WESSEL, M.D.  
UNDER 37 C.F.R. § 1.132

I, David L. Wessel, do hereby declare the following:

1. I currently hold the position of Senior Vice President, The Center for Hospital-based Specialties, at Children's National Medical Center in Washington, D.C., where I am also the Division Chief of Critical Care Medicine. I am also the Ikaria Distinguished Professor of Critical Care Medicine. A copy of my *curriculum vitae* is attached as **Exhibit 1**.

2. I received a bachelor's degree (B.S.) in physics from the College of William and Mary in 1972, a bachelor's degree (B.A.) in physiology from Oxford University in 1974, a doctoral degree (*cum laude*) in medicine (M.D.) from the Yale University School of Medicine in 1978, and a master's degree (M.A.) in physiology from Oxford University in 1983.

3. Following my graduation from Yale, the majority of my time as a practicing physician was spent in academic medicine, where I focused on pediatric cardiology. From 1978-1981, I performed an internship in pediatrics followed by a clinical fellowship at the Yale University School of Medicine. From 1981-1985, I was a fellow in pediatric anesthesiology at



Harvard Medical School, where I later became an instructor (1985), assistant professor (1987), associate professor (1994), and ultimately professor (2002), all in the area of pediatrics. In 2011, I will become a professor of pediatrics at the George Washington University School of Medicine and Health Sciences in Washington, DC.

4. In addition to my academic experience, I have extensive experience in the pharmaceutical industry as a member of scientific advisory boards, advisory panels or steering committees for companies such as Pfizer, Johnson & Johnson, Eli Lilly, Bristol-Myers Squibb, Sanofi-Aventis, and INO Therapeutics.<sup>1</sup>

5. In 2005, I chaired the Steering Committee of the Sponsor, INO Therapeutics LLC (INOT), to establish, design and oversee the INOT22 Study. In addition to being the Chair of the INOT22 Steering Committee, I also am the senior author of Atz and Wessel, *Seminars in Perinatology* 1997, 21(5), pp. 441-455 (Atz et al.).

6. At the time of the design of the INOT22 Study protocol, neither I, the other Steering Committee members, nor the study Sponsor appreciated or anticipated that a child with left ventricular dysfunction who is not dependent on right-to-left shunting of blood would be at additional risk when treated with inhaled nitric oxide (iNO). This is the reason such children were not originally excluded from the INOT22 Study entry criteria.

7. Neither the Atz et al. article that I co-authored, nor the medical literature or medical experience of which I was aware at the time, predict this risk. Instead, Atz et al. describes two distinct, independent precautions with respect to the use of iNO. First, with respect to adults, Atz et al. stated that iNO may be more effective in newborns than in older patients, and noted that it should be used with caution in adults with ischemic cardiomyopathy in whom a risk of pulmonary edema is a consideration (see page 452, left column). Second, with respect to neonates, we stated the well-known contraindication (currently found in the INOMAX<sup>®</sup>

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<sup>1</sup> In the interest of full disclosure, I formerly served as a consultant for INO Therapeutics LLC. I currently serve without remuneration as a member of the Ikaria Scientific Board of Advisors. In 2010, I was appointed by my institution as the Ikaria Distinguished Professor of Critical Care Medicine.

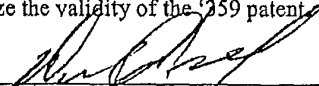
prescribing information) that iNO should not be used in newborns dependent upon right-to-left shunting of blood across a patent ductus arteriosus to avoid circulatory collapse. What we did not disclose or predict was that neonatal patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood would be at greater risk of adverse events.

8. It is ironic that my own publication would be cited to suggest that it would have been obvious to predict the adverse events and outcomes of the INOT22 Study when I, the senior author of Atz et al., failed to anticipate or predict these unexpected outcomes at the time I participated in drafting the original INOT22 Study protocol. If so, I would have been acting either negligently or intentionally to harm babies, and I most certainly was not. Furthermore, to my knowledge, none of the other members of the INOT22 Steering Committee who assisted me in designing the study, nor the approximately 18 Institutional Review Boards and 2 National Health Authorities who reviewed and approved the study prior to its initiation, predicted the adverse events in children with left ventricular dysfunction who are not dependent on right-to-left shunting of blood.

9. In summary, although it was known that neonates dependent on right-to-left shunt should not receive iNO and it had been reported that adults with pre-existing left ventricular dysfunction may be at risk when provided iNO, it was unanticipated and surprising that children with left ventricular dysfunction who are not dependent on right-to-left shunting would be at increased risk of adverse events when administered iNO.

10. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the '359 patent.

Dated: July 15 2011

  
\_\_\_\_\_  
David L. Wessel, M.D.

Applicant : James S. Baldassarre et al.  
Serial No. : 12/820,866  
Filed : June 22, 2010

Attorney Docket No. 26047-0003002

# EXHIBIT 1

## CURRICULUM VITAE

### 1) PERSONAL DATA

Date prepared: April 2011  
Name: David Lloyd Wessel  
Home address: 3251 Prospect St. NW, Suite 404 Washington, D.C. 20007  
Home phone: 202-342-0908  
Office Address: Children's National Medical Center  
111 Michigan Ave, NW Suite 3W-100 Washington, DC 20007  
TEL: 202 476 5047 FAX: 202 476-5868  
E-Mail Address: dwessel@childrensnational.org  
Place of Birth: Newton, Iowa U.S.A.  
Citizenship: United States

### 2) EDUCATION:

1972 B.S. College of William and Mary (Physics), Williamsburg, VA  
1974 B.A. Oxford University (Physiology), Oxford, England  
1978 M.D. Yale University School of Medicine (Medicine), New Haven, CT  
1983 M.A. Oxford University (Physiology), Oxford, England

#### **POSTDOCTORAL TRAINING:**

##### *Internship and Residencies:*

1978-79 Intern in Pediatrics, Yale-New Haven Hospital, New Haven, CT  
1979-80 Resident in Pediatrics, Yale-New Haven Hospital, New Haven, CT  
1981-83 Resident in Anesthesia, Massachusetts General Hospital, Boston, MA

##### *Fellowships:*

1980-81 Fellow in Pediatric Cardiology and Intensive Care, Yale-New Haven Hospital, New Haven, CT  
1983-84 Fellow in Pediatric Cardiology, Children's Hospital, Boston, MA  
1984-85 Fellow in Anesthesia and Intensive Care, Children's Hospital, Boston, MA

### 3) EMPLOYMENT

#### **CHILDREN'S HOSPITAL, BOSTON**

1985-87 Assistant in Anesthesia  
1985-88 Assistant in Cardiology  
1987-00 Associate in Anesthesia  
1988-89 Associate in Cardiology  
1988-07 Associate in Cardiovascular Surgery  
1988-02 Chief, Cardiovascular Intensive Care Unit  
1989-07 Senior Associate in Cardiology  
1995-02 Division Chief  
2000-07 Senior Associate in Anesthesia  
2002-03 Honorary Consultant, Royal Brompton Hospital, London, U.K.

**CHILDREN'S NATIONAL MEDICAL CENTER, WASHINGTON, DC**

- 2007- Interim Chief, Division of Critical Care Medicine
- 2007-09 Executive Director, Center for Hospital Based Specialties
- 2009- Senior Vice President, Center for Hospital Based Specialties
- 2010- IKARIA Distinguished Professor of Critical Care Medicine, Children's National Medical Center, Washington, DC

**ACADEMIC APPOINTMENTS:**

- 1980-81 Fellow in Pediatrics (Cardiology), Yale School of Medicine, New Haven, CT
- 1981-83 Clinical Fellow in Anaesthesia, Harvard Medical School, Boston, MA
- 1983-84 Clinical Fellow in Pediatrics, Harvard Medical School, Boston, MA
- 1984-85 Clinical Fellow in Anaesthesia, Harvard Medical School, Boston, MA
- 1985-86 Instructor in Anaesthesia, Harvard Medical School, Boston, MA
- 1987-93 Assistant Professor of Anaesthesia (Pediatrics), Harvard Medical School, Boston, MA
- 1987-94 Assistant Professor of Pediatrics (Anaesthesia), Harvard Medical School, Boston, MA
- 1994-99 Associate Professor of Pediatrics, Harvard Medical School, Boston, MA
- 1999-02 Associate Professor of Pediatrics (Anaesthesia), Harvard Medical School, Boston, MA
- 2002-03 Visiting Professor Imperial College, University of London, London UK (4/024/03)
- 2002-07 Professor of Pediatrics (Anaesthesia), Harvard Medical School, Boston, MA
- 2011- Professor of Pediatrics, George Washington University School of Medicine and Health Sciences, Washington, DC (pending)

**4) LICENSURE AND CERTIFICATION:**

- 1979 National Board of Medical Examiners
- 1985-07 Massachusetts License Registration
- 1985 American Board of Pediatrics (Permanent)
- 1985 American Board of Pediatrics, Sub-board of Pediatric Cardiology (Permanent)
- 1986 American Board of Anesthesiology (Permanent)
- 1987 American Board of Pediatrics, Sub-board of Critical Care (Re-certified 1996, 2004, 2010)

**5) PROFESSIONAL SOCIETIES & HONORS:**

- 1982- American Society of Anesthesiologists
- 1982-2007 Massachusetts Medical Society
- 1986- American Academy of Pediatrics
- 1987- Society of Critical Care Medicine
- 1987- American Society of Critical Care Anesthesiologists
- 1987- Society of Pediatric Anesthesia
- 1989- American Heart Association (Fellow)
- 1991- Society of Cardiovascular Anesthesiologists
- 1995- Society of Pediatric Research
- 1999- Pediatric Cardiac Intensive Care Society - President 2000-2004; Vice President, Development 2010-

**AWARDS, HONORS AND NAMED LECTURES:**

- 1968 Maytag Scholar (industry sponsored competitive college scholarship)
- 1971 Phi Beta Kappa
- 1971 Omicron Delta Kappa
- 1971 National Physics Honor Society (President)
- 1972 General Honors (William and Mary)
- 1972 Drapers' Scholar (Oxford)
- 1972 Mathematics Honor Society
- 1974 Balliol College Prize (Oxford)
- 1974 First Class Honours (Oxford)
- 1978 Cum Laude (Yale)
- 1978 Alpha Omega Alpha Honor Medical Society
- 1978 Harry S. Greene Prize (Yale)

- 1994 Katkov-Lundeen Memorial Lecture, Minneapolis Children's Hospital, Minneapolis, MN  
 1994 Saul Usher Memorial Lecture, Montreal Children's Hospital, Montreal, Canada  
 1994 Farouk Idriss Memorial Lecture, Children's Memorial Hospital, Chicago, IL  
 1995 A. W. Conn Lecture, Hospital for Sick Children, Toronto, Canada  
 1995 DiCerbo Foundation Lectureship in Pediatric Critical Care, North Shore University Hospital, New York, NY  
 1996 Teaching Award, Pediatric Cardiology, Children's Hospital Boston  
 1997- Listed, *Best Doctors in America*, continuously since inception  
 1999 29<sup>th</sup> Annual Jennifer B. Lalin Lecture, Babies Hospital, Columbia University College of Physicians and Surgeons, New York, NY  
 2000 Tenth Anniversary Lecture, Taiwan Pediatric Association, Critical Care Sub Committee, Kaohsiung Veterans General Hospital, Taipei, Taiwan  
 2001 Recipient, Papas Gift Award for Outstanding Clinical Care (\$25,000 to Children's Hospital Boston)  
 2002 M.A. (Honorary) Harvard University, Cambridge, MA  
 2004 Keynote Address, Opening Ceremony, Annual Meeting of the European Society of Pediatric and Neonatal Intensive Care, London, United Kingdom  
 2004 Leadership & Mentor Award: "In recognition of your contributions toward improving children's heart health," *The Fifth International Symposium on Pediatric Cardiac Intensive Care*-co-sponsored by the Pediatric Cardiac Intensive Care Society and the Texas Children's Heart Center  
 2005 Jared Ellsworth Memorial Lecture, Rainbow Babies and Children's Hospital, Cleveland, Ohio  
 2006 Eddie Farrell Memorial Lecture, Massachusetts Society of Respiratory Care  
 2007 Robert A. Boxer, M.D. Memorial Lecture, Schneider Children's Hospital LIJ, North Shore  
 2010 John J. Downes, Jr., M.D. Lecture, Cardiology 2010, Orlando, FL. Sponsored by Children's Hospital Philadelphia.  
 2010 Outstanding Research Award in Pediatric Cardiology (Council on Cardiovascular Disease in the Young), AHA Scientific Sessions, Chicago, IL  
 2010 Anthony Chang Honorary (Inaugural) Lecture. Pediatric Cardiac Intensive Care Society.

## **6) ADMINISTRATIVE DUTIES & UNIVERSITY ACTIVITIES**

### **HOSPITAL AND HEALTH CARE ORGANIZATION SERVICE RESPONSIBILITIES:**

#### **CHILDREN'S HOSPITAL, BOSTON**

- 1985-91 Attending Physician and Associate Director, Multidisciplinary Intensive Care Unit  
 1985-07 Attending Physician in Cardiology (Intensive Care)  
 1985-07 Attending Physician in Anesthesia (Cardiac)  
 1985-07 Associate in Cardiovascular Surgery (teaching)

#### **CHILDREN'S NATIONAL MEDICAL CENTER, WASHINGTON, DC**

- 2007- Attending Physician in Critical Care Medicine, Cardiology, Cardiac Anesthesia  
 2007- Member, Children's National Heart Institute

### **MAJOR ADMINISTRATIVE RESPONSIBILITIES:**

#### **CHILDREN'S HOSPITAL, BOSTON**

- 1988-02 Director, Cardiac Intensive Care Unit  
 1990 Associate Director, Critical Care Pediatrics Training Program  
 1993-02 Treasurer, Board of Directors, Boston Children's Heart Foundation including investigative and forensic accounting responsibilities surrounding departed chairman (1993-96)  
 1997-98 Board of Directors, Children's Hospital Physicians' Organization, Boston, MA  
 1998-03 Physician Leadership Council, Children's Hospital, Boston, MA  
 1999-02 Medical Director, Pharmacy, Children's Hospital, Boston, MA  
 2000-02 Clinical Sponsor, Critical Care Clinical Information System, Children's Hospital, Boston, MA  
 2003-04 Interdisciplinary Peer Review Assignments and Presentation of Critical Events to JCAHO  
 2004-05 Board of Directors, Boston Children's Heart Foundation  
 2004-05 Physician Leadership Council, Children's Hospital, Boston, MA

CHILDREN'S NATIONAL MEDICAL CENTER, WASHINGTON DC

- 2007- Accountable executive for clinical Center of Excellence; \$200M revenue, more than 700 full time employees. Includes divisions and departments of critical care medicine (both cardiac and pediatric ICI neonatology; hospitalist medicine (inpatient general pediatrics); emergency medicine; radiology; respiratory care services (respiratory therapy); infectious disease, hospital infection control and epidemiology; endocrinology and the diabetes care complex; transport medicine, fetal and transitional medicine, ECM
- 2007- Leadership Council
- 2007- Children's Hospital Foundation Board of Directors
- 2007- Critical Care Committee (Co-Chair)
- 2007- Executive Committee of the Medical Staff
- 2007- Executive Directors Council (Senior Vice President Council 2008-)
- 2007- Hospital Based Specialties (HBS) Leadership Committee (Chair)
- 2007- HBS Campaign Council (Chair)
- 2007- Strategic Planning Council
- 2007- Interim Chief, Division of Critical Care Medicine
- 2008- Healthcare Review Committee (risk management financial governance)
- 2009- Steering Committee Strategic Planning Council (2010-15)

**MAJOR COMMITTEE ASSIGNMENTS:**HARVARD MEDICAL SCHOOL

- 1996-98 Faculty of Care Task Force, Harvard Medical School
- 1999 Search Committee, Chief of Pediatric Pulmonary Medicine, Children's Hospital, Boston, MA
- 2005-07 Ad Hoc Evaluation Committee for Professorial Promotion

CHILDREN'S HOSPITAL, BOSTON

- 1988-93 Multidisciplinary Intensive Care Committee
- 1989-90 Chairman, Hospital Task Force on Sedation
- 1990-92 Hospital HMO Committee
- 1991-92 Medical Staff Quality Improvement Committee
- 1991-93 Department Quality Improvement Officer
- 1991 Hospital Review Committee for Department of Clinical Laboratories
- 1992 Chairman, Nominating Committee, Medical Staff Association
- 1992-99 Chairman, Special Care Units Committee
- 1992 Hospital Search Committee for Director of Clinical Laboratories
- 1992 Physician Advisory Committee on Computers
- 1992 Operations Improvement Committee
- 1993 Hospital Search Committee for MICU Director
- 1993-01 Cardiovascular Program, Quality Improvement Committee
- 1996-98 Product Standardization Council
- 1998-01 Planning and execution committee for ICU electronic clinical information system
- 1998-01 Clinical Oversight Committee for Transport
- 2000 Nominating Committee, Physicians' Organization
- 2000-02 Chairman, Pharmacy and Therapeutics Committee
- 2000-02 Hospital Task Force on Clinical Building and New Construction
- 2000-06 ICU Committee
- 2004-05 Committee on Pension Investments, Physicians' Organization
- 2004-07 Quality and Outcomes Measurement, Physicians' Organization
- 2005-07 Program for Patient Safety and Quality Implementation Committee
- 2006 Hospital Search Committee for Non-invasive Cardiology Division Chief
- 2006-07 Hospital Peer Review Panel
- 2006-07 Physician Profile Task Force

DEPARTMENT OF CARDIOLOGY, CHILDREN'S HOSPITAL, BOSTON

1988-01 Fellowship Selection Committee  
 1998-02 Audit and Finance Committee  
 1998-02 Computing Committee  
 2004-05 Audit and Finance Committee

CHILDREN'S NATIONAL MEDICAL CENTER, WASHINGTON DC

2007-09 Facilities Leadership Committee  
 2007- Growth Management/ CARE  
 2007- NICU Steering Committee  
 2007- Quality and Clinical Effectiveness Committee  
 2007- Quality and Safety Council  
 2007- Information Technology Oversight Committee  
 2007-09 CTI Clinical Advisory Council (electronic medical record)  
 2007- Task Force on Access/Referral  
 2007-08 Hospital Search Committee for Cardiology Division Chief  
 2007- Safety Transformation Advisory Council  
 2009- Executive Oversight Committee (post graduate education)  
 2009- Physicians Advisory Committee (third party payor contracts)  
 2011- Physician Productivity Committee (Chair)  
 2011- Internal Advisory Board, GWU / CNMC, for NIH funded CTSI Award (Chair)

NATIONAL & INTERNATIONAL

1995 Clinical Trials Review Committee (*Ad hoc* reviewer), National Institutes of Health  
 1995-98 Invited Speaker, Cardio-renal Advisory Panel, U.S. Food and Drug Administration  
 2004-06 Task Force ACC AHA AAP: Requirements for Pediatric Cardiac Critical Care Training  
 2005-06 Multi-Societal Committee (PCICS/EACTS/STS) Complications in Pediatric and Congenital Cardiac Surgery Project  
 2008- National Institute of Allergy and Infectious Disease Transplant Data and Safety Monitoring Board (DSMB) - Member  
 2010 FDA Invited Speaker, Continuing Education Series  
 2010 International Liaison Committee on Resuscitation (ILCOR): 2010 Consensus Statement and Treatment Recommendations.  
 2011 Joint American Heart Association (AHA) – American Thoracic Society Expert Guidelines Statement on Pediatric Pulmonary Hypertension.

INDUSTRY

1994-97 Scientific Advisory Board on Nitric Oxide, Ohmeda Pharmaceuticals  
 1998-02 Curriculum Development Committee, INO Therapeutics  
 1999-01 Steering Committee, Prophylactic use of Primacor® in pediatric patients at high risk of developing low cardiac output syndrome following cardiac surgery. PRIMACORP study-Prophylactic intravenous use of milrinone after cardiac operation in pediatrics. Sanofi-Synthelabo Inc.  
 2001-06 Chairman, Advisory Panel INO Therapeutics  
 2001-02 Scientific Advisory Board AGA-Linde  
 2001-03 Protocol Planning Committee (PDE V inhibitors) Pfizer  
 2001-09 Scientific Advisory Board for pulmonary hypertension research development, Pfizer  
 2003 Steering Committee for Multicenter Trial on Diagnostic Use of Inhaled Nitric Oxide  
 2005-07 Steering Committee for Multicenter Trial on Use of Nesiritide in Children, SCIOS (Johnson & Johnson)  
 2005-07 Advisory Committee on Iloprost and Treatment of Pulmonary Hypertension in Children, Cotherix  
 2005-07 Advisory Board, Eli Lilly Vardenafil for Pediatric Pulmonary Hypertension  
 2006- Steering Committee (Chairman) for Multicenter Trial on Use of Clopidogrel in Children (CLARINET), Bristol-Myers Squibb & Sanofi-Aventis  
 2009 Advisory Panel, Nesiritide Use in Pediatric Cardiovascular patients, Johnson & Johnson



**COMMUNITY SERVICE RELATED TO PROFESSIONAL WORK:**

- 1994-97 Lecturer, Human Body Curriculum, Wellesley Public School System, Wellesley, MA
- 1996 Hospital Spokesman, Boston/Filenes' Holiday Festival
- 1996 Campaign for William & Mary, 25<sup>th</sup> Anniversary Committee
- 2000-02 Hospital Spokesman, Capital Campaign and Children's Hospital Boston Fundraising, including keynote speaker, 2000
- 2007- Multiple CNMC Fundraising and Community Benefit Events presentations to Emeritus and Lady Visiting Boards, etc.
- 2008 Speaker, CNMC Corporate Leadership Council "What's Up, Doc?" Breakfast, World Bank, Washington D.C.

**EDITORIAL BOARDS/REVIEW COMMITTEES:**

*Ad Hoc Reviewer:*

Acta Paediatrica  
American Journal of Cardiology, American Journal of Physiology  
American Review of Respiratory Diseases and Critical Care  
Anesthesia & Analgesia, Anesthesiology  
Annals of Thoracic Surgery  
Archives of Diseases of Childhood  
Cardiovascular and Interventional Radiology  
Chest  
Circulation  
Critical Care Medicine  
European Heart Journal  
Future Cardiology  
Journal of Intensive Care Medicine  
Journal of Pediatrics  
Journal of Thoracic and Cardiovascular Surgery  
Mayo Clinic Proceedings  
Pediatrics, Pediatric Cardiology, Pediatric Critical Care Medicine, Pediatric Research  
Proceedings of the National Academy of Science

Invited consultant, to review and make recommendations to institutional programs for pediatric cardiovascular care (national and international)

Asked by Children's Hospital Boston to chair ad hoc committees reviewing sentinel events, other critical incidents and report the hospital's analysis and action to the Hospital's Board of Trustees, JCAHO, etc.

**7) EDUCATIONAL ACHIEVEMENTS**

**REPORT OF TEACHING**

**1. LOCAL CONTRIBUTIONS**

**a) MEDICAL SCHOOL**

Yale University School of Medicine, New Haven, CT

1975-76 Program leader, Cardiovascular physiology core lectures in Physician's Associate Program  
Designed lecture series for new PA program; 20 hours/year

Harvard Medical School, Boston, MA

1983-98 Instructor, Cardiovascular Physiology Animal Laboratory, Harvard Medical School  
Approximately 60 medical students; one day per year

1985-89 Cardiovascular Pathophysiology, Laboratory section on congenital heart disease  
Approximately 30 medical students; half day per year

- 1985-89 PGY clerkship in Pediatrics  
Lecturer in Critical Care (Multidisciplinary ICU)  
2 medical students each lecture; 12 hours/year
- b) GRADUATE MEDICAL EDUCATION (LOCAL)**
- 1985-89 Didactic seminars on cardiovascular pathophysiology for pediatric critical care fellows and rotating residents  
Lecture once per week, 1 hour, 6 trainees per lecture
- 1986-93 Developed and taught core curriculum: introduction to anesthesia and critical care for cardiologists  
Lecture once per week, 1 hour, six weeks, 20 fellows and junior faculty. Preparation, 40 hours per year
- 1985-89 Co-developed tutorials on congenital heart disease and supervised core staff (3 tutors) for instruction of cardiology and cardiac ICU fellows during ICU rotation  
Lectures three mornings per week, 1/2 hour, 34 fellows; preparation, 2 hours per week
- 1985-07 CICU attending rounds  
3 pediatric residents (1985-1989), 4-8 fellows and senior surgical residents; 18 hours/week, 16-40 weeks/year (varies with year)
- 1990-96 Chiefs' Ward Rounds  
3 medical students, 3 pediatric residents, 1 cardiology fellow; monthly 12 hours/year
- 1996-07 Didactic lectures to cardiology fellows teaching program  
20 fellows 3 times per year
- 2002-03 Didactic lectures (monthly) to trainees at Royal Brompton Hospital. London
- c) BOSTON INVITED TEACHING PRESENTATIONS (SELECTED)**
- 1984 Anesthesia Grand Rounds, Children's Hospital, Boston, MA  
1991 Anesthesia Grand Rounds, Children's Hospital, Boston, MA  
1992 Surgical Grand Rounds, Children's Hospital, Boston, MA  
1992 Medical Grand Rounds, Children's Hospital, Boston, MA  
1994 Anesthesia Grand Rounds, Children's Hospital, Boston, MA  
1996 Anesthesia Grand Rounds, Massachusetts General Hospital, Boston, MA  
1996 PICU Teaching Sessions, Massachusetts General Hospital, Boston, MA  
1997 Surgical Grand Rounds, Children's Hospital, Boston, MA  
1997 Medical Grand Rounds, Children's Hospital, Boston, MA  
1998 Anesthesia Grand Rounds, Children's Hospital, Boston, MA  
2003 Grand Rounds and teaching rounds, Royal Brompton Hospital, London, UK  
2004 Neonatology Clinical Working Group, Children's Hospital, Boston, MA  
2004 Department of Respiratory Therapy Clinical Working Group, Children's Hospital, Boston, MA  
2005 Department of Cardiology, Didactic Series, Children's Hospital Boston, Boston, MA
- d) WASHINGTON DC AREA INVITED TEACHING PRESENTATIONS (SELECTED)**
- Chief Rounds Monthly to ICU & Cardiology fellows and staff (15-20 physicians, 2hrs/month), CNMC, DC
  - ICU Attending Rounds, Children's National Medical Center, DC
  - Clinical Research Presentation to ICU/Cardiology Fellows 2 times per year, Children's National Medical Center, DC
  - Grand Rounds, Children's National Medical Center, DC
  - Grand Rounds, Mary Washington Hospital, VA
  - Grand Rounds, Anne Arundel Medical Center, MD
  - Teaching Rounds, Division of Critical Care Medicine, National Institutes of Health

**e) CONTINUING MEDICAL EDUCATION (LOCAL)**

- 1988 Lecturer  
Harvard Medical School, Continuing Education Course in Pediatric Anesthesia  
"Anesthesia for Congenital Heart Disease"
- 1990 Lecturer  
Harvard Medical School Continuing Education Course in Pediatric Anesthesia  
"Common Congenital Cardiac Lesions"
- 1989 Moderator  
Harvard Medical School, Continuing Education Course in Pediatric Cardiovascular Disease
- 1993 Lecturer  
Symposium on Brain Injury and Cardiac Surgery, Harvard Medical School, Boston, MA  
"Choreoathetosis After Cardpulmonary Bypass"
- 1996 Lecturer  
Harvard Medical School Continuing Education Course in Pediatric Anesthesia  
"New Vasoactive Drugs"
- 1998 Co-director, First Annual Course: Frontiers in the Diagnosis and Management of Congenital Heart Disease, Children's Hospital, Boston, Harvard Medical School, Boston, MA
- 1999 Co-director, Second Annual Course: Frontiers in the Diagnosis and Management of Congenital Heart Disease, Children's Hospital, Boston, Newport, Rhode Island
- 2001 Co-director, Third Annual Course: Frontiers in the Diagnosis and Management of Congenital Heart Disease, Children's Hospital, Boston, Newport, Rhode Island

**f) ADVISORY AND SUPERVISORY RESPONSIBILITIES (LOCAL)**

- 1987- Responsible for clinical supervision and educational component of critical care for cardiology fellows in a large pediatric cardiology training program (two months each year for each of 18 fellows spread over 2-3 years of training).
- 1990-02 Responsible as mentor for clinical, educational and clinical research activities of 2-3 senior clinical fellows each year.
- 1985- Shared responsibilities for cardiovascular education and clinical supervision of pediatric critical care fellows in the CICU (3-5 months per year for 5-6 fellows spread over 2-3 years of training).
- 1985-02 Shared responsibilities for critical care educational component of pediatric cardiovascular surgical training program (10 surgical residents each year rotating for 6 months each).
- 1987-02 Responsible for medical education and clinical advisory tasks for continuing education seminars for 80 critical care nurses.

**g) LEADERSHIP ROLE (LOCAL)**

- 1998-01 Program Co-Director  
Annual Course, "Frontiers in Diagnosis and Management of Congenital Heart Disease" Shared responsibility for organizing and executing post graduate course attended by 200 pediatric cardiologists cardiovascular surgeons and nurses from the US and abroad.

h) NAMES OF SELECTED TRAINEES AND/OR FORMER CICU STAFF WHO HAVE CURRENT LEADERSHIP POSITIONS

- 1985-88 Gil Wernovsky, MD, FACC \*†§  
Director of Program Development  
Former Director, Cardiac Intensive Care Unit  
The Children's Hospital of Philadelphia  
Professor of Pediatrics  
University of Pennsylvania School of Medicine  
Philadelphia, Pennsylvania
- 1988-89 Ling Chen, MD \*  
Director, Cardiac Intensive Care Unit  
Shanghai Children's Medical Center  
Shanghai, China
- 1989-92 Pierre C. Wong, MD \*†  
Cardiology Medical Director, Transplantation  
Children's Hospital of Los Angeles  
Los Angeles, California
- 1989-92 Stephen J. Roth, MD, MPH \*†  
Director, Cardiac Intensive Care Unit  
Lucile Packard Children's Hospital  
Associate Professor of Pediatrics  
Stanford University School of Medicine  
Palo Alto, California
- 1989-92 Nancy Bridges, MD  
Chief, Transplantation Immunology Branch, Division of Allergy, Immunology, and  
Transplantation  
National Institute of Allergy and Infectious Disease  
Bethesda, Maryland
- 1990-92 Howard A. Zucker, MD, FACC\*  
Deputy Director of the World Health Organization  
Geneva, Switzerland
- 1990-93 Kevin B. Churchwell, MD  
Chief Executive Officer (CEO) for Nemours/Alfred I. duPont Hospital for Children  
Wilmington, DE.
- 1990-93 Anthony C. Chang, MD \*†§  
Medical Director, CHOC Children's Heart Institute  
Children's Hospital Orange County  
Orange, California
- 1991-94 Ian Adatia, MB, ChB, MRCP (UK), FRCP (C) \*†  
Director, Pediatric Cardiac Critical and Intermediate Care Program,  
Director, Pediatric Pulmonary Hypertension Clinic,  
Stollery Children's Hospital,  
Professor of Pediatrics  
University of Alberta  
Edmonton, Alberta, Canada

- 1992-96 Andrew M. Atz, MD \*†§  
Director, Pediatric Cardiac Intensive Care Unit  
The Children's Heart Program  
Associate Professor of Pediatrics  
Medical University of South Carolina  
Charleston, South Carolina
- 1992-96 David P. Nelson, MD, PhD \*  
Director, Cardiac Intensive Care  
Cincinnati Children's Hospital Medical Center  
Professor of Pediatrics  
Cincinnati, Ohio
- 1992-97 Sarah Tabbutt, MD, PhD \*  
Director, Pediatric Cardiac Intensive Care Unit  
UCSF Children's Hospital  
San Francisco, California
- 1994-97 Ricardo A. Muñoz, MD \*†§  
Director, Pediatric Cardiac Intensive Care  
Director, Global Business and Telemedicine  
Children's Hospital Pittsburgh  
Associate Professor of Pediatrics  
University of Pittsburgh  
Pittsburgh, Pennsylvania
- 1994-99 Melvin C. Almodovar, MD \*†§  
Medical Director, Cardiac Intensive Care Unit  
Boston Children's Hospital  
Assistant Professor  
Harvard Medical School  
Boston, Massachusetts
- 1995-96 Brendan O'Hare, MD \*  
Consultant in Anesthesia and Critical Care  
Our Lady's Hospital for Sick Children  
Crumlin, Dublin, Ireland
- 1995-96 Steven Schwartz, MD  
Director of Cardiac Intensive Care  
Hospital for Sick Children  
Assistant Professor of Pediatrics  
University of Toronto  
Toronto, Ontario, Canada
- 1996-97 Alain Fraisse, MD \*†  
Chief, Clinical Pediatric Cardiology  
Hopital D'Enfants de la Timone  
Professer of Pediatrics  
Universitaire de Marseille  
Marseille, France

- 1997-98 Guillermo Palacio, MD  
Director Pediatric Cardiac Intensive Care Unit  
Fundacion Cardio Infantil  
Bogota, Colombia
- 1997-98 Mary B. Taylor, MD \*  
Director, Pediatric Cardiac Critical Care  
Cardiology and Critical Care  
Vanderbilt Children's Hospital  
Associate Professor of Pediatrics  
Vanderbilt University Medical Center  
Nashville, Tennessee
- 1997-99 Rajiv Chaturvedi, MB BChir, MRCP (UK), MD \*  
Pediatric Cardiology  
Hospital for Sick Children  
Assistant Professor  
University of Toronto  
Toronto, Ontario, Canada
- 1998-01 Ravi Thiagarajan, M.D.\* † §  
Director, Cardiac ECMO Program  
Children's Hospital Boston  
Associate Professor of Pediatrics  
Harvard Medical School  
Boston, Massachusetts
- 1998-02 Peter C. Laussen, MBBS §  
Chief, Division of Cardiovascular Intensive Care  
D.D. Hansen Chair in Pediatric Anesthesia  
Senior Associate in Cardiology  
Children's Hospital Boston  
Professor of Anesthesia  
Harvard Medical School  
Boston, Massachusetts
- 1998-99 Mary P. Mullen, MD, PhD \*§  
Director, Pulmonary Hypertension Program  
Assistant in Cardiology  
Children's Hospital Boston  
Assistant Professor in Pediatrics  
Harvard Medical School  
Boston, Massachusetts
- 1999 Janet M. Simsic, M.D.\*  
Director, Pediatric Cardiac Intensive Care Unit  
Nationwide Children's Hospital  
Columbus, Ohio
- 2000 Erica A. Kirsch, MD\*  
Director of Pediatric ECMO Program  
Associate Professor of Pediatrics  
University of Missouri-Kansas City School of Medicine  
Kansas City, Missouri

2003-05 Margarita Burmester, MBBS\* †  
Consultant in Pediatric Intensive Care  
Royal Brompton Hospital  
Imperial College  
London, United Kingdom

\* Clinical Trainees  
† Research Trainees  
§ Faculty in CICU, Children's Hospital Boston  
during my tenure as Chief

**TEACHING AND EDUCATIONAL LEADERSHIP ROLES (LOCAL AND INTERNATIONAL)**

- 1987 Critical Care Consultant for Project Hope and the Cardiac Intensive Care Unit, Xin Hua, Shanghai, China. Developed teaching program for critical care and supervised clinical training of physicians during 2-6 month exchange programs.
- 1996- Abstract and Program Reviewer for many National and International Societies including SPR, AHA, ACC, PCICS, World Congress
- 2000 Invited faculty and cardiovascular program curriculum track convener III International Congress of Pediatric Intensive Care, Montreal, Canada.
- 2002 Scientific Programme, Coordinator  
The Third Special Topics in Paediatric Cardiac Intensive Care, The Failing Myocardium  
Royal Brompton Hospital, Imperial College, London, United Kingdom
- 2003 Invited faculty and cardiovascular program curriculum track convener IV International Congress of Pediatric Intensive Care, Boston, MA
- 2004 Discussant Leader and Co-author (after Tom Kulik) on Critical Care Training Guidelines in Cardiology (SCCM, PCICS, AHA, ACC)
- 2005 Scientific Program Committee Pediatric Cardiac Intensive Care Symposium 2005 (PCICS 2005), Miami, FL
- 2006 Planning Committee, First International Conference on Childhood Pulmonary Vascular Disease, San Francisco, CA 2007
- 2008 Critical Care Consultant, University of Mississippi Medical Center, Jackson, MS

**TEACHING AWARD(S) RECEIVED**

- 1996 Faculty Teaching Award, Dept. Cardiology, Children's Hospital, Harvard Medical School
- 2010 Top rated faculty teacher for division of critical care medicine in trainee survey

**MAJOR CURRICULUM OFFERING, TEACHING CASES OR INNOVATIVE EDUCATIONAL PROGRAMS DEVELOPED**

- 1990-02 Developed a senior clinical fellowship training program for cardiac intensive care with short term training experience available through formal training program relationships with the MICU, Children's Hospital; PICU, Massachusetts General Hospital; Neonatology, Children's Hospital; Neonatology, University of Vermont. Long term (6-36 month) training program applicants accepted (2-3 per year) from candidates in advanced levels of fellowship training from national and international programs.

- 1988-90 In collaboration with the Cardiovascular Nursing Director, developed, reviewed and edited algorithms for care, nursing practice and clinical practice guidelines and quality improvement manuals for the Cardiovascular Program, Children's Hospital, Bosbn.
- 2004 In collaboration with Pediatric Cardiac Intensive Care Society and the Training Program Directors for Pediatric Cardiology, coauthored (with T. Kulik and others) the report to the Joint Committee on Training Programs (AHA/ACC) on training requirements in critical care for pediatric cardiology trainees.
- 2008 As interim division chief of critical care medicine at Children's National Medical Center, I implemented and supervised a reorganization of the fellowship training program, its leadership and aspects of its curriculum

**8) CONSULTANT APPOINTMENTS**

**VISITING PROFESSORSHIP:**

- 1986 Visiting Professor  
"Critical Care of the Child with Congenital Heart Disease"  
Department of Cardiology, Children's National Medical Center, Washington, D.C.
- 1993 Visiting Professor,  
"Perioperative Care of the Neonate with Congenital Heart Disease"  
University of Southern California, Children's Hospital of Los Angeles
- 1993 Visiting Professor  
"Nitric Oxide and ECMO Therapies for Persistent Pulmonary Hypertension of the Newborn"  
Schneider Children's Hospital, Albert Einstein College of Medicine, New York, NY
- 1994 Visiting Professor  
"Perioperative Care of the Critically Ill Neonate with Congenital Heart Disease; Perioperative Management of Low Cardiac Output"  
Medical University of South Carolina, Charleston, SC
- 1994 Visiting Professor  
"Inhaled Nitric Oxide in the Treatment of Children with Congenital Heart Disease"  
Dennison Young Memorial Symposium, Montefiore Medical Center, New York, NY
- 1994 Visiting Professor  
"Care of the Critically Ill Neonate"  
Minneapolis Children's Hospital, Minneapolis, MN
- 1994 Visiting Professor  
"Therapeutic Applications of Inhaled Nitric Oxide"  
Children's Memorial Hospital, Chicago, IL
- 1994 Visiting Professor  
Grand Rounds: "Treatment of Pulmonary Hypertension"  
Montreal Children's Hospital, Montreal, Canada
- 1995 Visiting Professor  
"Multidisciplinary Management of Complex Congenital Heart Disease"  
Anesthesia and Critical Care Grand Rounds, Hospital for Sick Children  
University of Toronto, Toronto, Canada



- 1995 Visiting Professor  
"Controversy in Critical Care: New Views of Simple Gases (O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub> and NO)"  
Anesthesia Grand Rounds, Children's Hospital of Philadelphia, Philadelphia, PA
- 1995 Visiting Professor  
"Nitric Oxide: Magic and Medicine"  
Medical College of Georgia, Augusta, GA
- 1995 Visiting Professor  
"Controversy in Critical Care: New Views of Simple Gases"  
Children's Hospital of Pittsburgh, Dept of Surgery, University of Pittsburgh, Pittsburgh, PA
- 1995 Visiting Professor  
"Perioperative Care of the Newborn with Congenital Heart Disease"  
Division of Pediatric Cardiology, Yale University School of Medicine, New Haven, CT
- 1997 Visiting Professor  
"Perioperative Care in the Child with Congenital Heart Disease"  
Pediatric Grand Rounds, Vanderbilt Children's Hospital, Nashville, TN
- 2000 Visiting Professor  
"Newborns with Heart Disease: Extending the Limits of Intervention"  
Columbia-Presbyterian Medical Center, Babies Hospital, New York, NY
- 2003 Visiting Professor  
"Treatment of Low Cardiac Output"  
Cardiovascular Rounds, Hospital for Sick Children, Great Ormand Street,  
London, United Kingdom
- 2005 Visiting Professor  
Multiple lectures, University of Pittsburgh, Department of Critical Care Medicine, University of  
Pittsburgh Medical  
Center and the Children's Hospital of Pittsburgh
- 2005 Visiting Professor  
"Progress and problems in the treatment of critical heart disease"  
Ellsworth Memorial Lecture, Pediatric Grand Rounds, Rainbow Babies & Children's Hospital,  
Cleveland, OH
- 2006 Visiting Professor  
"Navigating a career in Medicine". Health Careers Club, College of William & Mary,  
Williamsburg, VA
- 2009 Visiting Professor  
"The Challenges of Postoperative Care of the Child with CHD"  
Pediatric Grand Rounds, Vanderbilt Children's Hospital, Nashville, TN

**9) PRESENTATIONS**

**NATIONAL**

- 1990 Seminar Moderator  
"Cardiovascular Disease"  
Fourth Pediatric Critical Care Colloquium, Waterville, NH

- 1991 Invited Lecture  
"Perioperative Management of Congenital Heart Disease"  
Annual Meeting, Society of Pediatric Anesthesia, San Francisco, CA
- 1992 Workshop Faculty  
"Anesthesia for Congenital Heart Disease"  
Annual Meeting of the Society of Cardiovascular Anesthesiologists, Boston, MA
- 1992 Invited Lectures  
"Perioperative Management & Decision making in the Neonate with Congenital Heart Disease"  
Critical Care Pediatrics Symposium, Arnold Palmer Hospital, Orlando, FL
- 1992 Invited Lectures  
Multiple topics on Critical Care of Children with Heart Disease and  
"Treatment of Pulmonary Hypertension with Inhaled Nitric Oxide"  
First World Congress of Pediatric Critical Care, Baltimore, MD
- 1992 Anesthesia Grand Rounds  
"Postoperative Care of the Child with Congenital Heart Disease"  
Maine Medical Center, Portland, ME
- 1992 Invited Faculty  
"Postoperative Management of the Open Heart Surgery Patient"  
Society of Critical Care Medicine, Pediatric Critical Care Clinical Review Series,  
San Antonio, TX
- 1993 NIH Invited Lecture  
"Nitric Oxide in Congenital Heart Disease"  
National Institutes of Health Workshop: The effects of Nitric Oxide on the Lung, Bethesda, MD
- 1993 NIH Invited Lecture  
"Indications for NO in the Newborn with Heart Disease"  
National Institutes of Health Workshop on Nitric Oxide and the Perinatal Period, Bethesda, MD
- 1993 Symposium  
"Nitric Oxide Gas in the Evaluation and Management of Pulmonary Hypertension"  
Annual Meeting of the American College of Cardiology, Anaheim, CA
- 1993 Invited Lecture  
"New Strategies for Treating Pulmonary Hypertension"  
Annual Meeting, American Academy of Pediatrics, Washington, DC
- 1993 Invited Lecture  
"Use of Inhaled Nitric Oxide for the Acute Treatment of Pulmonary Hypertension in Patients  
with Congenital Heart Disease" Annual Meeting, American Heart Association, Atlanta, GA
- 1993 NIH Workshop Lecture  
"Nitric Oxide in the Perinatal Period" National Institutes of Health, Bethesda, MD
- 1993 Invited Lecture  
"Inhaled Nitric Oxide for the Treatment of Persistent Pulmonary Hypertension of the Newborn"  
Fourth Annual New England ECMO Symposium, Children's Hospital, Boston, MA

- 1993 Symposium  
"Vasodilator Therapy and Inhaled Nitric Oxide in Children" Infant Hearts and Lungs  
Transplantation and Alternative Strategies.  
Children's Hospital of Los Angeles, Long Beach, CA
- 1994 Symposium  
"Update on Nitric Oxide"  
Annual Meeting, Society of Critical Care Medicine, Orlando, FL
- 1994 Symposium  
"Nitric Oxide Gas in the Evaluation and Management of Pulmonary Hypertension"  
Annual Meeting of the American College of Cardiology, Atlanta, GA
- 1994 Invited Lecture  
"Nitric Oxide for Pulmonary Hypertension"  
Post Graduate Course on Congenital Heart Disease  
American Association of Thoracic Surgery, New York, NY
- 1994 Plenary Session  
"Inhaled Nitric Oxide for the Treatment of Pulmonary Hypertension in Children"  
International Conference on Biochemistry and Molecular Biology of Nitric Oxide, University of  
California, Los Angeles, CA
- 1994 Guest Faculty  
"Nitric Oxide in the Treatment of Pulmonary Hypertension in Congenital Heart Disease"  
Pediatric Cardiology-The Failing Heart Conference, Given Biomedical Institute, University of  
Colorado, Aspen, CO
- 1994 Invited Lecture  
"Perioperative Use of Inhaled Nitric Oxide"  
Annual Meeting of the American Academy of Pediatrics, Dallas, TX
- 1994 Invited Faculty  
"Serious Heart Disease of the Neonate: Management"  
American Academy of Pediatrics Neoprep Course, St. Louis, MO
- 1994 Invited Faculty  
"Perioperative Care of the Critically Ill Child with Congenital Heart Disease"  
Society of Critical Care Medicine, Pediatric Critical Care Clinical Review Series, San  
Francisco, CA
- 1995 Invited Lecture  
"Pulmonary Hypertension and Nitric Oxide"  
Annual Meeting, American College of Cardiology, New Orleans, LA
- 1995 Invited Lecture  
"Current Therapeutic Applications of Inhaled Nitric Oxide"  
International Business Communications, Nitric Oxide Conference, Philadelphia, PA
- 1995 Invited Lecture  
"Choreoathetosis After Cardiopulmonary Bypass"  
Annual Meeting, American Society of Extra-Corporeal Technology, Boston, MA
- 1995 Invited Lecture  
"Nitric Oxide for Perioperative Management of Congenital Heart Disease"  
Annual Meeting of the American College of Surgeons, New Orleans, LA

- 1995 Invited Lecture  
Controversy in Critical Care: New Views of Simple Gases  
DiCerbo Foundation Lectureship in Pediatric Critical Care, North Shore University Hospital,  
New York, NY
- 1995 Dinner Speaker  
"Diagnostic and Therapeutic Applications of Inhaled Nitric Oxide"  
Annual Dinner Meeting, New York Society of Pediatric Critical Care Medicine, New York, NY
- 1995 Pediatric Grand Rounds  
"Controversy in Critical Care: New Views of Simple Gases"  
Cornell University Medical Center, New York, NY
- 1995 FDA Invited Lecture  
"Inhaled Nitric Oxide for the Treatment of Persistent Pulmonary Hypertension of the Newborn"  
Open Meeting, Cardiovascular and Renal Drugs Advisory Committee, United States Food &  
Drug Administration, Bethesda, MD
- 1995 FDA Invited Discussant  
"Use of Inhaled Nitric Oxide in Pediatrics"  
Division of Cardioresenal Drug Products, U.S. Food & Drug Administration Rockville, MD
- 1996 Invited Lecture  
"Persistent Pulmonary Hypertension and Alveolar/Capillary Dysplasia"  
Pediatric Grand Rounds, Elliot Hospital, Manchester, NH
- 1996 Invited Lecture  
"Clinical Use of Inhaled Nitric Oxide"  
International Business Communications Nitric Oxide Conference, Philadelphia, PA
- 1996 Seminar Speaker  
"Postoperative Management of Pulmonary Hypertension in Pediatric Patients with Congenital  
or Acquired Heart Disease" Annual Meeting, American College of Cardiology, Orlando, FL
- 1996 Invited Lecture  
"Inhaled Nitric Oxide-Clinical Experience"  
First International Meeting on Pediatric Cardiac Intensive Care, Miami, FL
- 1996 Invited Lecture  
"Pre and Postoperative Manipulation of the Vascular Resistance"  
Annual Meeting, American Heart Association, New Orleans, LA
- 1996 Invited Lecture  
"Current Concepts in Neonatology"  
Section on Perinatology, American Academy of Pediatrics and the Joint Program in  
Neonatology, Harvard Medical School, Boston, MA
- 1997 Seminar  
"Medical Management of Perioperative Pulmonary Hypertension"  
Annual Meeting, Society of Critical Care Medicine, San Diego, CA
- 1997 Invited Lecture  
"Nitric Oxide and the Treatment of Postoperative Pulmonary Hypertension"  
Second World Congress of Pediatric Cardiology and Cardiac Surgery, Honolulu, Hawaii

- 1997      Invited Lecture  
"Inhaled Nitric Oxide for the Treatment of Persistent Pulmonary Hypertension of the Newborn"  
Open Meeting, Division of Cardioresenal Drugs, United States Food & Drug Administration,  
Bethesda, MD
- 1997      Invited Lecture  
"Perioperative Care of the Child with Congenital Heart Disease: New Treatment  
Strategies for Pulmonary Hypertension"  
Cardiothoracic Anesthesia Meeting, Washington University, St. Louis, MO
- 1997      Plenary Session  
"Advances and Controversies in Cardiac Management"  
Tenth Annual Pediatric Critical Care Colloquium, Hot Springs, AR
- 1997      Invited Faculty  
"Critical Care of the Child with Congenital Heart Disease" (moderator lecturer, judge)  
Second International Symposium on Pediatric Cardiac Intensive Care, Palm Beach, FL
- 1997      Invited Speaker  
"Nitric Oxide in Neonatal Care"  
Topics in Neonatal and Respiratory Care, Brigham & Women's Hospital, Boston, MA
- 1998      Invited Lectures  
"Cardiac Surgery in Neonates: Morbidity and Mortality"  
Charleston Symposium on Congenital Heart Disease, Medical University of South Carolina,  
Charleston, SC
- 1998      Symposium  
"Advances in ICU Management for Congenital Heart Disease"  
Annual Meeting, American College of Cardiology, Atlanta, GA
- 1998      Invited Lecture  
"Intensive Care After Neonatal Cardiac Surgery: State-of-the-Art"  
First Annual Course on Frontiers in Diagnosis and Management of Congenital Heart Disease,  
Boston, MA
- 1999      Invited Faculty  
"Myocardial Support for Low Cardiac Output"  
Society of Critical Care Medicine  
Current Concepts in Pediatric Critical Care Course, San Francisco, CA
- 1999      Invited Lecture  
"Nitric Oxide and the Treatment of Pulmonary Hypertension"  
Oral Presentation Moderator, Walk Rounds with the Professor  
28<sup>th</sup> Scientific Symposium, Society of Critical Care Medicine, San Francisco, CA
- 1999      Symposium  
"The Airway, Mechanical Ventilation and Cardiopulmonary Interaction"  
Annual Meeting, American Heart Association, Atlanta, GA
- 1999      Invited Speaker  
"Nitric Oxide and New Therapies"  
Third International Symposium on Pediatric Cardiac Intensive Care, Miami, FL

- 2000 Invited Faculty  
"Nitric Oxide In the Perioperative Management of CHD"  
Cardiology Y2K, Annual Update on Pediatric Cardiovascular Disease, Orlando, FL
- 2000 Symposium  
"Intensive Care Unit Management After Surgery for Single Ventricle HLHS Syndrome"  
Annual Meeting, American College of Cardiology, Anaheim, CA
- 2000 Invited Lecture  
"Perioperative Care of the Premature Newborn with Congenital Heart Disease"  
Castañeda Society Meeting, Boston, MA
- 2000 Invited Faculty  
"Perioperative Care of the Premature Newborn with Congenital Heart Disease"  
Tenth Charleston Symposium on Congenital Heart Disease, Charleston, SC
- 2001 Invited Faculty  
"Clinical Research"  
The Changing Face of Pediatric Cardiology 1950-2000: A Tribute to Alexander S. Nadas, M.D.  
The Cardiovascular Program at Children's Hospital, Boston, MA
- 2001 Invited Faculty  
"Cardiopulmonary Support in the Pediatric Cardiac Intensive Care Unit"  
Third Course on Frontiers in Diagnosis and Management of Congenital Heart Disease,  
Newport, RI
- 2001 Invited Faculty  
Diverse Topics  
Fourth International Symposium on Pediatric Cardiac Intensive Care, Palm Beach, FL
- 2002 Invited Speaker  
"Sildenafil for Treatment of Pulmonary Hypertension"  
ECMO Meeting, Children's National Medical Center, Keystone, Colorado
- 2002 Invited Speaker  
"Novel Pediatric Applications of Commonly Used Adult Drugs"  
Back to our Future: Establishing Safety and Evidence in Pediatric Research  
Duke University, FDA & Industry, Washington, DC
- 2002 Invited Lecturer  
"The Future of Inhaled Nitric Oxide for Children with Congenital Heart Disease"  
CME Course in Hematology, Northwestern University Medical School  
Chicago, Illinois
- 2002 Invited Faculty  
"Manipulating Vascular Resistance in the Newborn: Is it Feasible?"  
3<sup>rd</sup> International Pediatric Cardiovascular Symposium, Atlanta, Georgia
- 2002 Invited Speaker  
"Viagra for Pulmonary Hypertension"  
Hot Topics in Neonatology, Washington, DC

- 2003 Plenary Speaker  
"Changes in Worldwide Activity and Mortality in Cardiac Intensive Care"  
Debate: "Cardiac Patients Need Their Own ICU"  
Symposium Chairman: "New Strategies in Treatment of Pulmonary Hypertension"  
4<sup>th</sup> World Congress of Pediatric Intensive Care, Boston, Massachusetts
- 2004 Invited Faculty  
"Pharmacologic Management of Low Cardiac Output Syndrome After Congenital Heart Surgery" Current Concepts in Pediatric Critical Care Medicine Course  
Society for Critical Care Medicine, Orlando, Florida
- 2004 Invited Faculty  
"Structure of a Training Program in Pediatric Cardiac Intensive Care"  
33<sup>rd</sup> Annual Meeting of the Society for Critical Care Medicine, Orlando, Florida
- 2004 Invited Faculty  
"Reconciling FDA, Academic, and Industry Objectives in Pediatric Clinical Trials"  
Cardiology 2004, Orlando, Florida (Children's Hospital of Philadelphia)
- 2004 Invited Speaker  
"Cardiac and Central Nervous System Interactions"  
15<sup>th</sup> Annual Pediatric Critical Care Colloquium, New York City, New York
- 2004 Invited Faculty  
"Advances in the Management of Pulmonary Hypertension"  
"Physician Perspective on Electronic Billing:  
Congenital Cardiovascular Surgery Symposium, San Diego, California
- 2004 Invited Participant in "How To" Session  
"How to Evaluate and Manage Pediatric Patients with Pulmonary Hypertension"  
American Heart Association, Scientific Sessions 2004, New Orleans, LA
- 2004 Invited Faculty, Special Session  
"Twenty Year Retrospective: The Early Years and Later"  
Pediatric Cardiac Intensive Care Symposium, Miami, FL
- 2004 Invited Faculty  
"Nitric Oxide and the Intensive Care Setting"  
Pediatric Cardiac Intensive Care Symposium, Miami, FL
- 2004 Invited Faculty  
"How to Design and Conduct Drug Trials"  
Pediatric Cardiac Intensive Care Symposium, Miami, FL
- 2005 Invited Faculty  
"Therapies to Enhance the Effect of Inhaled Nitric Oxide"  
Symposium on New Directions in Nitric Oxide Therapy, Baylor College of Medicine, Texas  
Children's Hospital, Houston, Texas
- 2005 Invited Speaker  
"Pulmonary Hypertension: Approaches to Management", 21<sup>st</sup> Annual Fetus and Newborn  
Conference, Boston, MA

- 2005 Invited Moderator  
"Low Birth Weight Neonates with Congenital Heart Disease", Pediatric Cardiac Intensive Care Symposium 2005 (PCICS 2005), Miami, FL
- 2005 Invited Faculty  
Consensus Report on Treatment of Myocarditis. Pediatric Cardiac Intensive Care Symposium 2005 (PCICS 2005), Miami, FL
- 2006 Invited Faculty  
"Challenges in Industry Sponsored Trials" and "Management of PVR in the Neonate"  
Ninth Annual Update on Pediatric Cardiovascular Disease (Children's Hospital of Philadelphia), Scottsdale, AZ
- 2006 Invited Speaker  
Eddie Farrell Memorial Lecture, Massachusetts Society of Respiratory Care, Sturbridge, MA
- 2006 Invited Faculty  
Second International Conference on Heart Failure in Children and Young Adults Children's Hospital Orange County, Laguna Niguel, CA
- 2007 Invited Speaker  
"Pulmonary Vascular Alterations in CHD" & "Drug Treatment for Pulmonary Hypertension",  
First International Conference on Childhood Pulmonary Vascular Disease, San Francisco, CA
- 2008 Invited Speaker  
"Cardiac Critical Care: What's New and What Matters "STS Congenital Surgical Symposium,  
Ft. Lauderdale, FL.
- 2008 Invited Speaker  
Session Chair "Anticipating the Growing ACHD Population"  
Update on Pediatric Cardiovascular Disease- New and Evolving Concepts and Practices,  
Speaker: "Considerations for Caring for Adult Patients in a Pediatric ICU" & "Current Status of Inpatient Therapy"  
Scottsdale, AZ
- 2008 Invited Speaker  
Forum Moderator: "Inhaled Nitric Oxide in the OR"  
ASA 2008 Annual Meeting, Orlando, FL
- 2008 Invited Speaker  
"Postoperative Management and Outcome of the Term vs. Premature Newborn with Congenital Heart Disease"  
Management of Congenital Heart Disease in the Fetus & Neonate Symposium, Washington, DC
- 2008 Invited Speaker  
"Pulmonary Hypertension"  
NPCNA Annual Fall Conference, Innovation and Inquiry in Pediatric Cardiology Nursing  
Washington, DC
- 2008 Invited Speaker  
"Critical Treatment Strategies for Acute Pulmonary Hypertension in Infants and Children  
cGMP-related Drugs »  
PCICS Annual Symposium 2008, Miami, FL



- 2009 Invited Speaker  
Session Moderator. "Cardiac Surgery"  
38<sup>th</sup> Annual Critical Care Congress of the Society of Critical Care Medicine, Nashville, TN
- 2009 Invited Speaker  
Session Moderator. "Cardiac ECMO: State-of-the-Art"  
The 25<sup>th</sup> Annual CNMC Symposium: ECMO & The Advanced Therapies for Respiratory Failure  
Keystone, CO
- 2009 Invited Speaker  
Session Moderator. "Pulmonary Vascular Alterations in Congenital Heart Disease"  
The 2<sup>nd</sup> International Neonatal and Childhood Pulmonary Vascular Disease Conference  
San Francisco, CA
- 2009 Invited Speaker  
"Advances in Cardiac Intensive Care"  
9<sup>th</sup> Annual Cardiac Research Symposium – A.I. DuPont Hospital for Children, Nemours  
Symposia, Wilmington, DE
- 2010 Invited Speaker  
"Cardiac Intensive Care: Celebrating Successes, Meeting Challenges"  
3rd Annual John J. Downes Lecture in Pediatric Anesthesia and Critical Care Medicine  
Orlando, FL
- 2010 Invited Speaker  
"A Randomized Trial of Clopidogrel to Reduce Mortality and Shunt-Related Morbidity in Infants  
Palliated with a Systemic to Pulmonary Artery Shunt  
Outstanding Research Awards (Council on Cardiovascular Disease in the Young)  
AHA Scientific Sessions, Chicago, IL
- 2011 Invited Speaker  
"Working with the FDA & Industry in Designing Pediatric Trials"  
The 27<sup>th</sup> Annual CNMC Symposium: ECMO & The Advanced Therapies for Respiratory Failure  
Keystone, CO
- 2011 Invited Speaker  
"Resuscitation of the Patient with Pulmonary Hypertension"  
4th International Neonatal and Childhood Pulmonary Vascular Disease  
San Francisco, CA

#### INTERNATIONAL

- 1986 Invited Lecture  
"Recent Advances in the Intensive Treatment of Neonates with Congenital Heart Disease,"  
A Week with the Experts, Ospedale Pediatrico Bambino Gesù, Rome, Italy
- 1988 Invited Lecture  
"Perioperative Care of the Patient with HLHS"  
European Congress on Hypoplastic Left Heart Syndrome, Ospedale Pediatrico Bambino  
Gesù, Rome, Italy

- 1990 Invited Lecture  
"Perioperative Care of the Neonate with Congenital Heart Disease"  
Pediatric Critical Care Conference, Hospital for Sick Children, University of Toronto, Toronto  
Canada
- 1991 Invited Lecture  
"Perioperative Intensive Care of the Child with Congenital Heart Disease"  
First International Pediatric Intensive Care Congress, Buenos Aires, Argentina
- 1993 Invited Faculty  
"Regulation of the Pulmonary Circulation: Therapeutic Implications"  
First European Postgraduate Course in Neonatal and Pediatric Intensive Care, Berne,  
Switzerland
- 1993 Invited Faculty  
"Pulmonary Hypertension: Pathophysiologic and Therapeutic Implications in Post Surgical  
Patients" Third International Meeting on Pediatric Intensive Care, University of Padova, Italy
- 1993 Invited Lecture  
"Nitric Oxide to Test Pulmonary Vascular Reactivity to Control Hypertensive Crises and as a  
Potential Chronic Therapy" Canadian Cardiovascular Society, Vancouver, Canada
- 1993 Invited Lecture  
"Nitric Oxide Inhalation after Correction of Congenital Heart Defects"  
International Conference on ARDS, Tutzing, Germany
- 1994 Plenary Presentation  
"Perioperative Care of the Neonate"  
Cardiac Surgery Today: State of the Art, Onassis Medical Center, Athens, Greece
- 1995 Invited Faculty  
"Nitric Oxide in the Treatment of Congenital Heart Disease"  
Annual Meeting of the Austrian Society for Lung Diseases, Gmunden, Austria
- 1995 Plenary Speaker  
"Inhaled Nitric Oxide for Perioperative Management of Congenital Heart Disease"  
The VII Brazilian Congress of Intensive Care Medicine, Recife, Brazil
- 1996 Invited Lecture  
"Nitric Oxide in Pulmonary Hypertension after Surgery for Congenital Heart Defects"  
Annual Meeting, European Society of Cardiology, Birmingham, United Kingdom
- 1997 Symposium  
"The Failing Heart—Pediatric Aspects"  
The 7th World Congress of Intensive & Critical Care Medicine, Ottawa, Canada
- 1997 Plenary Session  
"Inhaled Nitric Oxide"  
XXX Brazilian Pediatrics Congress and International Pediatric Symposium, Rio de Janeiro,  
Brazil
- 1998 Invited Faculty  
Multiple lectures and workshops  
Pediatric Cardiac Intensive Care at the European Heart House  
European Society of Cardiology, Nice, France

- 1998 Invited Faculty  
Lectures on Congenital Heart Disease  
Argentine Congress of Cardiology, Buenos Aires, Argentina
- 1999 Invited Lecture  
"Critical Aortic Stenosis in the Neonate"  
Second Postgraduate Course on Congenital and Acquired Heart Disease, Modena, Italy
- 1999 Invited Lecture  
"Pathophysiology and Treatment of Pulmonary Hypertension"  
Lund University Hospital, Lund, Sweden
- 1999 Invited Lecture  
"Pulmonary Hypertension and Mechanical Support in Children with Heart Disease"  
Lindgren Children's Hospital at the Karolinska Institute, Stockholm, Sweden
- 1999 Plenary Speaker  
"Frontiers in Pediatric Intensive Care"  
Annual Meeting, Society of Anesthesia and Critical Care, Gothenburg, Sweden
- 1999 Invited Faculty  
"ICU Management of Two Stage Arterial switch"  
"The Role of Nitric Oxide in the Cardiac Patient"  
The First Hispano Latin American Course, Diagnosis and Management of Congenital Heart Disease, San Juan, Puerto Rico
- 1999 Invited Lecture  
"Current Concepts in Post-operative Management"  
"ECMO in the New Millennium"  
Symposium on Pediatric Cardiology, Cordoba, Argentina
- 1999 Invited Speaker  
"Inhaled Nitric Oxide"  
"Perioperative Care of the Newborn"  
The First Sino-American Symposium: New Developments in the Care of Children with Congenital Heart Disease, Shanghai Children's Medical Center, Shanghai, China
- 2000 Invited Faculty and Track Convener  
"Issues in Perioperative Care" and multiple lectures  
The Third International Symposium on Pediatric Cardiac Intensive Care, Montreal, Canada
- 2000 Invited Lecture  
"Endothelial Cell Function During Cardiopulmonary Bypass"  
5<sup>th</sup> World Congress on Trauma, Shock, Inflammation and Sepsis, Munich, Germany
- 2000 Invited Lecture  
"Inhaled Nitric Oxide Therapy in Children after Cardiac Surgery"  
American Thoracic Society, 96<sup>th</sup> International Conference, Toronto, Canada
- 2000 Invited Lecture  
"Pulmonary Hypertension and its Impact on Hemodynamics"  
Special Topics in Pediatric Cardiac Intensive Care Symposium, Royal Brompton & Harefield NHS Trust, London, United Kingdom

- 2000 Invited Faculty  
 "Critical Care and Congenital Heart Disease"- diverse topics  
 Pediatric FCCS Course, Taipei, Taiwan
- 2000 Invited Lecture  
 "Advances in Perioperative Care of the Child with Congenital Heart Disease"  
 Tenth Anniversary Lecture, Kaohsiung Veterans General Hospital, Taiwan
- 2000 Invited Lecture  
 "Postoperative Care of the Child with AV Septal Defect"  
 European Cardiovascular Surgery's Postgraduate Course, Frankfurt, Germany
- 2000 Seminar  
 "Postoperative Care of Patients with Hypoplastic Left Heart Syndrome"  
 European Association of Cardio-Thoracic Surgery, Annual Meeting, Frankfurt, Germany
- 2000 Plenary Lecture  
 "Diagnosis and Treatment of Pulmonary Hypertension"  
 XIX Pan American Congress of Pediatrics, Montevideo, Uruguay
- 2000 Invited Lecture  
 "Postoperative Management of the Child with D-Transposition of the Great Arteries"  
 "Diagnosis and Management of Pulmonary Arterial Hypertension"  
 I Pediatric Cardiology Symposium, Dr. Aldo Castañeda, Guatemala City, Guatemala
- 2001 Invited Faculty  
 "Pulmonary Hypertension and Nitric Oxide"  
 "Assessing and Managing Premature Newborns for Surgical and Catheter Intervention"  
 Harvard Winter Course in Congenital Heart Management, Dubai, United Arab Emirates
- 2001 Invited Lecture  
 "Brain Protection During CPB"  
 V European Postgraduate Course in Neonatal and Pediatric Intensive Care, Bern, Switzerland
- 2001 Invited Lecture  
 "Strategic Management of the Patient after Surgery"  
 Third World Congress of Pediatric Cardiology and Cardiac Surgery, Toronto, Canada
- 2001 Invited Faculty  
 Special Topics in Paediatric Cardiac Intensive Care – 2001, The Challenging Neonate,  
 The Royal Brompton Hospital & The National Heart & Lung Institute, London, England
- 2002 Moderator  
 European Consensus Meeting on Inhaled Nitric Oxide  
 European Society of Pediatric and Neonatal Intensive Care, Rome, Italy
- 2002 Invited Faculty  
 "Assessment of Myocardial Function in the ICU"  
 "Postoperative Management After Staged Repair of HLHS"  
 "ECMO Management of the Single Ventricle Circulation"  
 New Era in Congenital Heart Management  
 Universidad Complutense Madrid and Real Colegio Complutense en Harvard, The Heart  
 Institute Hospital, Universitario "12 de Octubre", Madrid, Spain

- 2002 Guest Lecturer  
 "Failing Hearts: The Paediatric Problem and Current Treatments"  
 "Inhaled Nitric Oxide and Pulmonary Vasodilators for the Failing Right Heart"  
 "Routine ECMO for Resuscitation"  
 The Third Special Topics in Paediatric Cardiac Intensive Care, The Failing Myocardium  
 Royal Brompton Hospital, Imperial College, London, United Kingdom
- 2003 Invited Faculty  
 "Support for the Failing Ventricle"  
 "Management of Pulmonary Hypertension: From the OR to the Home"  
 Debate: "Early Extubation is the Best Defense Against Postoperative Complications"  
 First Asia Pacific Symposium on Pediatric Cardiac Intensive Care, Phuket, Thailand
- 2003 Guest Lecturer  
 "Pharmacologic Management of Pulmonary Hypertension" and Other Topics  
 IX Curso de Actualización en Cardiología Pediátrica, Madrid, Spain
- 2003 Guest Lecturer  
 "Recent Advances in the Use of Inhaled Nitric Oxide in Patients with Congenital Heart Disease". Inhaled Nitric Oxygen Symposium for Neonatologists. Madrid, Spain
- 2003 Invited Participant  
 Third World Symposium on Pulmonary Arterial Hypertension (WHO). Venice, Italy
- 2003 Special Guest Lecturer  
 "Indications for Inhaled Nitric Oxide in the Neonatal and Postoperative Care of Critically Ill Children".  
 Annual Meeting of the German Society of Pediatric Cardiology. Weimar, Germany
- 2003 Invited Speaker  
 "Predicting and Treating Low Cardiac Output in the Postoperative Patient"  
 Annual Meeting of the European Association of Cardiothoracic Surgeons. Vienna, Austria
- 2003 Invited Faculty  
 "The Paperless ICU"  
 "Pulmonary and Systemic Vasodilators"  
 "Genetic Basis for Heterotaxy"  
 Harvard Medical International, Children's Hospital Boston Course in Congenital Heart Disease  
 Abu Dhabi, United Arab Emirates
- 2003 Invited Speaker  
 "Extracorporeal Membrane Oxygenation for Cardiopulmonary Resuscitation in Children"  
 Hammersmith Hospital Workshop on Perfusion. London, United Kingdom
- 2004 Keynote Speaker  
 "Pulmonary Hypertension Therapy—Now and in the Future"  
 Pulmonary Hypertension in Early Life, St. Guys and St. Thomas' Hospital  
 London, United Kingdom
- 2004 Keynote Address  
 "Pulmonary Hypertension: State of the Art"  
 Opening Ceremony, Annual Meeting of the European Society of Pediatric and Neonatal Intensive Care, London, United Kingdom

- 2005 Plenary Speaker  
"Recent Advances in Heart Failure and Pulmonary Hypertension", The Fourth World Congress of Pediatric Cardiology and Cardiac Surgery, Buenos Aires, Argentina.
- 2005 Invited Speaker  
Controversy Session: "Inhaled Iloprost is the Best Pulmonary Vasodilator?", The Fourth World Congress of Pediatric Cardiology and Cardiac Surgery, Buenos Aires, Argentina.
- 2005 Invited Speaker  
Chair, Oral Presentations: "Cardiac Intensive Care", The Fourth World Congress of Pediatric Cardiology and Cardiac Surgery, Buenos Aires, Argentina.
- 2006 Invited Faculty  
"Outcomes of Heart Failure in the ICU: Mechanisms of Postoperative Dysfunction." Congress of Ventricular Dysfunction in Childhood, OPBG Cardiovascular International. Rome, Italy
- 2007 Invited Speaker  
Multiple Oral Presentations and Panel Chair  
Fifth World Congress on Pediatric Critical Care, Geneva, Switzerland
- 2007 Invited Speaker  
"Cuidado perioperatorio del recién nacido con enfermedad cardíaca congénita", VI Annual Colombian Critical Care Congress, Medellín, Colombia
- 2007 Invited Speaker  
"Postoperative Treatment of Pulmonary Hypertension," & "Postoperative Care of Hypoplastic Left Heart: Comparing Norwood with BT Shunt vs. Sano from Birth through the Fontan."  
International Cardiology Meeting, Avignon, France
- 2008 Invited Faculty  
Plenary Lecture: "Pediatric Cardiac Intensive Care: Past, Present and Future"; "Dedicated Training Pathways in Pediatric Cardiac Intensive Care" & "How to plan a Research Study in ICU"  
PCICS Europe Symposium, Monte Carlo, Monaco
- 2009 Invited Speaker  
"Acute Heart Failure Pathophysiology", Treatment of Postoperative Acute Cardiac Failure",  
"Mechanical Support of Acute Cardiac Failure"  
International Pediatric Cardiology Conference  
Cartagena, Colombia
- 2010 Invited Faculty  
Session Moderator: Pulmonary Hypertension, Right Ventricular Function and Congenital Heart Disease  
3<sup>rd</sup> International Conference Neonatal and Childhood Pulmonary Vascular Disease  
Banff, Alberta, Canada
- 2010 Invited Speaker  
"Intraoperative Care and Perioperative Management for Transposition"  
The World Society for Pediatric and Congenital Heart Surgery  
Antigua, Guatemala

**10) GRANTS AWARDED****FUNDING INFORMATION**

- 1987-89 The effects of ventilation on pulmonary vascular resistance in infants following cardiopulmonary bypass. Principal Investigator, American Society of Anesthesiologists Research Starter Grant.
- 1988-91 Infant heart surgery: CNS sequelae of circulatory arrest. Co-Investigator, National Institutes of Health. Grant No. HL41786.
- 1993-96 Ischemic neonatal brain injury: clinical and basic science. Co-investigator, National Institutes of Health. Grant No. P20 NS32570
- 1994-96 Inhaled nitric oxide for the treatment of pulmonary hypertension and acute respiratory failure in children. Principal Investigator, Clinical Research Grant-in-Aid Award, Children's Hospital, Boston, Massachusetts. Grant No. CH 89430.
- 1994-99 Pathogenesis of brain injury in infant heart surgery. Clinical advisor / mentor to Dr. Adre J. DuPlessis, National Institutes of Health. Grant No. K08 NS01721
- 1996-99 Dose response of inhaled nitric oxide in congenital heart disease. Principal Investigator, U.S. Food and Drug Administration. Grant No. FD R-001316.
- 1997-99 Neurodevelopmental follow up of patients with PPHN in a randomized trial of nitric oxide. Principal Investigator, Industry Sponsored.
- 1997-00 Echocardiographic assessment of right ventricular function in patients with pulmonary hypertension. Sponsor for Dr. Ricardo Munoz (MCAP), National Institutes of Health Grant No. M01 RR02172.
- 2000-01 Prophylactic use of Primacor® in pediatric patients at high risk of developing low cardiac output syndrome following cardiac surgery. Principal Investigator, Industry Sponsored.
- 2004-06 Principal Investigator (Boston) on three industry sponsored trials of sildenafil for treatment of pediatric pulmonary hypertension (see below).
- 2004-08 A Randomized, Double-Blind, Placebo Controlled, Dose Ranging, Parallel Group Study of Oral Sildenafil in the Treatment of Children, Aged 1-16 Years, With Pulmonary Hypertension. Principal Investigator, Industry Sponsored
- 2004-08 Multicenter, Long-Term Extension Study to Assess Safety of Oral Sildenafil in the Treatment of Subjects Who Have Completed Study A1481131. Principal Investigator, Industry Sponsored
- 2004-06 7-Day, Open-Label, Multicenter, Pharmacokinetic Study (Part 1) of IV Sildenafil in the Treatment of Neonates With Persistent Pulmonary Hypertension of the Newborn (PPHN) or Hypoxic Respiratory Failure and at Risk for PPHN. Principal Investigator, Industry Sponsored
- 2006-08 Pilot Study of the Effects of Nesiritide on Hemodynamics and Urine Output Following Cardiopulmonary Bypass in Children. Co-investigator and mentor (John M. Costello); American Heart Association.
- 2006-10 Multinational Trial on the Efficacy and Safety of Clopidogrel in Infants with Cyanotic Congenital Heart Disease Palliated with a Systemic to Pulmonary Shunt (CLARINET). (Chair, Steering Committee, Institutional Co-Investigator). Industry Sponsored (Sanofi-Aventis).

- 2009-14 Collaborative Pediatric Critical Care Research Network (CPCCRN). NIH-NICHD U10410HD049981. Principal Investigator; 20% effort. Base award over 5 years \$925,000 direct costs plus annual awards for protocol funds (e.g. 2010 = \$200,000)
- Critical Pertussis in US Children. Protocol #001
  - The Critical Illness Stress-induced Immune Suppression Prevention Trial (CRISIS). Protocol #003
  - Development of a Quantitative Functional Status Scale (FSS) for Pediatric Patients. Protocol #004
  - Therapeutic Hypothermia after Pediatric Cardiac Arrest Trials (THAPCA). Protocol #010
  - Cortisol Quantification Investigation. Protocol #012
  - Measuring Opioid Tolerance Induced by Fentanyl (or Other Opioids). Protocol #026
  - Physician's Perspectives on the Physician-Parent Follow-Up Conference.
  - Pediatric Intensive Care Unit Bereavement Study
  - CPCCRN Asthma Study

#### REPORT OF CURRENT RESEARCH ACTIVITIES

1. My primary current research activity involves designing and executing national and international pediatric clinical trials:
2. Safety and efficacy of type V phosphodiesterase inhibitors in children as selective pulmonary vasodilators and to augment vasodilatory potential of nitric oxide and attenuate rebound pulmonary hypertension. I was the overall primary scientific advisor in the development and execution of international multicenter randomized trials on type V inhibitors in pediatrics, Industry sponsored. Final publications in press.
3. Outcome studies evaluating ventilator management, inotropic agents, mechanical support of the circulation and new strategies in the critical care management and perioperative care of
  - a) premature newborns with congenital heart disease
  - b) newborns after reparative surgery involving the right ventricle
  - c) extracorporeal membrane oxygenation resuscitation of children with congenital heart disease.
4. Multinational Trial on the Efficacy and Safety of Clopidogrel in Infants with Cyanotic Congenital Heart Disease Palliated with a Systemic to Pulmonary Shunt (CLARINET). (Chair, Steering Committee, Institutional Co-investigator). Industry Sponsored.
5. I am the Principal Investigator (CNMC) and steering committee member for the NIH funded clinical research network with multiple active protocols listed above.

## 11) PUBLICATIONS

### PAPERS IN REFEREED JOURNALS

1. Hickey PR, Hansen DD, Wessel DL, Lang P, Jonas RA. Pulmonary and systemic hemodynamic responses to fentanyl in infants. *Anesth Analg* 1985;64:483-6.
2. Hickey PR, Hansen DD, Wessel DL, Lang P, Jonas RA. Blunting of stress responses in the pulmonary circulation by fentanyl. *Anesth Analg* 1985;64:1137-42.
3. Wessel DL, Keane JF, Fellows KE, Robichaud H, Lock JE. Fibrinolytic therapy for femoral arterial thrombosis after cardiac catheterization in infants and children. *Am J Cardiol* 1986;58:347-51.
4. Wessel DL, Lock JE. Transcatheter umbrella closure of congenital cardiac defects: technical considerations. *Adv Bioeng (ASME)*. 1987;12:143-144.
5. Wessel DL, Keane JF, Parness I, Lock JE. Outpatient closure of the patent ductus arteriosus. *Circulation* 1988;77:1068-1071.



6. Castaneda AR, Mayer JE, Jonas RA, Lock JE, Wessel DL, Hickey PR. The neonate with critical congenital heart disease: repair - a surgical challenge. *J Thorac Cardiovasc Surg* 1989;98:869-75.
7. DiDonato RM, Wernovsky G, Walsh EP, Colan SD, Lang P, Wessel DL, Jonas RA, Mayer JE Jr, Castaneda AR. Results of the arterial switch operation for transposition of the great arteries with ventricular septal defect: Surgical considerations and midterm follow-up data. *Circulation* 1989;80:1689-1705.
8. Wernovsky G, Jonas RA, Colan SD, Sanders SP, Wessel DL, Castaneda AR, Mayer JE: Results of the arterial switch operation in patients with transposition of the great arteries and abnormalities of the mitral valve or left ventricular outflow tract. *J Am Coll Cardiol* 1990;16:1446-1454.
9. Bellinger DC, Wernovsky G, Rappaport LA, Mayer JE Jr, Castaneda AR, Farrell DM, Wessel DL, Lang P, Hickey PR, Jonas RA, Newburger JW. Cognitive development of children following early repair of transposition of the great arteries using deep hypothermic circulatory arrest. *Pediatrics* 1991;87:704-707.
10. Chang AC, Wernovsky G, Kulik TJ, Jonas RA, Wessel DL. Management of the neonate with transposition of the great arteries and persistent pulmonary hypertension. *Am J Cardiol* 1991;68:1253-1256.
11. Chang AC, Hanley FL, Weindling SN, Wernovsky G, Wessel DL. Left heart support with a ventricular assist device in an infant with acute myocarditis. *Crit Care Med* 1992;20:712-715.
12. Hickey PR, Wessel DL, Streitz SL, Fox ML, Kern FH, Bridges, ND, Hansen, DD. Transcatheter closure of atrial septal defects: Hemodynamic complications and anesthetic management. *Anesth Analg* 1992;74:44-50.
13. Wernovsky G, Giglia TM, Jonas RA, Mone SM, Colan SD, Wessel DL. Course in the intensive care unit after 'preparatory' pulmonary artery banding and aortopulmonary shunt placement for transposition of the great arteries with low left ventricular pressure. *Circulation* 1992;86[suppl II]:II133-139.
14. Wong PC, Barlow CF, Hickey PR, Jonas RA, Castaneda AR, Farrell DM, Lock JE, Wessel DL. Factors associated with choreoathetosis after cardiopulmonary bypass in children with congenital heart disease. *Circulation* 1992;86[suppl II]:II118-II126.
15. Chang AC, Wernovsky G, Wessel DL, Freed MD, Parness IA, Perry SB, O'Brien P, Van Praagh R, Hanley FL, Jonas RA, Castaneda AR, Mayer JE. Surgical management for late right ventricular failure after Mustard or Senning repair. *Circulation* 1992;86[suppl II]:II140-II149.
16. Chang AC, Kulik TJ, Hickey P, Wessel DL. Real-time gas exchange measurement of oxygen consumption in neonates and infants after cardiac surgery. *Crit Care Med* 1993;21:1287-1295.
17. Irazuzta J, Pearlman N, Pascucci R, Wessel DL. Effects of fentanyl administration on respiratory system compliance in infants. *Crit Care Med* 1993;21:1001-1004.
18. Chang AC, Hanley FL, Wernovsky G, Rosenfeld H., Wessel DL, Jonas RA, Mayer JE, Castaneda AR. Early bidirectional cavopulmonary shunt in young infants: postoperative course and early results. *Circulation* 1993; 86[suppl II]:II-149-II158.
19. Hanley FL, Heinemann MK, Jonas RA, Mayer JE, Cook NR, Wessel DL, Castaneda AR. Repair of truncus arteriosus in the neonate. *J Thorac Cardiovasc Surg* 1993;105:1047-1056.
20. Wessel DL. Hemodynamic responses to perioperative pain and stress in infants. *Crit Care Med* 1993; 21[suppl]:S361-S362.

21. Newburger JW, Jonas RA, Wernovsky G, Wypij D, Hickey PR, Kuban KCK, Farrell DM, Holmes GL, Helmers SL, Constantinou J, Carrazana E, Barlow JK, Walsh AZ, Lucius KC, Share JC, Wessel DL, Hanley FL, Mayer JE, Castaneda AR, Ware JH. A comparison of the perioperative neurologic effects of hypothermic circulatory arrest versus low-flow cardiopulmonary bypass in infant heart surgery. *N Engl J Med* 1993;329:1057-1064.
22. Wessel DL. Inhaled nitric oxide for the treatment of pulmonary hypertension before and after cardiopulmonary bypass. *Crit Care Med* 1993;21[suppl]:S344-S345.
23. Adatia I, Thompson J, Landzberg M, Wessel DL. Inhaled nitric oxide in chronic obstructive lung disease. *Lancet* 1993;341:307-308. (Letter)
24. Wessel DL, Adatia I, Giglia TM, Thompson JE, Kulik TJ. Use of inhaled nitric oxide and acetylcholine in the evaluation of pulmonary hypertension and endothelial function after cardiopulmonary bypass. *Circulation* 1993;88:2128-2138.
25. Wessel DL, Adatia I, Thompson JE, Hickey PR. Delivery and monitoring of inhaled nitric oxide in patients with pulmonary hypertension. *Crit Care Med* 1994;22:930938.
26. Drucker N, Colan S, Lewis AB, Beiser A, Wessel DL, Takahashi M, Rosen FS, Baker A, Perez A, Newburger JW. Gamma globulin treatment of acute myocarditis in the pediatric population. *Circulation* 1994;89:252-257.
27. Jonas RA, Hansen DD, Cook N, Wessel DL. Anatomic subtype and survival after reconstructive operation for hypoplastic left heart syndrome. *J Thoracic Cardiovasc Surg* 1994;107:1121-1128.
28. du Plessis AJ, Treves ST, Hickey PR, O'Tauma L, Barlow CF, Costello J, Castaneda AR, Wessel DL. Regional cerebral perfusion abnormalities after cardiac operations. *J Thoracic Cardiovasc Surg* 1994;107:1036-1043.
29. Chang AC, Hanley FL, Lock JE, Wessel DL. Management and outcome of low birth weight neonates with congenital heart disease. *J Pediatr* 1994;124:461-466.
30. Adatia I, Lillehei C, Arnold JH, Thompson JE, Palazzo R, Fackler JC, Wessel DL. Inhaled nitric oxide in the treatment of postoperative graft dysfunction after lung transplantation. *Ann Thor Surg* 1994;57:1311-1318.
31. du Plessis AJ, Kramer U, Jonas RA, Wessel DL, Riviello JJ. West syndrome following deep hypothermic infant cardiac surgery. *Pediatr Neurol* 1994;11:245-251.
32. Lillehei CW, Shamberger RC, Mayer JE, Burke RP, Koka BV, Arnold J, Wessel DL, Landzberg M, Palazzo R. Size disparity in pediatric lung transplantation. *J Pediatr Surg* 1994;29(8):1152-1155.
33. Chang AC, Zucker HE, Hickey PR, Wessel DL. Pulmonary vascular resistance in infants after cardiac surgery: role of carbon dioxide and hydrogen ion. *Crit Care Med* 1995;23:568-574.
34. Adatia I, Perry S, Landzberg M, Moore P, Thompson JE, Wessel DL. Inhaled nitric oxide and hemodynamic evaluation of patients with pulmonary hypertension before transplantation. *J Am Coll Cardiol* 1995;25:1656-1664.
35. du Plessis AJ, Chang AC, Wessel DL, Lock JE, Wernovsky G, Newburger JW, Mayer JE. Cerebrovascular accidents following the Fontan operation. *Pediatr Neurol* 1995;12:230-236.
36. Wernovsky G, Wypij D, Jonas RA, Mayer JE, Hanley FL, Hickey PR, Walsh AZ, Chang AC, Castaneda AR, Newburger JW, Wessel DL. Postoperative course and hemodynamic profile after the arterial switch operation in neonates and infants: A comparison of low-flow cardiopulmonary bypass and circulatory arrest. *Circulation* 1995;92:2226-2235.

37. Betit P, Adatia I, Benjamin P, Thompson JE, Wessel DL. Inhaled nitric oxide: evaluation of a continuous titration delivery technique for infant mechanical and manual ventilation. *Resp Care* 1995;40(7):706715.
38. Chang AC, Atz AM, Wernovsky G, Burke RP, Wessel DL. Milrinone: Systemic and pulmonary hemodynamic effects in neonates after cardiac surgery. *Crit Care Med* 1995;23:1907-1914.
39. Curran RD, Mavroudis C, Backer CL, Sautel M, Zales VR, Wessel DL. Inhaled nitric oxide for children with congenital heart disease and pulmonary hypertension. *Ann Thorac Surg* 1995;60:1765-1771.
40. Adatia I, Atz AM, Jonas RA, Wessel DL. Diagnostic use of inhaled nitric oxide after neonatal cardiac surgery. *J Thoracic Cardiovasc Surg* 1996;112:1403-1405.
41. Atz AM, Adatia I, Jonas RA, Wessel DL. Inhaled nitric oxide in children with pulmonary hypertension and congenital mitral stenosis. *Am J Cardiol* 1996;77:316-319.
42. Atz AM, Adatia I, Wessel DL. Rebound pulmonary hypertension following inhalation of nitric oxide. *Ann Thorac Surg* 1996;62:1759-1764.
43. Betit P, Grenier B, Thompson JE, Wessel DL. Evaluation of four analyzers used to monitor nitric oxide and nitrogen dioxide concentrations during inhaled nitric oxide administration. *Res Care* 1996;41(9):817825.
44. Wessel DL. Simple Gases and Complex Single Ventricles. *J Thoracic Cardiovasc Surg* 1996;112:655-7.
45. Hornberger LK, Colan SD, Lock JE, Wessel DL, Mayer JE. Outcome of patients with Ectopia Cordis and significant intracardiac defects. *Circulation* 1996;94[suppl II]:II-32-II-37.
46. du Plessis AJ, Jonas RA, Wypij D, Hickey PR, Riviello J, Wessel DL, Roth SJ, Burrows FA, Walter G, Farrell DM, Walsh AZ, Plumb CA, del Nido P, Burke RP, Castaneda AR, Mayer JE Jr., Newburger JW. Perioperative effects of alpha-stat versus pH-stat strategies for deep hypothermic cardiopulmonary bypass in infants.
47. Christou H, Adatia I, Van Marter LJ, Kane JW, Thompson JE, Stark AR, Wessel DL, Kourembanas S. Effect of inhaled nitric oxide on endothelin-1 and cyclic guanosine 5'-monophosphate plasma concentrations in newborns with persistent pulmonary hypertension. *J Pediatrics* 1997;130(4):603611.
48. Walsh EP, Saul P, Sholler G, Triedman JK, Jonas RA, Mayer JE, Wessel DL. Evaluation of a staged treatment protocol for rapid junctional ectopic tachycardia after surgery for congenital heart disease. *J Am Coll Cardiol* 1997;29(5):1046-1053.
49. Tabbutt S, Duncan BW, McLaughlin D, Wessel DL, Jonas RA, Laussen PC. Delayed sternal closure after cardiac operations in a pediatric population. *J Thorac Cardiovasc Surg* 1997;113(5):886-893.
50. Wessel DL, Adatia I, Thompson JE, Van Marter L, Kane JW, Stark AR, Kourembanas S. Improved oxygenation in a randomized trial of inhaled nitric oxide for persistent pulmonary hypertension of the newborn. *Pediatrics* 1997;100(5):1-7.
51. Atz AM, Wessel DL. Inhaled nitric oxide in sickle cell disease with acute chest syndrome. *Anesthesiology* 1997;87(4):988-990.
52. Atz AM, Wessel DL. Inhaled nitric oxide and heparin for infantile primary pulmonary hypertension. *The Lancet* 1998;351:1701.
53. Duncan BW, Ibrahim AE, Hraska V, del Nido PJ, Laussen PC, Wessel DL, Mayer JE Jr, Bower LK, Jonas RA. Use of rapid-deployment extracorporeal membrane oxygenation for the resuscitation of pediatric patients with heart disease after cardiac arrest. *J Thorac Cardiovasc Surg* 1998;116(2):305-311.

54. Weindling SN, Saul JP, Gamble WJ, Mayer JE, Wessel DL, Walsh EP. Duration of complete atrioventricular block after congenital heart disease surgery. *Am J Cardiol* 1998;82(2):525-527.
55. Atz AM, Adatia I, Lock JE, Wessel DL. Combined effects of nitric oxide and oxygen during acute pulmonary vasodilator testing. *J Am Coll Card* 1999;33(3):813-819.
56. Christou H, Magnani B, Morse DS, Allred EN, Van Marter LJ, Wessel DL, Kourembanas S. Inhaled nitric oxide does not affect adenosine 5'-diphosphate-dependent platelet activation in infants with persistent pulmonary hypertension of the newborn. *Pediatrics* 1998;102:1390-1393.
57. Duncan BM, Hraska V, Jonas RA, Wessel DL, del Nido PJ, Laussen PC, Mayer JE, Lapierre RA, Wilson JM. Mechanical circulatory support in children with cardiac disease. *J Thorac Cardiovasc Surg* 1999;117:529-542.
58. del Nido PJ, Duncan BW, Mayer JE, Wessel DL, LaPierre R, Jonas RA. Left ventricular assist device improves survival in children with left ventricular dysfunction after repair of anomalous origin of the left coronary artery from the pulmonary artery. *Ann Thorac Surg* 1999;67(1):169-172.
59. Atz AM, Feinstein JA, Perry SB, Wessel DL. Preoperative management of pulmonary venous hypertension in hypoplastic left heart syndrome with restrictive atrial septal defect. *Am J Card* 1999;83:1224-1228.
60. Atz AM, Wessel DL. Sildenafil ameliorates effects of inhaled nitric oxide withdrawal. *Anesthesiology* 1999;91:307-310.
61. Munoz R, Laussen PC, Palacio G, Zienko L, Piercey G, Wessel DL. Changes in whole blood lactate levels during cardiopulmonary bypass for surgery for congenital cardiac disease: An early indicator of morbidity and mortality. *J Thorac Cardiovasc Surg* 2000;119:155-162.
62. Munoz R, Laussen PC, Palacio G, Zienko L, Piercey G, Wessel DL. Whole blood ionized magnesium: Age-related differences in normal values and clinical implications of ionized hypomagnesemia in patients undergoing surgery for congenital cardiac disease. *J Thorac Cardiovasc Surg* 2000;119:891-898.
63. Cataltepe S, Van Marter LJ, Kozakewich H, Wessel DL, Lee PJ, Levy HL. Pulmonary hypertension associated with nonketotic hyperglycinemia. *J Inher Metab Dis* 2000;23:137-144.
64. Munoz R, Marcus E, Palacio G, Gauvreau K, Wessel DL, Colan SD. Reconstruction of three dimensional right ventricular shape and volume from three orthogonal planes. *J Am Soc Echocardiogr* 2000;13 (3):177-185.
65. Marcus EN, Munoz RA, Palacio G, Wessel DL, Colan SD. A new quantitative method for the diagnosis of right ventricular hypertensive disorders in 3 dimensions. *J Am Soc Echocardiogr* 2000;13(3):186-193.
66. Christou H, Van Marter LJ, Wessel DL, Allred EN, Kane JW, Thompson JE, Stark AR, Kourembanas S. Inhaled nitric oxide reduces the need for extracorporeal membrane oxygenation in infants with persistent pulmonary hypertension of the newborn. *Crit Care Med* 2000;28(11):3722-3727.
67. Ellington M Jr., O'Reilly D, Allred EN, McCormick MC, Wessel DL, Kourembanas S. Child health status, neurodevelopmental outcome, and parental satisfaction in a randomized, controlled trial of nitric oxide for persistent pulmonary hypertension of the newborn. *Pediatrics* 2001;107:1351-1356.
68. Bacha EA, Almodovar MC, Zurakowski D, Wessel DL, Mayer JE Jr., Jonas RA, del Nido PJ. Surgery for coarctation of the aorta in infants weighing less than 2 kg. *Ann Thorac Surg*. 2001;71(4):1260-4.
69. Duncan BW, Bohn DJ, Atz AM, French JW, Laussen PC, Wessel DL. Mechanical circulatory support for the treatment of children with acute fulminant myocarditis. *J Thorac Cardiovasc Surg* 2001; 22(3):440-8.

70. Rosales AM, Walsh EP, Wessel DL, Triedman JK. Postoperative ectopic atrial tachycardia in children with congenital heart disease. *Am J Cardiol* 2001; 88(10):1169-72.
71. Hoffman TM, Wernovsky G, Atz AM, Bailey JM, Akbary A, Kocsis JF, Nelson DP, Chang AC, Kulik TJ, Spray TL, Wessel DL. Prophylactic intravenous use of milrinone after cardiac surgery in pediatrics. (PRIMACORP) Study. *Am Heart J* 2002; 143:15-21.
72. du Plessis AJ, Bellinger D, Gauvreau K, Plumb C, Newburger JW, Jonas RA, Wessel DL. Choreoathetosis following cardiac surgery in children. Long-term neurologic, cognitive, and behavioral outcome. *Ped Neurol* 2002; 27:9-17.
73. Menache CC, du Plessis AJ, Wessel DL, Jonas RA, Newburger JW. Current incidence of acute neurologic complications following open-heart surgery in children. *Ann Thorac Surg* 2002; 73:17528.
74. Booth KL, Roth SJ, Perry SB, del Nido PJ, Wessel DL, Laussen PC. Cardiac catheterization of patients supported by extracorporeal membrane oxygenation. *J Am Coll Cardiol* 2002; 40:16816.
75. Marcus EN, Munoz RA, Margossian R, Colan SD, Wessel DL. Echocardiographic assessment of the right ventricular response to hypertension in neonates on the basis of average-shaped contraction models. *J Am Soc Echocardiogr* 2002; 15:1145-53.
76. Hoffman TM, Wernovsky G, Atz AM, Kulik TJ, Nelson DP, Chang AC, Bailey JM, Akbary A, Kocsis JF, Kaczmarek R, Spray TL, Wessel DL. Efficacy and safety of milrinone in preventing low cardiac output syndrome in infants and children after corrective surgery for congenital heart disease. *Circulation* 2003; 107:996-1002.
77. Atz AM, Munoz RA, Adatia I, Wessel DL. Diagnostic and therapeutic uses of inhaled nitric oxide in neonatal Ebstein's anomaly. *Am J Cardiol*. 2003 Apr 1;91(7):906-8.
78. Newburger JW, Wypij D, Bellinger DC, du Plessis AJ, Kuban KC, Rappaport LA, Almirall D, Wessel DL, Jonas RA, Wernovsky G. Length of stay after infant heart surgery is related to cognitive outcome at age 8 years. *J Pediatr*. 2003 Jul;143(1):67-73.
79. Bailey JM, Hoffman TM, Wessel DL, Nelson DP, Atz AM, Chang AC, Kulik TJ, Spray TL, Akbary A, Miller RP, Wernovsky G. A population pharmacokinetic analysis of Milrinone in pediatric patients after cardiac surgery. *Journal of Pharmacokinetics and Pharmacodynamics*, Vol 31, No 1, 2004
80. Fraisse A, Geva T, Gaudart J, Wessel DL. Predictive factors of Doppler echocardiography in persistent pulmonary artery hypertension of the neonate (French). *Arch Mal Coeur Vaiss*, 2004; May;97(5):501-506.
81. Fraisse A, Geva T, Gaudart J, Wessel DL. Doppler echocardiographic predictors of outcome in newborns with persistent pulmonary hypertension. *Cardiology in the Young* 2004 Jun;14(3):277-283.
82. Adatia I, Atz AM, Wessel DL. Inhaled nitric oxide does not improve systemic oxygenation after the bidirectional cavopulmonary anastomosis. *J Thorac Cardiovasc Surg* 2005; 129(1):217-9.
83. Kulik T, Giglia TM, Kocis KC, Mahoney LT, Schwartz SM, Wernovsky G, Wessel DL. ACCF/AHA/AAP recommendations for training in pediatric cardiology. Task forces 5: requirements for pediatric cardiac critical care. *J Am Coll Cardiol* 2005; vol 46(7): 1396-1399.

84. Graham TP, Beekman RH, Allen HD, Bricker JT, Wessel DL, et al. ACCF/AHA/AAP recommendations for training in pediatric cardiology. A report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence (ACC/AHA/AAP Writing Committee to Develop Training Recommendations for Pediatric Cardiology). *Circulation* 2005;vol 112(16):2555-2580.
85. Costello JM, Thiagarajan RR, Dionne RE, Allan CK, Booth KL, Burmester M, Wessel DL, Laussen PC. Initial experience with fenoldapam following cardiac surgery in neonates with an insufficient response to conventional diuretics. *Pediatr Crit Care Med* 2006;7:28-33
86. Cua C.L., Thiagarajan R.R., Gauvreau K., Lai L., Costello J.M., Wessel D.L., del Nido P.J., Mayer Jr J.E., Newburger J.W., Laussen P.C.. Post-operative outcomes in a concurrent series of infants with hypoplastic left heart syndrome undergoing stage I palliation operation with either modified Blalock-Taussig shunt or right ventricle to pulmonary artery conduit. *Pediatr Crit Care Med* 2006;7:238-244.
87. Allen HD, Bricker JT, Freed MD, Hurwitz RA, McQuinn TC, Schlieken RM, Strong WB, Zahka KG, Sanders SP, Colan SD, Cordes TM, Donofrio MT, Ensing GJ, Geva T, Kimball TR, Sahn DJ, Silverman NH, Sklansky MS, Weinberg PM, Beekman RH 3rd, Hellenbrand WE, Lloyd TR, Lock JE, Mullins CE, Rome JJ, Teitel DF, Vetter VL, Silka MJ, Van Hare GF, Walsh EP, Kulik T, Giglia TM, Kocis KC, Mahoney LT, Schwartz SM, Wernovsky G, Wessel DL, Murphy DJ Jr, Foster E, Benson DW Jr, Baldwin HS, Mahoney LT, McQuinn TC; American College of Cardiology Foundation; American Heart Association; American Academy of Pediatrics. ACC/AHA/AAP recommendations for training in pediatric cardiology. *Pediatrics*. 2005 Dec;116(6):1574-96.
88. Wessel DL. Testing new drugs for heart failure in children. *Ped Crit Care Med* 2006. 7(5):493-4..
89. Schwartz SM, Wessel DL. Medical cardiovascular support in acute viral myocarditis in children. *Ped Crit Care Med* 2006;7:S12-S16.
90. Lai L, Laussen PC, Cua CL, Wessel DL, Costello JM, del Nido PJ, Mayer JE, Thiagarajan RR. Outcomes After Bidirectional Glenn Operation: Blalock-Taussig Shunt Versus Right Ventricle-to-Pulmonary Artery Conduit. *Ann Thorac Surg* 2007;83:1768-73.
91. Mullen MP, Wessel DL, Thomas KC, Gauvreau K, Neufeld EJ, McGowan FX Jr, Dinardo JA. The Incidence and Implications of Anti-Heparin-Platelet Factor 4 Antibody Formation in a Pediatric Cardiac Surgical Population. *Anesth Analg*. 2008 Aug;107(2):371-8.
92. Scheurer MA, Salvin JW, Vida VL, Fynn-Thompson F, Bacha EA, Pigula FA, Mayer JE Jr, del Nido PJ, Wessel DL, Laussen PC, Thiagarajan RR. Survival and Clinical Course at Fontan after Stage One Palliation with either a Modified Blalock-Taussig Shunt or a Right Ventricle to Pulmonary Artery Conduit. *J Am Coll Cardiol*. 2008 Jul 1;52(1):52-9.
93. Bacha EA, Cooper D, Thiagarajan R, Franklin RC, Krogmann O, Deal B, Mavroudis C, Shukla A, Yeh T, Barach P, Wessel DL, Stellin G, Colan SD. Cardiac Complications Associated with the Treatment of Patients with Congenital Heart Disease: Consensus Definitions from the Multi-Societal Database Committee for Pediatric and Congenital Heart Disease. *Cardiol Young*. 2008 Dec; 18 Suppl 2:196-201.
94. Larovere JM, Jeffries HE, Sachdeva RC, Rice TB, Wetzel RC, Cooper DS, Bird GL, Ghanayem NS, Checchia PA, Chang AC, Wessel DL. Databases for Assessing the Outcomes of the Treatment of Patients with Congenital and Paediatric Cardiac Disease – the Perspective of Critical Care. *Cardiol Young*. 2008 Dec; 18 Suppl 2:130-6.
95. Steinhorn R, Kinsella JP, Butrous G, Dilleen M, Oakes M, Wessel DL. Intravenous sildenafil in the treatment of neonates with persistent pulmonary hypertension. *J Pediatr*. 2009 Dec;155(6):841-847.e1.

96. Fraisse A, Butrous G, Taylor MB, Oakes M, Dilleen M, Wessel DL. Intravenous Sildenafil for Postoperative Pulmonary Hypertension in Children with Congenital Heart Disease. *Intensive Care Medicine* 2010 Nov 11.
97. Barst RJ, Agnoletti G, Fraisse A, Baldassarre J, Wessel DL for the NO Diagnostic Study Group. Vasodilator Testing with Nitric Oxide and/or Oxygen in Pediatric Pulmonary Hypertension. *Pediatr Cardiol*. 2010 Jul;31(5):598-606. Epub 2010 Apr 20.
98. Fraisse A, Wessel DL. Acute Pulmonary Hypertension in Infants and Children: cGMP-related drugs. *Pediatr Crit Care Med*. 2010 Vol. 11, No. 2 (Suppl.)
99. Pediatric basic and advanced life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Kleinman, ME and the Pediatric Basic and Advanced Life Support Chapter Collaborators. *Circulation* 2010 Oct 19; 122 (16 Suppl 2):S466-515.
100. Macrae D, Wessel DL. Iceberg or pyramid? *Pediatr Crit Care Med*. 2010 Mar;11(2 Suppl):S1-2.
101. Barst RJ, Ivy DD, Gaitan G, Szatmari A, Rudzinski A, Garcia A, Sastry BKS, Pulido T, Layton GR, Serdarevic-Pehar M, Wessel DL. A Double-Blind, Placebo-Controlled, Dose-Ranging Study of Oral Sildenafil Citrate in the Treatment of Children With Pulmonary Arterial Hypertension. Revised for *Circulation* 2010.
102. DL Wessel; F Berger; J S Li; S Fontecave; A Rakhit; J W Newburger; for the CLARINET Investigators. A Randomized Trial of Clopidogrel to Reduce Mortality and Shunt-Related Morbidity in Infants Palliated with a Systemic to Pulmonary Artery Shunt. *Circulation*. 2010;122:A19459. Publication pending.

#### CHAPTERS, REVIEWS:

2. Hickey PR, Wessel DL. Anesthesia for repair of congenital heart disease. In: Kaplan JA, ed. *Cardiac anesthesia*. 2nd ed. New York: Grune and Stratton, 1987.
3. Crone RK, Hickey PR, Wessel DL. Development of the cardiovascular system. In: Shoemaker WC, Thompson WL, Holbrook PR, eds. *Textbook of critical care*. 2nd ed. Philadelphia: W.B. Saunders, 1988.
4. Hickey PR, Wessel DL. Anesthesia for congenital heart disease. In: Gregory FA, ed. *Pediatric anesthesia*. 2nd ed. New York: Churchill Livingstone, 1989.
5. Hansen DD, Wessel DL. The neonatal pulmonary circulation. *Current opinion in anesthesiology* 1988;1:38-44.
6. Wernovsky G, Erickson LC, Wessel DL. Cardiac emergencies. In: May HL, Aghababian RV, Fleisher, eds. *Emergency Medicine*. Boston: Little, Brown and Company, 1992;1914-1927.
7. Wessel DL. Postoperative management of the open heart surgery patient. In: *Pediatric Critical Care Review Series*. Anaheim: Critical Care Medicine, 1992.
8. Hickey PR, Wessel DL, Reich DL. Anesthesia for treatment of congenital heart disease. In: Kaplan JA, ed. *Cardiac Anesthesia* 3rd ed. Philadelphia: W. B. Saunders, 1993.
9. Wessel DL, Hickey PR. Anesthesia for congenital heart disease. In: Gregory GA, ed. *Pediatric Anesthesia* 3rd ed. New York: Churchill Livingstone, 1994.
10. Wessel DL. Perioperative management of the infant and neonate with congenital heart disease. In: Castaneda AR, Jonas RA, Mayer JE, Hanley FL, eds. *Cardiac surgery of the neonate and infant*. W.B. Saunders, 1994.

11. Wernovsky G, Chang AC, Wessel DL. Intensive Care. In: Adams FH, Emmanouilides GC, Riemenschneider TA, eds. Moss and Adams heart disease in infants, children, and adolescents. 5th ed. Williams & Wilkins, 1995.
12. Adatia I, Wessel DL. Therapeutic use of inhaled nitric oxide. *Current Opinion in Pediatrics*, 1994;6:583-590.
13. Wessel DL, Adatia I. The use of inhaled nitric oxide in the treatment of pulmonary hypertension in children. In: *Advances in Pharmacology*, Ignarro I, Murad F, eds. Nitric oxide: biochemistry, molecular biology, and therapeutic implications. Academic Press, 1995.
14. Adatia I, Wessel DL. The use of inhaled nitric oxide in congenital heart disease. In: Reeves J, Archer SL, Weir K, eds. Nitric oxide and radicals in the pulmonary vasculature. Armonk, NY: Futura Publishing Company, Inc. 1996.
15. Rykerson S, Thompson J, Wessel DL. Inhalation of nitric oxide: an innovative therapy for treatment of increased pulmonary vascular resistance. In: Hickey PA, ed. *The Nursing Clinics of North America*. 1995;30(2):381-389.
16. Wessel DL, Newburger JW. Research in the cardiac intensive care unit. *Progress in Pediatric Cardiology* 1995;(4):177-184.
17. Adatia I, Wessel DL. Diagnostic and therapeutic uses of inhaled nitric oxide in congenital heart disease. In: Zapol WM, Bloch KD, eds. Nitric Oxide and the Lung. Marcel Dekker, Inc., New York, NY 1997;165392.
18. Atz AM, Wessel DL. Delivery and monitoring of nitric oxide. *Current Opinion in Critical Care* 1997;3:243-249.
19. Atz AM, Wessel DL. Inhaled nitric oxide in the neonate with cardiac disease. In: D'Alton ME, Gross I, eds. *Seminars in Perinatology*. WB Saunders. 1997;21(5):441-455.
20. Atz AM, Wessel DL. Inhaled nitric oxide in the neonate with cardiac disease. *Seminars in Perinatology* 1997;21(5):441-455.
21. Atz AM, Wessel DL. Nitric oxide inhalation. In: Rubanyi GM, Furchgott R, Moncada S, eds. *The Pathophysiology and Clinical Application of Nitric Oxide*. Humana Press, 1998.
22. Nelson DP, Wessel DL. Normal physiology of the respiratory system. In: Chang AC, Hanley FL, Wernovsky G, Wessel DL, eds. *Pediatric Cardiac Intensive Care*. Williams & Wilkins, Baltimore, MD. 1998;67-81.
23. Wernovsky G, Chang AC, Wessel DL. Intensive Care. In: Adams FH, Emmanouilides GC, Riemenschneider TA, eds. Moss and Adams heart disease in infants, children, and adolescents. 6th ed. Williams & Wilkins, Baltimore, MD. 1999.
24. Wessel DL. Postoperative care of the patient with congenital heart disease—nitric oxide. In: Mohan OE, Fineman JR, eds. *Current concepts in pediatric critical care-1999*. Society of Critical Care Medicine, Anaheim, CA. 1999;9-14.
25. Laussen PC, Wessel DL. Anesthesia for congenital heart disease. In: Gregory GA, ed. *Pediatric Anesthesia* 4th ed. New York: Churchill Livingstone, 2001.
26. Wessel DL, Almodovar MC, Laussen, PC. Intensive care management of cardiac patients on extracorporeal membrane oxygenation. In: Duncan BW, ed. *Mechanical Support for Cardiac Respiratory Failure in Pediatric Patients*. Marcel Dekker, Inc. 2001;75-111.
27. Wessel DL. Current and future strategies in the treatment of childhood pulmonary hypertension. In: Barst R, ed. *Progress in Pediatric Cardiology*. Elsevier Science Ireland Ltd. 2001;289318



28. Wessel DL, Managing low cardiac output syndrome after congenital heart surgery. In: Crit Care Med 2001 (10 Suppl):S220-30.
29. Barst R, Ivy D, Bridges H, Wessel DL. Controversies and Concerns: Pulmonary Arterial Hypertension in Congenital Heart Disease; In: Advances in Pulmonary Hypertension, vol 2, No. 2, 2003.
30. Wessel DL. Pharmacologic management of low cardiac output syndrome after congenital heart surgery. In: Shanley TB, ed. Current Concepts in Pediatric Critical Care 2004. Society of Critical Care Medicine, Des Plaines, IL 2004: 59-72.
31. Wessel DL and Laussen PC. Critical care for congenital cardiac disease. In: Furhman BP, Zimmerman JJ, ed. Pediatric Intensive Care 3<sup>rd</sup> Edition. Elsevier Science, St. Louis, MO, 2006.
32. Wessel DL, Laussen PC. Intensive Care Unit. In: Keane JF, Lock JE, Fyler DC, eds: Nadas' Pediatric Cardiology. 2<sup>nd</sup> ed. Elsevier, 2006.
33. Wessel DL. Treatment of postoperative pulmonary hypertension. In: Beghetti M, eds. Pulmonary Arterial Hypertension Associated with Congenital Heart Disease. Urban & Fischer Verlag. 2006.
34. Wernovsky G, Chang AC, Wessel DL, Ravishankar, C. Intensive care. In: Adams FH, Emmanouilides GC, Riemenschneider TA, eds. Moss and Adams Heart Disease in Infants, Children, and Adolescents. 7th ed. Williams & Wilkins, 2008.
35. Wessel DL, Mullen MP. Pulmonary vasodilators. In: Munoz R, Schmitt C, Roth S, Da Cruz E, eds. Handbook of Pediatric Cardiovascular Drugs. Springer London. 2008.
36. Fraisse A, Wessel DL. Preoperative Care of the Pediatric Cardiac Surgical Patient. In: Nichols David G ed. The Rogers Textbook of Pediatric Intensive Care, 4<sup>th</sup> Edition. Lippincott Williams & Wilkins. 2008; 1149-1158.
37. Fraisse A, Wessel DL. Postoperative Care of the Pediatric Cardiac Surgical Patient: General Considerations. In: Nichols David G ed. The Rogers Textbook of Pediatric Intensive Care, 4<sup>th</sup> Edition. Lippincott Williams & Wilkins. 2008; 1159-1179.
38. Rotta AT, Laussen PC, Wessel DL, Critical Care for Congenital Cardiac Disease. In: Furhman BP, Zimmerman JJ, ed. Pediatric Intensive Care. Elsevier Science, St. Louis, MO, 2011. In Press

#### BOOKS EDITED OR WRITTEN:

1. Pediatric Cardiac Intensive Care. Chang AC, Hanley FL, Wernovsky G, Wessel DL, eds. Williams and Wilkins, 1998.

#### OTHER PUBLICATIONS

##### PROCEEDINGS OF MEETINGS:

1. Lang P, Wessel DL, Wernovsky G, Jonas RA, Mayer JE, Castaneda AR. Hemodynamic effects of amrinone in infants after cardiac surgery. In Curpi G, Parenzan L, Anderson RH (eds.). Perspectives in pediatric cardiology, vol. 2, pediatric cardiac surgery, part 2. Futura Publishing Co., Inc., Mount Kisco, NY; 1989.
2. Wessel DL, du Plessis, AJ. Choreoathetosis. In: Jonas RA, Newburger JW, Volpe JJ, eds. Brain Injury and Pediatric Cardiac Surgery. Butterworth-Heinemann, Newton, MA. 1995.
3. Wessel DL, Atz AM. Inhaled nitric oxide. In: Yasuharu I, Kazuo M, eds. Proceedings of the Second World Congress of Pediatric Cardiology and Cardiac Surgery. Futura, Armonk, NY. 1998 332334.

4. Wessel DL; editor. Proceedings from the World Congress in Pediatric Critical Care Symposium on "New strategies in the treatment of pulmonary hypertension. University of Colorado Continuing Medical Education. 2004.

**CLINICAL COMMUNICATIONS:**

1. Belko J, Wessel DL, Malley R. Endocarditis due to *Corynebacterium Diphtheriae*: A case report and review of the literature. *Pediatr Infect Dis J* 2000;19:159-63.
2. Kulik TJ, Giglia TM, Mahoney LT, Schwartz SM, Wernovsky G, Wessel DL. Reply to letter to the editor. *J Am Coll Cardiol*. 2006 Jul 4;48(1):222-223.
3. Allen HD, Bricker JT, Freed MD, Hurwitz RA, McQuinn TC, Schieken RM, Strong WB, Zahka KG, Sanders SP, Colan SD, Cordes TM, Donofrio MT, Ensing GJ, Geva T, Kimball TR, Sahn DJ, Silverman NH, Sklansky MS, Weinberg PM, Beekman RH 3rd, Hellenbrand WE, Lloyd TR, Lock JE, Mullins CE, Rome JJ, Teitel DF, Vetter VL, Silka MJ, Van Hare GF, Walsh EP, Kulik T, Giglia TM, Kocis KC, Mahoney LT, Schwartz SM, Wernovsky G, Wessel DL, Murphy DJ Jr, Foster E, Benson DW Jr, Baldwin HS, Mahoney LT, McQuinn TC; American College of Cardiology Foundation; American Heart Association; American Academy of Pediatrics . Author reply. *Pediatrics*. 2005 Dec;116(6):1574-96.
4. Olivieri, L. et al, Hypoplastic Left Heart Syndrome with Intact Atrial Septum: Sequelae of Left Atrial Hypertension in Utero, *JACC*, in press

**NONPRINT MATERIALS:**

1. Wessel DL, Atz AM. Therapeutic use of inhaled nitric oxide. In: *Am Coll Cardiol. ACC Self-Assessment Programs on CD-ROM*. 1998.
2. Wessel DL; Session Chair, Inhaled nitric oxide therapy in newborns: reaching a European consensus. *ESPNIC, Rome 2002*. CD-ROM.
3. Kinsella J, Steinhorn R, Clark R, Wessel D, ed. Hypoxic respiratory failure in the neonate: diagnosis and treatment. . CD-ROM and Slide Kit. *INO 2003*.
4. Wessel DL; editor. Proceedings from the World Congress in Pediatric Critical Care Symposium on "New strategies in the treatment of pulmonary hypertension." Monograph and CD-ROM. University of Colorado Continuing Medical Education.

# EXHIBIT 7

Exhibit 7

USSN: 12/820,866

UNITED STATES PATENT AND TRADEMARK OFFICE	
Application Serial Number	12/820,866
Confirmation Number	2913
Filing Date	22-JUN-2010
Title of Application	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
First Named Inventor	JAMES S. BALDASSARRE
Assignee	IKARIA, INC.
Group Art Unit	1616
Examiner	ARNOLD, ERNST V.
Attorney Docket Number	I001-0002USC1

Mail Stop Amendment  
 Commissioner for Patents  
 P.O. Box 1450  
 Alexandria, VA 22313-1450

DECLARATION OF DOUGLAS A. GREENE, M.D.  
UNDER 37 C.F.R. § 1.132

I, Douglas A. Greene, do hereby declare the following:

1. I currently hold the position of Executive Vice President and Head of Research and Development at INO Therapeutics LLC ("INO"), which is a wholly-owned subsidiary of Ikaria, Inc. A copy of my *curriculum vitae* is attached as **Exhibit 1**.

2. I received an undergraduate degree in biology (*cum laude*) from Princeton University in 1966 and a doctoral degree in medicine (M.D.) from Johns Hopkins School of Medicine in 1970.

3. I spent the next thirty years of my medical career (1970-2000) practicing and teaching medicine at some of America's foremost academic medical centers, including Johns Hopkins, Penn, Pitt, and the University of Michigan. At Michigan, I was a full professor of internal medicine, director of the Michigan Diabetes Research and Training Center, and chief of the Division of Endocrinology and Metabolism.

4. In 2000, I left Michigan to join Merck as Executive Vice President in charge of clinical sciences and product development. In this role, I supervised and directly managed all clinical research at Merck Research Laboratories, among other duties.

5. In 2003, I left Merck for Sanofi-Aventis, where I became a Senior Vice President and Chief Medical Officer. My duties at Sanofi-Aventis included overseeing all aspects of pre-clinical and clinical regulatory development of the company's products and overseeing all medical aspects of the company's US business.

6. In 2010, I joined INO, where – as noted above – I am presently Executive Vice President and Head of Research and Development.

7. I have been shown a Non-Final Office Action issued by the United States Patent and Trademark Office (USPTO) on June 8, 2011 in a pending patent application having US serial number 12/820,866. This Non-Final Office Action rejected the pending claims of 12/820,866 as "obvious" based on clinical interpretations presented by the USPTO regarding the teaching and disclosure of Atz & Wessel. (Seminars in Perinatology 1997, 21(5), 441-455), Kinsella et al. (Lancet 1999, 354 1061-1065) and Loh et al. (Circulation 1994, 90, 2780-2785). Below is my professional opinion and interpretation of the arguments and clinical interpretations presented by the USPTO within the Non-Final Office Action of June 8, 2011, for 12/820,866 (the "Office Action").

8. On page 7 of the Office Action, the Examiner states:

*"Atz et al. teach that: 'Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension.' (page 452, left column)."*

A more complete excerpt from Atz & Wessel, p. 452, left column is as follows:

**"Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension. In adults with ischemic cardiomyopathy, sudden pulmonary vasodilation may occasionally**

unload the right ventricle sufficiently to increase pulmonary blood flow and harmfully augment preload in a compromised left ventricle. The attendant increase in left atrial pressure may produce pulmonary edema. ... A different but related phenomenon may be operative in the newborn ...." (emphasis added)

Thus, although Atz & Wessel warns that "[c]aution should be exercised when administering nitric oxide (NO) to patients with severe left ventricular dysfunction and pulmonary hypertension[,] this caution is specifically limited to two populations of patients. In the first population, the statement in Atz & Wessel p. 452, left column, is directed to adult patients with ischemic cardiomyopathy who also exhibit severe left ventricular dysfunction and pulmonary hypertension. This patient population is clearly different from the neonatal population that is the object of the teaching of the present claims.

9. Further in the same paragraph, Atz & Wessel specifically refers to a second patient population, which is also distinct from that of the present patent application, to whom inhaled NO should not be administered, namely, neonates depending on right-to-left shunting of blood:

"A different but related phenomenon may be operative in the newborn with severe left ventricular dysfunction and pulmonary hypertension. In these patients, the systemic circulation may depend in part on the ability of the right ventricle to sustain cardiac output through a right-to-left shunt across the patent ductus arteriosus. Selective pulmonary vasodilation may redirect the right ventricular output to the lungs and away from the systemic circulation." (emphasis added)

For this second patient population, Atz & Wessel state that these patients exhibit a "different but related phenomenon" from that observed in adults with ischemic cardiomyopathy. This second population of patients consists of newborn patients with congenital heart disease and left ventricular dysfunction who are dependent on a right-to-left shunt through a ductus arteriosus in order to maintain peripheral circulation necessary to survive. In these patients, a patent ductus provides the only alternate pathway for blood being pumped by the right ventricle to bypass the dysfunctional left ventricle and thereby substitute for the dysfunctional left ventricle in providing life-sustaining blood flow to the peripheral circulation. Blood emerging

from the right ventricle has only two possible pathways, either through the pulmonary circulation and then back to the dysfunctional left ventricle, or to pass through the patent ductus arteriosus in a right-to-left shunt to reach the systemic circulation. Inhaled NO dilates the pulmonary circulation, and therefore would divert blood to the lungs at the expense of the patent ductus arteriosus and systemic circulation, causing systemic vascular collapse and death. Again, this second patient population described by Atz & Wessel is also completely different from the patient population addressed in the present claims, which is term or near term neonates with left ventricular dysfunction who are **NOT dependent upon right-to-left shunting**.

10. The risk of circulatory collapse in the subset of newborns with congenital heart disease and severe left ventricular dysfunction **who are dependent upon a right-to-left shunt** through a patent ductus arteriosus was well known in this field long before the Atz & Wessel publication, as evidenced by the contraindication stated in the US Food and Drug Administration (FDA) prescribing information for INOMAX<sup>®</sup> (nitric oxide) for inhalation from the time of its initial approval by the FDA in 1999: "**CONTRAINDICATIONS: Neonates known to be dependent on right-to-left shunting of blood**".

11. As a result of the INOT22 study, it was recognized that a second population of neonates existed, distinct from the population described in Atz & Wessel, that had an increased risk of adverse events when inhaled NO was administered, namely: pediatric patients with left ventricular dysfunction **who are not dependent upon right-to-left shunting of blood**. In view of this newly identified risk, the FDA imposed the addition of a distinct and separate precaution to the prescribing information for INOMAX specifically cautioning about an additional risk of pulmonary edema for patients with left ventricular dysfunction (see paragraph 15). It is important to note that patients covered in the pre-existing contraindication (specifically neonates known to be dependent on right-to-left shunting of blood) were completely excluded from INOT22 by virtue of the labeled contraindication. The newly discovered risk of adverse events in neonates and children with left ventricular dysfunction **who are not dependent on right-to-left shunting** was not addressed, suggested or otherwise inferred from the teachings of Atz & Wessel, because when Atz and Wessel recommend that inhaled NO should be used with caution

“if at all”, that warning relates to neonates who are dependent upon right-to-left shunting of blood – a completely different population of patients than the population that is addressed in the present claims.

12. On page 7 of the Office Action, the Examiner further states:

*“Since pulmonary hypertension is instantly claimed, then the subject intrinsically has hypoxic respiratory failure.”*

This statement is not medically accurate. Pulmonary hypertension occurs in many conditions other than hypoxic respiratory failure, such as congenital heart disease, maternal use of serotonin reuptake inhibitors, idiopathic pulmonary hypertension, etc.

13. On page 7 and 8 of the Office Action, the Examiner states:

*“Atz et al. continues with: ‘Therefore, in newborns with severe left ventricular dysfunction, predominantly left to right shunting at the foramen ovale and exclusively right to left shunting at the ductus arteriosus, NO should be used with extreme caution, if at all. We and others have reported adverse outcomes in this circumstance.’ (p. 452, left column) (emphasis differing from original).”*

This statement merely reiterates the “caution” delivered by Atz & Wessel for the second population of patients identified in that publication, namely neonates dependent upon a right-to-left shunt at the ductus arteriosus. In this statement, Atz & Wessel simply teach that patients with severe left ventricular dysfunction dependent upon an exclusively right-to-left shunt at the ductus arteriosus often have coexistent predominantly left-to-right shunt at the foramen ovale. This additional left-to-right shunt at the foramen ovale, upstream from the dysfunctional left ventricle, permits blood to bypass the dysfunctional left ventricle and enter the right side of the heart, thereby enhancing the ability of the right ventricle to pump sufficient blood through the ductus arteriosus to maintain the systemic circulation. The population of patients dependent upon right-to-left shunting of blood (with or without shunting at the foramen ovale) was already excluded by the pre-existing FDA-mandated contraindication for inhaled NO, and is distinct from the patient population addressed in the present claims.



14. On page 8 of the Office Action, the Examiner states:

*"Atz et al. thus identify conditions in the patients which is screening of the patient. Thus, Atz et al. fairly teaches excluding patients which include neonates with left ventricular dysfunction from inhaled NO treatment because the Examiner interprets "if at all" to mean no treatment and hence exclusion from treatment. The left ventricular dysfunction is intrinsically pre-existing."*

This statement misinterprets the teaching of Atz & Wessel. Specifically, "if at all" refers to the second patient population, wherein no treatment is allowed in the population of newborn "patients dependent upon right-to-left shunting of blood" who are at risk for circulatory collapse. Because these patients were already contraindicated in the drug labeling for inhaled NO prior to INOT22 (see paragraph 10 above), they were excluded from INOT22 and more importantly, are distinct from the patients identified in the new inhaled NO safety warnings mandated by the FDA in view of the risk that was newly identified as a result of the INOT22 study.

15. On February 25, 2009, INO Therapeutics LLC (owner of NDA 20845) submitted a label supplement to the FDA seeking to amend the prescribing information (i.e., the "label") for INOMAX® (nitric oxide) for inhalation, to include a new warning statement based on the unexpected outcome of the INOT22 study. On August 28, 2009, the FDA approved the INOMAX® label supplement to include the following new information:

WARNINGS AND PRECAUTIONS

*Heart Failure: In patients with pre-existing left ventricular dysfunction, inhaled nitric oxide may increase pulmonary capillary wedge pressure leading to pulmonary edema (5.4).*

5 WARNINGS AND PRECAUTIONS

*5.4 Heart Failure: Patients who had pre-existing left ventricular dysfunction treated with inhaled nitric oxide, even for short durations, experienced serious adverse events (e.g., pulmonary edema).*

Thereafter, similar warnings were added to the INOMAX label by Health Authorities in Japan, Europe, Canada and Australia. The FDA (and its counterparts in foreign nations) would

not add new warnings and precautions to the label of an approved drug that merely restate a known contraindication already existing on the approved drug label. Indeed, the new FDA-approved warnings for the use of nitric oxide are clinically distinct from the existing, original INOMAX contraindication disclosed by Atz & Wessel, with respect to neonates dependent on right-to-left shunt.

16. On page 8 and 9 of the Office Action, the Examiner states:

*"Kinsella et al. teach excluding patients (premature neonates) from inhaled nitric oxide treatment if they have fatal congenital anomalies or congenital heart disease (Abstract and p. 1062, Methods). Since left ventricular dysfunction is a congenital heart disease, as acknowledged by Applicant, (see specification [0028]), and it would be pre-existing, then the methods of Kinsella et al. intrinsically exclude this patient population from the method. ... The intended patient population is intrinsically at risk of one or more adverse events. Patients are intrinsically identified for nitric oxide inhalation treatment, diagnosed for congenital heart disease which intrinsically includes left ventricular dysfunction, and if the patient meets the criteria then treatment with NO is performed thereby reducing the risk of adverse events associated with the treatment."*

Based on these statements, it is clear that the Examiner fails to understand several critical aspects of the study of Kinsella et al.

17. First and foremost, the patients included in the Kinsella et al. trial were premature neonates who have severe respiratory failure due to immature lungs and surfactant deficiency, rather than term and near-term neonates suffering from pulmonary hypertension. In addition, none of the premature neonates enrolled in Kinsella et al. suffered from pulmonary hypertension. Thus, the patients included in Kinsella et al. were clinically differentiated, by age, etiology and pathophysiology, from the term and near-term neonates addressed in the present claims.

18. Secondly, exclusion of patients from a particular study may occur for a variety of reasons. For example, clinical trial inclusion and exclusion criteria are often chosen to define or restrict the study population in order to maximize homogeneity, thereby minimizing the presence of potentially confounding factors. This exclusion greatly facilitates the interpretation of the

study results, and increases the soundness of the conclusions reached in the study. Accordingly, patients with background disease sufficiently severe to overwhelm or confound an expected treatment effect are systematically identified and excluded quite independently from considerations of anticipated safety or efficacy of the test article in this particular patient group.

19. For example, patients with malignancy are often excluded from non-oncologic clinical trials, not because the test agents are unsafe, pose any specific risk in this population, or will not work, but rather because the clinical results will be confounded by the wholly unrelated effects of the underlying malignancy, thereby reducing the power of the clinical trial to answer a specific hypothesis regarding the test treatment. As a specific example, exclusion of patients with malignancy or advanced heart failure from cholesterol lowering trials does not imply that statins are unsafe or ineffective in these patients, but rather that their inclusion would confound the potential effects of statins on overall mortality or cardiovascular events.

20. In the specific case of Kinsella et al., it is clear that one of ordinary skill in the art would understand that the patients having fatal congenital anomalies or congenital heart disease were excluded not because of a suspected safety risk of treating these patients with inhaled NO (e.g., a risk of pulmonary edema), but rather solely because the inclusion of such patients would have made it much more difficult – if not impossible - for Kinsella et al. to interpret the target outcomes of the study (i.e., would have “confounded” the results).

21. On page 9 of the Office Action, the Examiner states:

*Loh et al. teach that inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure (Title and Abstract). Loh et al. clearly teaches that patients with pulmonary artery wedge pressure, which is synonymous with the instantly claimed pulmonary capillary wedge pressure, of greater than or equal to 18mm Hg had a greater effect of inhaled NO due to the greater degree of reactive pulmonary hypertension present in such patients (p. 2784, left column). Loh et al. state: “Since the degree of reactive pulmonary hypertension is generally related to the severity of hemodynamic compromise in patients with LV failure, it might be*

*anticipated that patients with more severe heart failure will have a more marked hemodynamic response to inhaled NO." Loh et al. examined this prediction further and verified it (p. 2784, left column).*

The Examiner apparently neglects to consider that the acute hemodynamic effect of inhaled NO was studied by Loh et al. only in **adult** patients with New York Heart Association Class III or IV congestive failure due to coronary artery disease or dilated cardiomyopathy, not in term or near-term neonates who were not dependent upon right-to-left shunting. Thus, their observations do not teach, or even suggest, the risk of inhaled NO in neonates or children with pulmonary hypertension and left ventricular dysfunction who are not dependent on right-to-left shunting of blood, the population that is addressed in the present claims.

22. The underlying etiologies and hemodynamic characteristics of both the primary heart disease and the increased pulmonary vascular resistance are drastically different from adults, as compared to non-adults, such that one cannot readily assume or anticipate clinical results within adults to translate into neonates or children. In particular, left ventricular dysfunction in neonates with congenital heart disease is primarily due to developmental structural disease of the heart, inborn errors of metabolism that impair energy generation in the heart muscle, or viral infection. Class III or class IV congestive heart failure in adults (in contrast to congenital heart disease in neonates or children) is due to ischemic or dilated cardiomyopathy, mostly secondary to coronary artery disease and/or chronic systemic hypertension. Pulmonary hypertension associated with neonatal congenital heart disease is secondary to chronic hypoxemia, developmental abnormalities of the pulmonary blood vessels and/or pulmonary vascular damage from abnormally high blood flow and/or pressure through the pulmonary vasculature, resulting in evident disease of the lung vasculature. In contrast, increased pulmonary vascular resistance in adult Class III or IV congestive heart failure is due to reactive pulmonary vasoconstriction secondary to increased sympathetic tone or circulating vasoactive molecules (Loh et al., p. 2780, left column) in otherwise structurally normal blood vessels. Therefore, the hemodynamic responses to pulmonary vasodilation by inhaled NO in children or neonates, without right-to-left shunting of blood, but with significant pulmonary hypertension and left ventricular dysfunction cannot be reasonably predicted from the hemodynamic responses to pulmonary vasodilation by inhaled NO of adults with advanced

atherosclerotic congestive heart failure and reactive neuro-humoral pulmonary vascular constriction (with or without pulmonary hypertension) as described by Loh et al.

23. On page 10 of the Office Action, the Examiner states:

*"It would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to perform the method of Atz et al. and identify patients with a second condition/risk factor and administer iNO to patients that do not have the first or second condition/risk factors of instant claims 20-27 and inform the medical provider that patients with a pulmonary capillary wedge pressure greater than 20 mm Hg that may increase pulmonary edema, as suggested by Loh et al., and Kinsella et al., and produce the instant invention."*

24. Atz & Wessel do not recommend exercising "caution" when treating term or near-term neonates who are not dependent upon right-to-left shunting, but rather refer to two other patient populations, namely (i) neonatal patients whose systemic circulation is dependent upon right-to-left shunting of blood and who therefore might suffer from systemic circulatory collapse if given inhaled NO (a well-known contraindication for inhaled NO) and (ii) adult patients with New York Heart Association Class III-IV heart failure due to ischemic or dilated cardiomyopathy and increased neuro-humorally-mediated pulmonary vascular resistance might be hemodynamically at risk for pulmonary edema if given inhaled NO (the same population discussed by Loh et al.).

25. On page 10 of the Office Action, the Examiner states:

*"One of ordinary skill in the art would have been motivated to do this because: 1) it is common sense that if the neonate is healthy then iNO therapy can be performed safely; 2) if the neonate is not healthy and has left ventricular dysfunction (LVD), then Atz et al. clearly teach using extreme caution or not using NO at all in the treatment of patients with LVD which would also render obvious all conditions/risk factors associated with LVD; and 3) the art of Kinsella et al. establishes excluding certain patients (premature neonates) from inhaled nitric oxide treatment if they have fatal congenital anomalies or congenital heart disease."*

The conclusion presented by the Examiner is not clinically accurate, nor does it accurately reflect the expectations or motivations of a clinician of ordinary skill in the art at the time of the invention. Their expectation would have been quite the opposite. It is by no means "1) ... common sense that if the neonate is healthy then iNO therapy can be performed safely; 2) if the neonate is not healthy and has left ventricular dysfunction (LVD), then Atz et al. clearly teach using extreme caution or not using NO at all in the treatment of patients with LVD." Firstly, inhaled NO would have no utility in healthy neonates, and is safely used in very severely ill neonates on a routine basis. Secondly, Atz & Wessel teach "using extreme caution or not using NO at all" only in neonates dependent upon right-to-left shunting of blood in order to avoid systemic circulatory collapse, and makes no statement regarding neonates with left ventricular dysfunction **who are not dependent upon right-to-left shunting**. Kinsella et al. do not teach about the safe or unsafe use of inhaled NO in neonates or children, let alone term or near-term neonates not dependent upon right-to-left shunting, but merely noted that they had excluded premature babies with fatal malformations or congenital heart disease from a clinical trial of inhaled NO in premature babies suffering from the respiratory distress of prematurity. Loh et al. teach about the effect of inhaled NO on hemodynamic measurements in adults with advanced heart failure and secondary neuro-humorally-mediated increased pulmonary vascular resistance, and speculate that these adults may be at increased risk for pulmonary edema, but do not teach anything about the use of inhaled NO in term or near-term neonates not dependent upon right-to-left shunting.

26. On page 11 of the Office Action, the Examiner states:

*"Furthermore, it is already known through the teachings of Loh et al. that a pulmonary capillary wedge pressure (PCWP) of greater than 18 mm Hg serves as a guidepost for alerting the artisan to adverse events from inhaled NO. Thus, it is not inventive to exclude patients with a PCWP of greater than 20 mm Hg when the art already suggests the risk of trouble of treating patients with a PCWP of 18 mm Hg because inhaled NO increases the wedge pressure as taught by Loh et al. (see entire document). In summary, it remains the position of the Examiner, which is in alignment with the written opinion of the international search authority, that it is simply not inventive to 'inform' a medical provider that a neonate with LVD is at risk of adverse/serious adverse*

events from iNO therapy when the art already has established that fact and the ordinary artisan is alerted to this fact. If the patient has LVD then they are at risk of adverse and/or serious adverse events from iNO therapy and it is not inventive to further identify other secondary conditions/risk factors associated with LVD and provide further warnings for secondary conditions/risk factors that are separate and independent from the first condition/risk factor but nevertheless associated with LVD to the medical provider. Screening for conditions that predispose the patient to adverse/serious adverse effects from medical treatment is obvious given the teachings above." (emphasis in original)

It is inaccurate to represent Loh et al as "serving as a guidepost for alerting the artisan to adverse events from inhaled NO," as Loh et al. reported no adverse events during administration of inhaled NO for 10 minutes to 19 stable patients with advanced heart failure. Rather, Loh et al. speculated that a finding of an elevation in PCWP in a subgroup of such patients could pose an increased risk of pulmonary edema in adults with congestive heart failure due to ischemic or dilated cardiomyopathy. As discussed above, extrapolation of that theoretical risk to neonates and children with different forms of heart disease, different cardiovascular hemodynamics, and different pulmonary vasculature physiology, pathophysiology and pathology was not obvious, as evidenced by the fact that the members of the INOT22 Screening Committee (including Dr. Wessel) who designed the INOT22 study protocol, the approximately 18 Institutional Review Boards and/or Independent Ethics Committee, and 5 National Health Authorities (FDA and national Health Authority for United Kingdom, France, Netherlands and Spain) who reviewed and approved the INOT22 study protocol prior to its initiation, all failed to predict that any untoward effects would be caused by the administration of inhaled NO within a pediatric patient population having left ventricular dysfunction who are not dependent on right-to-left shunting of blood.. Only after being informed of the present invention did the FDA mandate a change to the drug labeling for inhaled NO to include a new warning (separate and distinct from the pre-existing contraindication pertaining to neonates dependent on right-to-left shunting of blood) concerning the use of inhaled NO in patients with pre-existing left ventricular dysfunction.

27. On page 12 of the Office Action the Examiner states:

*Respectfully, the instantly claimed method steps are in the realm of common sense and not in the realm of invention because it is already known in the art that patients with pre-existing LVD are at risk of adverse effects from iNO. It is obvious to the ordinary artisan that if the neonate has LVD with or without any number of conditions/risk factors, then in order to avoid the risk of adverse or serious adverse events associated with iNO, to then exclude the neonate from iNO therapy. In other words, given the art as a whole, determination of further conditions/risk factors that would exclude the neonate from iNO therapy is obvious given the teachings in the art as discussed above which direct the artisan to screen neonates about to undergo treatment with NO by inhalation and to exclude those with LVD from such treatment. In light of the forgoing discussion, the Examiner concludes that the subject matter defined by the instant claims would have been obvious within the meaning of 35 USC 103(a). From the teachings of the references, it is apparent that one of ordinary skill in the art would have had a reasonable expectation of success in producing the claimed invention. Therefore, the invention as a whole was prima facie obvious to one of ordinary skill in the art at the time the invention was made, as evidenced by the references, especially in the absence of evidence to the contrary."*

The arguments by which this conclusion is supported are both medically and scientifically unsound. To summarize, the teaching of Atz & Wessel is inaccurately portrayed by the Examiner due to his confusion of the known risk of systemic vascular collapse if inhaled NO is administered to neonates dependent upon right-to-left shunting of blood, and the opposite case of adults where inhaled NO may be less effective than in children. The Examiner misconstrues Kinsella et al.'s clinical trial inclusion/exclusion criteria as a teaching of risk associated with inhaled NO administration, rather than as a routine practical measure in the design of clinical trials to minimize confounding factors and heterogeneity in the study population. Lastly, the Examiner grossly over-interprets the hemodynamic findings of Loh et al. in adults with ischemic or dilated cardiomyopathy and congestive heart failure (a disease process differing in etiology, physiology, pathophysiology and pathology from childhood congenital heart disease) as "a guidepost to the artisan" regarding the use of inhaled NO in children and neonates with pulmonary hypertension and left ventricular dysfunction, but not dependent on right-to-left shunting of blood. These inaccurate and erroneous interpretations of all three supporting publications cited by the Examiner lead the Examiner to draw incorrect conclusions regarding what is or is not taught or suggested by the prior art.



Applicant : Baldassarre et al  
Serial No. : 12/820,866  
Filed : 22JUN10  
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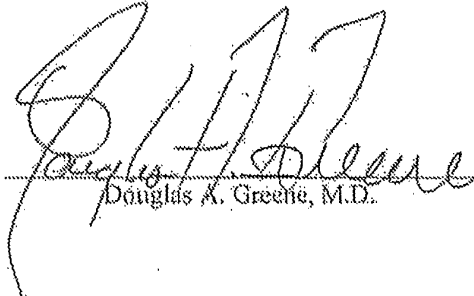
Attorney's Docket No.: 1001-0002USC1

28. On June 28, 2011, I met with Dr. David L. Wessel, the chair of the INOT22 Steering Committee and the senior author of *Atz & Wessel (Seminars in Perinatology 1997, 21(5), pp 441-455*. During our discussion, I informed Dr. Wessel of the 12/820,866 and 12/820,980 patent applications, and the fact that in both pending patent applications, the Examiner was citing Atz & Wessel to allege that it would have been obvious to predict the adverse events and outcomes of the INOT22 study that lead to the inventions claimed in 12/820,866 and 12/820,980.

29. Dr. Wessel disagreed with the Examiner's allegation and found it ironic that his own publication would be cited to suggest the obviousness of the unexpected outcomes of the INOT22 study, when Dr. Wessel himself, the senior author of Atz & Wessel, failed to predict that neonatal and child patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood would be at increased risk of adverse events when administered inhaled NO. A copy of a June 29, 2011 letter from Dr. Wessel to me stating this opinion is attached hereto as Exhibit 2.

30. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the '359 patent.

Dated: 7/7/11

  
Douglas K. Greene, M.D.

Applicant : Baldassarre et al  
Serial No. : 12/820,866  
Filed : 22JUN10  
Page : 15 of 15

Attorney's Docket No.: I001-0002USC1

# EXHIBIT 1

(curriculum vitae)

## CURRICULUM VITAE

### PERSONAL DATA

Name: Douglas Alan Greene, M.D.

### EDUCATION

High School Columbia High School, South Orange, NJ, 1962  
Undergraduate Princeton University, Princeton, NJ, BA Biology(cum laude), 1962-1966  
Graduate/Professional Johns Hopkins School of Medicine, Baltimore, MD, M.D., 1966-1970

### POSTDOCTORAL TRAINING

Medical Internship: Department of Medicine, Johns Hopkins, Baltimore, MD, 1970-1971  
Medical Residency: Department of Medicine, Johns Hopkins, Baltimore, MD, 1971-1972  
Fellowship: Medical Fellowship, Department of Medicine, Johns Hopkins University, School of Medicine, Baltimore, MD, 1970-1972

Post-doctoral Research Fellow, Diabetes, George S. Cox Medical Research Institute; Hospital of the University of Pennsylvania, Philadelphia, PA (Dr. Albert I. Winegrad, preceptor), 1972-1975

Medical Fellowship, Department of Medicine, University of Pennsylvania, School of Medicine, Philadelphia, PA, 1972-1975

### NON-ACADEMIC EMPLOYMENT

- 2000-2003 Executive Vice President, Clinical Sciences and Product Development (CSPD), Merck Research Laboratories, Rahway, New Jersey, and Corporate Officer, Merck, Inc. Supervised and directly managed all clinical research, regulatory affairs, clinical and non-clinical quality assurance and pharmaco-vigilance at Merck Research Laboratories.
- 2003-2006 Vice President, Head Corporate Regulatory Development, Sanofi-Aventis, Bridgewater, NJ. Overseeing all aspects of corporate regulatory development of all pre-clinical and clinical development projects/life-cycle products in Research & Development.
- 2006-2009 Senior Vice President, Chief Medical Officer, Sanofi-Aventis, Bridgewater, NJ. Overseeing medical, regulatory, pharmacovigilance, risk management, education and medical communications for US region, Member US Executive Committee, Member Committee Operational de Development, International Clinical Development.
- 2009-present Senior Vice President, Senior Scientific Advisor, Sanofi-Aventis, Bridgewater, New Jersey. Member Corporate Portfolio Valuation Process and Drug Development Committees. The position at the interface between the Research and Development and Pharmaceutical Operations is responsible for providing key scientific and medical guidance for sanofi-aventis' scientific strategy within U.S. and global contexts to enhance the quality and effectiveness of the company's research and product portfolio, including assessment and guidance of internal R&D product pipeline and franchise portfolio and external commercial and academic innovation opportunities.

#### ACADEMIC APPOINTMENTS

1975-1980	Assistant Professor of Medicine, University of Pennsylvania, School of Medicine, Philadelphia, Pennsylvania
1980-1986	Associate Professor of Medicine, Director, General Clinical Research Center and Diabetes Research Laboratories, University of Pittsburgh, School of Medicine
1986-2000	Professor of Internal Medicine, Director, Michigan Diabetes Research and Training Center, University of Michigan School of Medicine
1991-2000	Chief, Division of Endocrinology & Metabolism, University of Michigan School of Medicine
2000-Present	Adjunct Professor, Internal Medicine, Division of Endocrinology & Metabolism, University of Michigan, School of Medicine

#### SELECTED SCIENTIFIC ACTIVITIES

1988-1994	Chairman, Endocrinologic and Metabolic Drug Advisory Board, Food and Drug Administration, Washington D.C (Chair, 1990-1994)
1994-2000	Chairman, Merck Scientific Board of Advisors

#### SELECTED SCIENTIFIC PRIZES AND AWARDS

1986	First Annual Raymond A. and Robert L. Kroc Lecturer, Eisenhower Medical Center, Palm Springs, California
1987	Moore Award, The American Association of Neuropathologists, Seattle, Washington
1987	Carol Sinicki Manuscript Award (The Diabetes Educator), American Association of Diabetes Educators, Chicago, Illinois
1988	Kellion Lecture, International Diabetes Federation, Sydney, Australia
1989	Banting and Best Lecture, Toronto General Hospital, Toronto, Canada
1994	Charles H. Best Lecturer, Toronto Diabetes Association, Toronto, Canada
1996	Invited Speaker, Seventy-fifth Anniversary Celebrating the Discovery of Insulin, Toronto, Canada
1996	First Alan Robinson Lecturer, University of Pittsburgh
1998	Outstanding Foreign Investigator Award, Japan Society of Diabetic Complications

## SELECTED BIBLIOGRAPHY

### Peer-Reviewed Publications (Selected from over 170 peer-reviewed articles):

1. Greene DA, DeJesus PV, Winegrad AI: Effect of insulin and dietary Myo-Inositol on impaired peripheral motor nerve conduction velocity in acute streptozotocin diabetes. *J. Clin. Invest.* 55:1326-1336, 1975.
2. Winegrad AI, Greene DA: Diabetic polyneuropathy: The importance of insulin deficiency, hyperglycemia and alterations in myo-inositol metabolism in its pathogenesis. *N. Engl. J. Med.* 295:1416-1420, 1976.
3. Greene DA, Lattimer SA: Sodium- and energy dependent uptake of myo-inositol by rabbit peripheral nerve. Competitive inhibition by glucose and lack of an insulin effect. *J. Clin. Invest.* 70:1009-1018, 1982.
4. Greene DA, Lattimer SA: Impaired rat sciatic nerve sodium-potassium ATPase in acute streptozotocin diabetes and its correlation by dietary myo-inositol supplementation. *J. Clin. Invest.* 72:1058-1063, 1983.
5. Greene DA, Lattimer SA: Impaired energy utilization and Na-K-ATPase in diabetic peripheral nerve. *Am. J. Physiol.* 246:E311-E318, 1984.
6. Greene DA, Yagihashi S, Lattimer SA, Sima AAF: Nerve  $\text{Na}^+\text{K}^+$ -ATPase, conduction and myo-inositol in the insulin deficient BB rat. *Am J Physiol* 247:E534-E539, 1984.
7. Greene DA, Lattimer SA: Protein kinase C agonists acutely normalize decreased ouabain-inhibitable respiration in diabetic rabbit nerve: Implications for [Na,K]-ATPase regulation and diabetic complications. *Diabetes* 35:242-245, 1986.
8. Sima AAF, Lattimer SA, Yagihashi S, Greene DA: 'Axo-glial dysjunction' a novel structural lesion that accounts for poorly-reversible slowing of nerve conduction in the spontaneously diabetic BB-rat. *J. Clin. Invest.* 77:474-484, 1986.
9. Greene DA: A sodium-pump defect in diabetic peripheral nerve corrected by sorbinil administration: Relationship to myo-inositol metabolism and nerve conduction slowing. *Metabolism* 35:60-66, 1986.
10. Greene DA, Mackway AM: Decreased myo-inositol content and  $\text{Na}^+\text{K}^+$ -ATPase activity in superior cervical ganglion of STZ-diabetic rat and prevention by aldose reductase inhibition. *Diabetes* 35:1106-1108, 1986.
11. Carroll PB, Thornton BM, Greene DA: Glutathione redox state is not the link between polyol pathway activity and diminished (Na,K)-ATPase activity in experimental diabetic neuropathy. *Diabetes* 35:1282-1285, 1986.
12. Greene DA, Lattimer SA, Sima AAF: Sorbitol, phosphoinositides and the sodium-potassium ATPase in the pathogenesis of diabetic complications. *N. Engl. J. Med.* 316:599-606, 1987.
13. Greene DA, Chakrabarti S, Lattimer SA, Sima AAF: Role of sorbitol accumulation and myo-inositol depletion in paranodal swelling of large myelinated nerve fibers in the insulin-deficient spontaneously diabetic bio-breeding rat: Reversal by insulin replacement, an aldose reductase inhibitor, and myo-inositol. *J. Clin. Invest.* 79:1479-1485, 1987.

14. Sima AAF, Nathaniel V, Bril V, McEwen TAJ, Greene DA: Histopathological heterogeneity of neuropathy in insulin-dependent and non-insulin-dependent diabetes, and demonstration of axo-glial dysjunction in human diabetic neuropathy. *J. Clin. Invest.* 81:349-364, 1988.
15. Greene DA, Lattimer SA, Sima AAF: Perspectives in diabetes: Are disturbances of sorbitol, phosphoinositide, and  $\text{Na}^+\text{-K}^+\text{-ATPase}$  regulation involved in pathogenesis of diabetic neuropathy? *Diabetes* 37:688-693, 1988.
16. Greene DA, Lattimer SA, Sima AA: Pathogenesis and prevention of diabetic neuropathy. *Diabetes Metab Rev* 4:201-221, 1988.
17. Lattimer SA, Sima AAF, Greene DA: In Vitro correction of impaired  $\text{Na}^+\text{-K}^+\text{-ATPase}$  in diabetic nerve by protein kinase C agonists. *Am. J. Physiol.* 256 (Endocrinol. Metab. 19):E264-E269, 1989.
18. Greene DA, Lattimer SA, Sima AAF: Pathogenesis of diabetic neuropathy: Role of altered phosphoinositide metabolism. *CRC Critical Reviews in Neurobiology* (J. Nelson, ed., CRC Press, Inc.), pp. 143-219, 1989.
19. Greene DA, Lattimer SA, Carroll PB, Fernstrom JD, Finegold DN: A defect in sodium-dependent amino acid uptake in diabetic rabbit peripheral nerve: Correction by an aldose reductase inhibitor or myo-inositol administration. *J. Clin. Invest.* 85:1657-1665, 1990.
20. Greene DA, Sima AF, Pfeifer MA, Albers JW. Diabetic Neuropathy. *Annu Rev Med* 41:303-317, 1990.
21. Sima AAF, Prashar A, Zhang W-X, Chakrabarti S, Greene DA: Preventive effect of long-term aldose reductase inhibition (Ponalrestat) on nerve conduction and sural nerve structure in the spontaneously diabetic bio-breeding rat. *J. Clin. Invest.* 85:1410-1420, 1990.
22. Kim J, Kyriazi H, Greene DA: Normalization of (Na,K)-ATPase activity in an isolated membrane fraction from sciatic nerves of streptozotocin-diabetic rats by dietary myo-inositol supplementation in vivo or protein kinase C agonists in vitro. *Diabetes* 40:558-567, 1991.
23. Stevens MJ, Lattimer SA, Kumijo M, Van Huysen C, Sima AAF, Greene DA: Osmotically induced nerve taurine depletion in experimental diabetes: An hypothetical modulator of painful neuropathy. *Diabetologia* 36:608-614, 1993.
24. Henry DN, Del Monte M, Greene DA, Killen PD: Altered aldose reductase gene regulation in cultured human retinal pigment epithelial cells. *J. Clin. Invest.* 92:617-623, 1993.
25. The DCCT Research Group: The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N. Eng. J. Med.* 329:977-986, 1993.
26. Thomas TP, Feldman EL, Nakamura J, Kato K, Lien M, Stevens MJ, Greene DA: Ambient glucose and aldose reductase-induced myo-inositol depletion modulate basal and carbachol-stimulated inositol phospholipid metabolism and diacylglycerol accumulation in human retinal pigment epithelial cells in culture. *Proc. Natl. Acad. Sci. USA* 90:9712-9716, 1993.
27. Thomas TP, Porcellati F, Kato K, Stevens MJ, Shorman WR, Greene DA: Effects of glucose on sorbitol pathway activation, cellular redox, and metabolism of myo-inositol, phosphoinositide and

- diacylglycerol in cultured human retinal pigment epithelial cells. *J. Clin. Invest.* 93:2718-2724, 1994.
28. Stevens MJ, Dananberg J, Feldman EL, Lattimer SA, Kamijo M, Thomas TP, Shindo H, Sima AAF, Greene DA: The linked roles of nitric oxide, aldose reductase and (Na<sup>+</sup>,K<sup>+</sup>)-ATPase in the slowing of nerve conduction in the streptozotocin diabetic rat. *J. Clin. Invest.* 94:853-859, 1994.
  29. Feldman EL, Stevens MJ, Thomas PK, Brown MB, Canal N, Greene DA: A practical two-step quantitative clinical and electrophysiological assessment for the diagnosis and staging of diabetic neuropathy. *Diabetes Care* 17:1281-1289, 1994.
  30. The DCCT Research Group: The effect of intensive treatment of diabetes on nerve conduction measures in the DCCT. *Annals of Neuro.* 38:869-880, 1995.
  31. Stevens MJ, Feldman EL, Greene DA: The etiology of diabetic neuropathy: The combined roles of metabolic and vascular defects. *Diabetic Medicine* 12:566-579, 1995.
  32. Shindo H, Thomas TP, Larkin DD, Karihaloo AK, Inada H, Onaya T, Stevens MJ, Greene DA: Modulation of basal nitric oxide-dependent cyclic-GMP production by ambient glucose, myo-inositol, and protein kinase C in SH-SY5Y human neuroblastoma cells. *J Clin Invest* 97:736-745, 1996.
  33. Sima AAF, Ristic H, Merry A, Kamijo M, Lattimer SA, Stevens MJ, Greene DA: Primary preventive and secondary interventional effects of acetyl-L-carnitine on diabetic neuropathy in the bio-breeding Worcester rat. *J Clin Invest* 97:1900-1907, 1996.
  34. Karihaloo A, Kato K, Greene DA, Thomas TP: Protein kinase and cytosolic calcium modulation of myo-inositol transport in cultured retinal pigment epithelial cells. *Am J Physiol* 273:C671-678, 1997.
  35. The DCCT Research Group: Effect of intensive therapy on residual B-cell function in patients with Type I diabetes in the DCCT: A randomized, controlled trial. *Ann Int Med* 128:517-523, 1998.
  36. The DCCT Research Group: The effect of intensive diabetes therapy on measures of autonomic nervous system function in the DCCT. *Diabetologia* 41:416-423, 1998.
  37. Porcellati F, Hlaing T, Togawa M, Stevens MJ, Larkin DD, Hosaka Y, Glover TW, Henry DN, Greene DA, Killen PD: Human Na<sup>+</sup>-myo-inositol cotransporter gene: alternate splicing generates diverse transcripts. *Am J Physiol.* 274: C1215-C1225, 1998.
  38. Porcellati F, Hosaka Y, Hlaing T, Togawa M, Larkin DD, Karihaloo A, Stevens MJ, Killen PD, Greene DA: alternate splicing in human Na<sup>+</sup>-MI cotransporter gene yields differentially regulated transport isoforms. *Am J Physiol* 276:1325-1337, 1999.
  39. Greene DA, Stevens MJ, Obrosova I, Feldman EL. Glucose-induced oxidative stress and programmed cell death in diabetic neuropathy. *European Journal of Pharmacology* 375:217-223, 1999.
  40. Greene DA, Aronzo JC, Brown MB: Effect of aldose reductase inhibition on nerve conduction and morphometry in diabetic neuropathy. *Neurology* 53:580-591, 1999.

41. Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group: Retinopathy and nephropathy in patients with type 1 diabetes four years after a trial of intensive therapy. *N Engl J Med* 342:381-389, 2000.
42. Sundkvist G, Dahlin LB, Nilsson H, Eriksson KF, Lingarde F, Rosen I, Lattimer SA, Sima AAP, Sullivan KA, Greene DA: Sorbitol and myo-inositol levels and morphology of sural nerve in relation to peripheral nerve function and clinical neuropathy in men with diabetic, impaired, and normal glucose tolerance. *Diabetic Medicine* 17:259-268, 2000.
43. Stevens MJ, Obrosova I, Cao X, Van Huysen C, Greene DA: Effects of DL-alpha-lipoic acid on peripheral nerve conduction, blood flow, energy metabolism and oxidative stress in experimental diabetic neuropathy. *Diabetes* 49:1006-1015, 2000.
44. Obrosova IG, Pathallah L, Greene DA: Early changes in lipid peroxidation and antioxidative defense in diabetic rat retina: effect of DL-alpha-lipoic acid. *Eur J Pharmacol* 398:139-146, 2000.
45. White NH, Cleary PA, Dahms W, Goldstein D, Malone J, Tamborlane WV; Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) Research Group: Beneficial effects of intensive therapy of diabetes during adolescence: outcomes after the conclusion of the Diabetes Control and Complications Trial (DCCT). *J Pediatr* 139:804-812, 2001.
46. Perkins BA, Greene DA, Bril Y: Glycemic control is related to the morphological severity of diabetic sensorimotor polyneuropathy. *Diabetes Care* 24: 748-752, 2001.
47. Moller DE, Greene DA: Peroxisome proliferators-activated receptor (PPAR) gamma agonists for diabetes. *Adv Protein Chem* 56:181-212, 2001.
48. Obrosova IG, Van Huysen C, Pathallah L, Cao XC, Greene DA, Stevens MJ: An aldose reductase inhibitor reverses early diabetes-induced changes in peripheral nerve function, metabolism, and antioxidative defense. *FASEB J* 16:123-125, 2002.
49. Pop-Busui R, Marinescu V, Van Huysen C, Li F, Sullivan K, Greene DA, Larkin D, Stevens MJ: Dissection of metabolic, vascular, and nerve conduction interrelationships in experimental diabetic neuropathy by cyclooxygenase inhibition and acetyl-L-carnitine administration. *Diabetes* 51: 2619-2628, 2002.
50. Viberti G, Kahn SE, Greene DA, Herman WH, Zinman B, Holman RR, Haffner SM, Levy D, Lachin JM, Berry RA, Hoise MA, Jones NP, Freed MI: A diabetes outcome progression trial (ADOPT): an international multicenter study of the comparative efficacy of rosiglitazone, glyburide, and metformin in recently diagnosed type 2 diabetes. *Diabetes* 25:1737-1743, 2002.
51. The Writing Team for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group: Effect of intensive therapy on the microvascular complications of type 1 diabetes mellitus. *JAMA* 287:2563-2569, 2002.



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Attorney's Docket No.: 1001-0002USC1

## EXHIBIT 2

(June 29, 2011, letter from Dr. David Wessel to Dr. Douglas Greene)

8191933.2



David L. Wessel, MD  
Senior Vice President  
Center for Hospital-Based Specialties  
Ikaria® Distinguished Professor of  
Critical Care Medicine

June 29, 2011

Douglas Greene, M.D.,  
Executive Vice President and Head of Research & Development  
Ikaria, Inc.  
Perryville III Corporate Park  
53 Frontage Road, 3<sup>rd</sup> Floor  
PO Box 9001  
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RE: USSN 12/820,866 and 12/820,980  
*Atz et al., Seminars in Perinatology 1997,21(5), pp 441-455*

Dear Doug:

In 2005, I chaired the Steering Committee of the Sponsor, INO Therapeutics LLC (INOT), to establish, design and oversee the INOT22 Study. Presently, I am Chief, Division of Critical Care Medicine and Senior Vice President, Children's National Medical Center, Washington, D.C.<sup>1</sup>

In addition to being the Chair of the INOT22 Steering Committee, I also am the senior author of *Atz et al., Seminars in Perinatology 1997,21(5), pp 441-455* (Atz et al.).

At the time of the design of the INOT22 Study protocol, neither myself, the other Steering Committee members, nor the study Sponsor appreciated or anticipated that a child with left ventricular dysfunction who is not dependent on right-to-left shunting of blood would be at additional risk when treated with inhaled nitric oxide (INO). This is the reason such children were not originally excluded from the INOT22 Study entry criteria.

Neither the Atz et al. article that I co-authored, nor the medical literature or medical experience of which I was aware at the time, predict this risk. Instead, Atz et al. describes two distinct, independent precautions with respect to the use of INO. First, with respect to adults, Atz et al. stated that INO may be more effective in newborns than in older patients, and noted that it

<sup>1</sup> In the interest of full disclosure, I formerly served as a consultant for INO Therapeutics LLC, I currently serve without remuneration as a member of the Ikaria Scientific Board of Advisors. In 2010 I was appointed by my institution as the Ikaria Distinguished Professor of Critical Care Medicine.



should be used with caution in adults with ischemic cardiomyopathy in whom a risk of pulmonary edema is a consideration (see page 452, left column). Second, with respect to neonates, we stated the well-known contraindication (currently found in the INOMAX<sup>®</sup> prescribing information) that iNO should not be used in newborns dependent upon right-to-left shunting of blood across a patent ductus arteriosus to avoid circulatory collapse. What we did not disclose or predict was that neonatal patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood would be at greater risk of adverse events.

It is ironic that my own publication would be cited to suggest that it would have been obvious to predict the adverse events and outcomes of the INOT22 Study when I, the senior author of Atz et al., failed to anticipate or predict these unexpected outcomes at the time I participated in drafting the original INOT22 Study protocol. If so, I would have been acting either negligently or intentionally to harm babies, and I most certainly was not. Furthermore, to my knowledge, none of the other members of the INOT22 Steering Committee who assisted me in designing the study, nor the approximately 18 Institutional Review Boards and 2 National Health Authorities who reviewed and approved the study prior to its initiation, predicted the adverse events in children with left ventricular dysfunction who are not dependent on right-to-left shunting of blood.

In summary, although it was known that neonates whose systemic circulation was dependent on right-to-left shunt should not receive iNO; and it had been reported that adults with pre-existing left ventricular dysfunction (from coronary artery disease) may be at risk when provided iNO, it was unanticipated and surprising that children with left ventricular dysfunction who are not dependent on right-to-left shunting would be at increased risk of adverse events when administered iNO.

Sincerely,

David L. Wessel, M.D.

# EXHIBIT 8

Exhibit 8

USSN: 12/820,866

UNITED STATES PATENT AND TRADEMARK OFFICE	
Application Serial Number	12/820,866
Confirmation Number	2913
Filing Date	22-JUN-2010
Title of Application	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
First Named Inventor	JAMES S. BALDASSARRE
Assignee	IKARIA, INC.
Group Art Unit	1616
Examiner	ARNOLD, ERNST V.
Attorney Docket Number	I001-0002USC1

Mail Stop Amendment  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

DECLARATION OF JAMES S. BALDASSARRE, M.D.  
UNDER 37 C.F.R. § 1.132

I, James S. Baldassarre, do hereby declare the following:

1. I currently hold the position of Vice President of Clinical Research at INO Therapeutics LLC ("INO"), which is a wholly-owned subsidiary of Ikaria, Inc. A copy of my *curriculum vitae* is attached as **Exhibit 1**.

2. I have over 20 years of experience as a physician and over fifteen years of experience directing clinical research in the pharmaceutical industry.

3. In 2004, I was the Medical Monitor responsible for the design and execution of the INOT22 study.

4. The INOT22 study, entitled "Comparison of Supplemental Oxygen and Nitric Oxide for Inhalation Plus Oxygen in the Evaluation of the Reactivity of the Pulmonary Vasculature During Acute Pulmonary Vasodilatory Testing", was a randomized, multi-center study having an expected

enrollment of 150 patients, aged four weeks to 18 years, in approximately 18 study sites over approximately 2 years.

5. The INOT22 study was established and designed by the study sponsor, INO Therapeutics LLC and a Steering Committee comprising international recognized experts in the field of pediatric heart and lung disease, whose members would assist INO to develop the INOT22 protocol, monitor the progress of the trial, and provide recommendations to INO on changes in the procedures and conduct of the trial

6. The Steering Committee consisted of:

- a. David L. Wessel, MD, presently Senior Vice President, The Center for Hospital based Specialties, and Division Chief, Pediatric Critical Care Medicine at Children's National Medical Center, Washington, DC;
- b. Robyn J. Barst, MD, presently Professor Emeritus of Pediatrics and Medicine, Columbia University College of Physicians and Surgeons, New York; and
- c. Duncan J. Macrae, MD, presently Director, Pediatric Intensive Care, Royal Brompton Hospital, London, UK.

7. The original INOT22 study protocol designed by INO and the Steering Committee did not exclude study patients with pre-existing left ventricular dysfunction who were not dependent on right-to-left shunting of blood.

8. After the INOT22 study protocol design, but prior to study initiation and enrollment, the original INOT22 study protocol was reviewed by an Institutional Review Board (IRB) and/or Independent Ethics Committee (IEC) at each of the 18 participating study institutions, including review by the principal investigator within each study institution. In addition, prior to study initiation and enrollment, the original INOT22 study protocol was reviewed by the US Food and

Drug Administration (FDA) and separately reviewed by each national Health Authority (European equivalent to FDA) within the four European countries participating in the INOT22 trial (United Kingdom, France, Netherlands and Spain). In addition, INO regularly requested input and scientific guidance on clinical trials from its own Scientific Advisory Board. At no time did any member of the Steering Committee, INOT, an IRB, IEC, individual principal investigator, Advisory Board member, FDA or European Health Authority appreciate, recognize or otherwise suggest that subjects with pre-existing left ventricular dysfunction who are not dependent on right-to-left shunt should be excluded from the INOT22 study or that such subjects would be anticipated or predicted to have an increased risk of adverse events or serious adverse events arising from the administration to them of inhaled nitric oxide.

9. Under FDA regulations, an IRB is an appropriately constituted group that has been formally designated to review and monitor biomedical research involving human subjects. In accordance with FDA regulations, an IRB has the authority to approve, require modifications in (to secure approval), or disapprove research. This group review serves an important role in the protection of the rights and welfare of human research subjects. The purpose of IRB review is to assure, both in advance and by periodic review, that appropriate steps are taken to protect the rights and welfare of humans participating as subjects in the research. To accomplish this purpose, IRBs use a group process to review research protocols to ensure protection of the rights and welfare of human subjects of research. An IRB must have at least five members and each member must have enough experience, expertise and diversity to make an informed decision on whether the research is ethical, informed consent is sufficient and the appropriate safeguards have been put in place (see 21 CFR Part 56).

10. In Europe, an Ethics Committee is an independent body in a Member State consisting of healthcare professionals and non-medical members whose responsibility is to protect the rights, safety and well being of human subjects involved in a clinical trial and to provide public assurance of that protection by expressing an opinion on a proposed clinical trial protocol, the suitability of the investigators and adequacy of facilities involved in a trial (see Directive 2001/20/EC).

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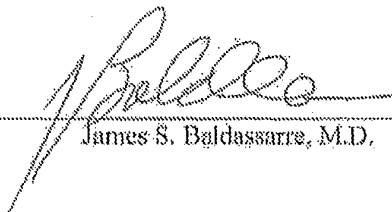
Attorney's Docket No.: 1001-0602USC1

11. In total, at least 115 individuals experienced in, and responsible for, the review of clinical trial protocols for patient safety. In addition to the FDA and four European Health Authorities reviewed the original INOT22 protocol prior to initiating the INOT22 study. Again, not a single individual or authority suggested, predicted or raised a concern about an increased risk associated with the use of inhaled nitric oxide in study subjects with pre-existing left ventricular dysfunction who are not dependent on right-to-left shunt.

12. On the contrary, it was only after unexpected serious adverse events (including at least one death) occurred during the course of the INOT22 study that the study protocol was amended to exclude study subjects with pre-existing left ventricular dysfunction who are not dependent on right-to-left shunt. In particular, the exclusion criteria of the INOT22 study was amended to exclude subjects having an elevated pulmonary capillary wedge pressure greater than 20 mm Hg.

13. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the '359 patent.

Dated: 7 July 2011

  
James S. Baldassarre, M.D.



## CURRICULUM VITAE

James S. Baldassarre, MD

**HOME ADDRESS:** 145 Pebble Woods Dr  
Doylestown, Pa  
18901 **PHONE:** 215-348-2835

**PERSONAL:** Married (Susan Cohen-Baldassarre)  
Children Alyssa (18), Julia (16) and Andrew (10)  
Citizenship: USA

**BUSINESS ADDRESS:** Ikaria/ INO Therapeutics  
6 Route 1173  
Clinton, NJ 08809 **PHONE:** 908-238-6363

**EDUCATION:** S.U.N.Y. Downstate Medical Center  
Brooklyn, NY  
1986 - M.D.

S.U.N.Y., Binghamton, NY  
1982 - Biology, B.S.

### EMPLOYMENT:

2007- present **Ikaria (INO Therapeutics)**  
VP, Clinical Research  
2009-present **Project Team Leader: IK 5001**  
2008-2010 **Project Team Leader: INOmax®**

2003- 2007 **INO Therapeutics**  
Senior Director, Clinical Research

2003 **Johnson & Johnson Pharmaceutical Research and Development LLC**  
Compound Development Team Leader/Clinical Leader-REGANEX®

2001-2003 **Johnson & Johnson Pharmaceutical Research and Development LLC**  
Senior Director, Operations Team Management

1999-2001 **Janssen Research Foundation**  
Director of Clinical Research Italy/Greece

1997 -1999 **Janssen-Cilag Limited, UK**  
Head of Clinical Research and Senior Medical Advisor

1993 - 1997 **R.W. Johnson Pharmaceutical Research Institute**  
Spring House, PA  
1993-1997 Associate Director, Clinical Research  
1993-1995 Assistant Director, Clinical Research

1992 - 1993 **Presbyterian Medical Center**  
Philadelphia, PA  
Attending Physician, Division of Infectious Diseases

1986 - 1993 **Medical College of Pennsylvania**  
Philadelphia, PA  
1990-1993 Fellow, Division of Infectious Diseases  
1989-1990 Medical Director (half time)

1986-1989 Internship/Residency Internal Medicine

1989 - 1990 Philadelphia Department of Health  
Philadelphia, PA  
Medical Director, Sexually Transmitted Diseases Clinic (half time)

**ACADEMIC APPOINTMENT :**

John Radcliffe Hospital, Oxford, UK

1999-2000 Honorary SHO, Dept of Clinical Pharmacology

Medical College of Pennsylvania, Philadelphia, USA

1994 - Clinical Assistant Professor, Department of Medicine

1991 - 1993 Instructor in Medicine

**CERTIFICATION:**

Diplomat, A.B.I.M.  
Internal Medicine, 1989  
Infectious Diseases, 1992  
Limited GMC registration, 1999

**EMPLOYMENT-RELATED ACTIVITIES/COMMITTEES:**

RWJ-PRI Continuous Process Improvement Committee	1995-1996
Johnson & Johnson Signature of Quality submission	1997 and 1999
JJ PRD New Product Development Committee Implementation Team	2002-2003
Ikaria Opportunity Review Team	2007-present

**PUBLICATIONS:**

1. Levison M E and Baldassarre J S: Intra-Abdominal Infections. *Current Practice of Medicine* 1993.
2. Baldassarre J S and Abrutyn E: Antibiotic-Resistant Streptococcus pneumoniae. *Infectious Disease Practice* 1993; 17 (9).
3. Baldassarre J S and Abrutyn E: Genital Ulcer Disease. *Infectious Disease Practice* 1992; 16 (9); 1-7.
4. Levison M E and Baldassarre J S: Community Acquired Pneumonia: Time to Reassess Treatment Strategies. *Modern Med* 1992; 60:12 86-91.
5. Levison M E and Baldassarre J S: Community Acquired Pneumonia: Keys to Making the Diagnosis. *Modern Med* 1992; 60: 11 42-58.
6. Baldassarre J S, Ingerman M J, Nansteel J, and Santoro J: Development of Listeria Meningitis during Vancomycin Therapy: A Case Report. *J Infect Dis* 1991; 164: 221-222.
7. Baldassarre J S, Update on the Management of Sexually Transmitted Diseases. *Phila Med* 1991; 87-5 230-233.
8. Baldassarre J S and Kaye D: Special Problems In Urinary Tract Infection in the Elderly. *Med Clin North Am* 1991; 75:2 375-390.
9. Baldassarre J S, Johnson CC and Levison M E: Peritonitis: Update on Pathophysiology, Clinical Manifestations and Management. *Clinical Infectious Diseases* 1997; 24(6); 1035-47.

10. Baldassarre JS and Levison ME: Intra-abdominal Infections *Current Practice of Medicine* 1999, vol 2 (4)591-605
11. Baldassarre JS and Pledger GW Clinical Trial Design for New Antiepileptic Drugs: Determination of Dose and Titration Schedules *Rev Contemp Pharmacother* 1999: 10
12. E. Potapov, D. Meyer, M. Swaminathan, M. Ramsay, A. El Banayosy, C. Diehl et al. Use of Inhaled Nitric Oxide After Left Ventricular Assist Device Placement: Results of a Prospective, Randomized, Double-Blind, Multicenter, Placebo-Controlled Trial *J Heart Lung Transplant* 2010 accepted
13. Mercier JC, Hummler H, Durrmeyer X, Sanchez-Luna M, Carnielli V, Field D, Greenough A, Van Overmeire B, Jonsson B, Hallman M, Baldassarre J; EUNO Study Group. Inhaled nitric oxide for prevention of bronchopulmonary dysplasia in premature babies (EUNO): a randomised controlled trial. *Lancet*. 2010 Jul 31;376(9738):346-54.
14. Barst RJ, Agnoletti G, Fraisse A, Baldassarre J, Wessel DL; NO Diagnostic Study Group. Vasodilator testing with nitric oxide and/or oxygen in pediatric pulmonary hypertension *Pediatr Cardiol*. 2010 Jul;31(5):598-606.

#### Book Chapters

Baldassarre J S and Kaye D: Principles and Overview of Antibiotic Use in Infective Endocarditis. In: Kaye D (ed) *Infective Endocarditis* 2nd ed. New York: Raven Press, 1992; 169-190.

#### Abstracts

1. Baldassarre J S and Stull T L: Cytosol-Mediated Ulcerogenesis in *Haemophilus ducreyi*. 1993 Annual Meeting of the Infectious Diseases Society of America, Abst #19, Oct. 16 and 17, 1993.
2. Sutherland J and Baldassarre JS : Mediastinal Adenopathy in a Patient with AIDS. American College of Physicians Regional Scientific Meetings, October 2, 1992.
3. Baldassarre J S and Stull T L: Characterization of Aminopeptidase (AP) Activity in *Haemophilus ducreyi*. American College of Physicians Regional Scientific Meetings, October 3, 1992.
4. Fontinella E, Dorfman M, Baldassarre J, Kaye D and Murasko D: Immune Response to Influenza Immunization in an Elderly Community Dwelling Africa American Population. *FASEB J* 1991 5: A1373 Abst 5814.
5. Doose DR, Walker SA, Baldassarre J. The effect of food on the oral bioavailability of topiramate from an investigational paediatric sprinkle formulation. *Epilepsia* 1997; 38(suppl 3):147.
6. Glauser TA, Olberding L, Clark P, Reife R, Baldassarre J, Conover D. Topiramate monotherapy substitution in children with partial epilepsy. *Epilepsia* 1996; 37(suppl 4):98.
7. JC Mercier, H. Hummler, X Durrmeyer, M. Sanchez-Luna, V Carnielli, D Field, A. Greenough, B. Van Overmeire, B Jonsson, M Hallman, J Baldassarre, for the EUNO Study Group. The effects of inhaled nitric oxide on the development of bronchopulmonary dysplasia (BPD) in preterm infants: the 'EUNO' multicentre randomised clinical trial. European Academy of Pediatrics; Nice, France October 2008
8. RJ Barst, G Agnoletti, A Fraisse, J Baldassarre, DL Wessel. Nitric Oxide in Combination with Oxygen Versus Either Oxygen Alone or Nitric Oxide Alone for Acute Vasodilator Testing in Children with Pulmonary Hypertension: A Multicenter, Randomized Study. Pediatric Academic Societies Scientific Meeting, Baltimore Md; May 2009 [3861.195]
9. EY Potapov; D Meyer; M Swaminathan; M Ramsay; A El Banayosy; C Diehl; B Veynovich; ID Gregoric; J Baldassarre; M J Zucker; R Heizer Use of Inhaled Nitric Oxide After Left Ventricular

**Assist Device Placement: Results of a Prospective, Randomized, Double-Blind, Multicenter,  
Placebo-Controlled Trial. American Heart Association Scientific Sessions Orlando, FL; Nov 2009  
[3663]**

# EXHIBIT 9

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE (USPTO)	
Application Serial Number	12/820,866
Confirmation Number	2913
Filing Date	June 22, 2010
Title of Application	Methods of Treating Term and Near-Term Neonates Having Hypoxic Respiratory Failure Associated with Clinical or Echocardiographic Evidence of Pulmonary Hypertension
First Named Inventor	James S. Baldassarre
Assignee	Ikaria, Inc.
Group Art Unit	1613
Examiner	Arnold, Ernst V.
Attorney Docket Number	1001-0002USC1

Mail Stop Amendment  
 Commissioner for Patents  
 P.O. Box 1450  
 Alexandria, VA 22313-1450

DECLARATION OF JAMES S. BALDASSARRE, M.D.  
UNDER 37 C.F.R. § 1.132

I, James S. Baldassarre, declare the following:

1. I currently hold the position of Vice President of Clinical Research at Ikaria, Inc. ("Ikaria"), the assignee of U.S. Patent Application No. 12/820,866. My *curriculum vitae* is attached as Exhibit 1.
2. I have over 20 years of experience as a physician, and over fifteen years of experience directing clinical research in the pharmaceutical industry.
3. Ikaria markets pharmaceutical grade nitric oxide (NO) gas under the brand name INOMAX® (nitric oxide) for inhalation. INOMAX® was approved by the U.S. Food and Drug Administration ("FDA") in December 1999, for the treatment of term and near-term (>34 weeks) neonates with hypoxic respiratory failure (HRF) associated with clinical or echocardiographic evidence of pulmonary hypertension, where it improves oxygenation and reduces the need for extracorporeal membrane oxygenation (ECMO).

4. In May 2004, INO Therapeutics LLC<sup>1</sup> initiated a clinical trial, entitled "Comparison of Supplemental Oxygen and Nitric Oxide for Inhalation Plus Oxygen in the Evaluation of the Reactivity of the Pulmonary Vasculature During Acute Pulmonary Vasodilator Testing", and designated the INOT22 trial, to compare the utility and side effects of oxygen (O<sub>2</sub>), nitric oxide (INO) and a combination of INO and O<sub>2</sub> for determining pulmonary reactivity.

5. The INOT22 study was to be an open, prospective, randomized, multi-center, controlled diagnostic trial, with an expected total enrollment of a minimum of 150 patients, in approximately 18 study sites over approximately 2 years.

6. The expected patient population for enrollment into the INOT22 trial were subjects between the ages of four (4) weeks and eighteen (18) years undergoing diagnostic right heart catheterization scheduled to include acute pulmonary vasodilation testing to assess pulmonary vasoreactivity. The expected population were subjects with idiopathic pulmonary arterial hypertension, congenital heart disease (with or without intravascular shunt) with pulmonary hypertension and cardiomyopathies.

7. The INOT22 study was established and designed by the study sponsor, INO Therapeutics LLC (INO), and a Steering Committee comprising internationally recognized experts in the field of pediatric heart and lung disease, whose members would assist INO to develop the INOT22 protocol, monitor the progress of the trial, and provide recommendations to INO on changes in the procedures and conduct of the trial.

8. The Steering Committee consisted of:

- a. David L. Wessel, MD, presently Division Chief, Pediatric Critical Care Medicine at Children's National Medical Center, Washington, DC (co-author of Atz., et al., Seminars in Perinatology);<sup>2</sup>

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<sup>1</sup> INO Therapeutics LLC is a wholly owned subsidiary of Ikaria, Inc., and holder of the NDA for INOMAX.

<sup>2</sup> Cited in pending Office Action.

b. Robyn J. Barst, MD, presently Professor Emeritus of Pediatrics and Medicine, Columbia University College of Physicians and Surgeons, New York; and

c. Duncan J. Macrae, MD, presently Director, Pediatric Intensive Care, Royal Brompton Hospital, London, U.K. (lead author of Macrae, et al., Intensive Care Medicine, 2004)<sup>3</sup>

9. The original INOT22 protocol designed by INO and the Steering Committee contained the following inclusion and exclusion criteria:

**Inclusion Criteria**

*The patient must meet the following criteria:*

1. *Have any one of the three disease categories:*

a. *Idiopathic Pulmonary Arterial Hypertension*

i. *PAPm >25mmHg at rest, PCWP  $\leq$  15mmHg, and PVRI >3 u·m<sup>2</sup> or diagnosed clinically with no previous catheterization.*

b. *CHD with pulmonary hypertension repaired and unrepaired,*

i. *PAPm >25mmHg at rest, and PVRI >3 u·m<sup>2</sup> or diagnosed clinically with no previous catheterization*

c. *Cardiomyopathy*

i. *PAPm >25mmHg at rest, and PVRI >3 u·m<sup>2</sup> or diagnosed clinically with no previous catheterization.*

2. *Scheduled to undergo right heart catheterization to assess pulmonary vasoreactivity by acute pulmonary vasodilation testing.*

3. *Males or females, ages 4 weeks to 18 years, inclusive.*

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<sup>3</sup> Cited in pending Office Action.



4. *Signed IRB/IEC approved informed consent (and assent if applicable).*

**Exclusion Criteria**

*The patient will be excluded from enrollment if any of the following are true:*

1. *Focal pulmonary infiltrates on chest radiograph.*
2. *Diagnosed with severe obstructive or restrictive pulmonary disease that is significantly contributing to the patient's pulmonary hypertension.*
3. *Received treatment with nitric oxide for inhalation within 30 days prior to study initiation, are on other investigational medications, nitroglycerin, sodium nitroprusside, sildenafil, other PDE-5 inhibitors, or prostacyclin.*
4. *Pregnant (urine HCG +).*

10. The INOT22 investigational plan and study protocol was further reviewed, and approved by the Institutional Review Board (IRB) and/or Independent Ethics Committee (IEC) at each of the participating study institutions, including review by the principal investigator within each study institution.

11. At no time did any member of the Steering Committee, nor any member of an IRB, IEC, or individual principal investigator, appreciate, recognize or otherwise suggest that the exclusion criteria be amended to exclude study subjects with pre-existing left ventricular dysfunction (LVD), due to an anticipated or predicted risk of adverse events or serious adverse events arising from the use of INO in patients with pre-existing LVD, and/or elevated pulmonary capillary wedge pressure. Nor was it, in my expert opinion, common sense to any expert in this field of medicine to exclude neonates, near-term neonates or children diagnosed with pre-existing LVD to be excluded from having INO administered for diagnostic or treatment purposes.

12. After initiation and enrollment of the first 24 subjects in INOT22, there were 5 serious adverse events (SAEs) – a rate much higher than expected by INO and

the Steering Committee based on prior clinical experience. These were all cardiovascular events, and included pulmonary edema, cardiac arrest and hypotension (low blood pressure).

13. Thereafter, in February 2005, INO and the Steering Committee convened to review the unexpected SAEs described above, and upon review and discussion, expressed concern that the unexpected SAEs may be due to the administration of INO in subjects having pre-existing LVD. Accordingly, based upon a review of the cases, the exclusion criteria of the INOT22 protocol was amended to thereafter exclude subjects with pre-existing LVD. For the purpose of the study, the exclusion criteria was amended to exclude subjects from enrollment if the subjects demonstrated an elevated pulmonary capillary wedge pressure (PCWP), defined within the study as subjects having a PCWP greater than 20 mmHg. All study sites were notified immediately. The amended exclusion criteria (see point 5.) was as follows:

**Exclusion Criteria**

*The patient will be excluded from enrollment if any of the following are true:*

- 1. Focal pulmonary infiltrates on chest radiograph.*
- 2. Diagnosed with severe obstructive or restrictive pulmonary disease that is significantly contributing to the patient's pulmonary hypertension.*
- 3. Received treatment with nitric oxide for inhalation within 30 days prior to study initiation, are on other investigational medications, nitroglycerin, sodium nitroprusside, sildenafil, other PDE-5 inhibitors, or prostacyclin.*
- 4. Pregnant (urine HCG +)*
- 5. Baseline PCWP > 20 mmHg*

14. Upon conclusion of the INOT22 study and completion of the final study report, INO noted that subsequent to excluding patients with pre-existing LVD, the rate of serious adverse events (including serious adverse events associated with heart failure) was significantly reduced. There were 5 SAEs amongst the first 24 subjects

prior to the additional exclusion criteria, but only 2 SAEs amongst the last 80 subjects in the study after the additional exclusion. Furthermore, there were 2 SAEs amongst the 4 subjects with evidence of pre-existing left ventricular dysfunction, but only 5 SAEs amongst the 120 subjects without evidence of left ventricular dysfunction.

15. Based upon this unexpected finding, on February, 25, 2009, INO submitted a labeling supplement to the FDA seeking to amend the prescribing information for INOMAX to include a warning statement for physicians such that the use of INO in patients with pre-existing LVD could cause serious adverse events, such as pulmonary edema.

16. On August 28, 2009, the FDA approved the INO labeling supplement and included (i) a statement in the Warnings and Precautions section of the INOMAX prescribing information that states "Heart Failure: In patients with pre-existing left ventricular dysfunction, inhaled nitric oxide may increase pulmonary capillary wedge pressure leading to pulmonary edema", and (ii) new section 5.4 of the INOMAX prescribing information that states "Patients who had pre-existing left ventricular dysfunction treated with inhaled nitric oxide, even for short durations, experienced serious adverse events (e.g., pulmonary edema)."

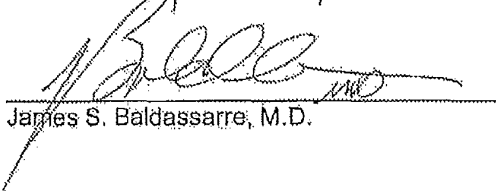
17. Based upon my review of the medical literature of record in this patent application and pending Office Action, none of the prior art suggests, appreciates or otherwise recognizes that exclusion of neonates, near-term neonates or children with LV dysfunction from administration of INO for diagnostic or treatment purposes would reduce the risk of adverse events and/or serious adverse events, as such terminology is well understood in the medical arts.

Applicant : Baldassarre, James S.  
Serial No. : 12/820,866  
Filed : June 22, 2010  
Page : 7 of 7

Attorney's Docket No.: 1001-0002USC1

18. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of any patent issuing from this patent application.

Dated: Sept 29, 2010

  
James S. Baldassarre, M.D.

## CURRICULUM VITAE

James S. Baldassarre, MD

**HOME ADDRESS:** 145 Pebble Woods Dr  
Doylestown, Pa  
18901 **PHONE:** 215-348-2835

**PERSONAL:** Married (Susan Cohen-Baldassarre)  
Children Alyssa (18), Julia (16) and Andrew (10)  
Citizenship: USA

**BUSINESS ADDRESS:** Ikaria/ INO Therapeutics  
6 Route 1173  
Clinton, NJ 08809 **PHONE:** 908-238-6363

**EDUCATION:** S.U.N.Y. Downstate Medical Center  
Brooklyn, NY  
1986 - M.D.  
  
S.U.N.Y., Binghamton, NY  
1982 - Biology, B.S.

**EMPLOYMENT:**

2007- present	<b>Ikaria (INO Therapeutics)</b> VP, Clinical Research
2009-present 2008-2010	Project Team Leader: IK 5001 Project Team Leader: INOmax®
2003- 2007	<b>INO Therapeutics</b> Senior Director, Clinical Research
2003	<b>Johnson &amp; Johnson Pharmaceutical Research and Development LLC</b> Compound Development Team Leader/Clinical Leader-REGRANEX®
2001-2003	<b>Johnson &amp; Johnson Pharmaceutical Research and Development LLC</b> Senior Director, Operations Team Management
1999-2001	<b>Janssen Research Foundation</b> Director of Clinical Research Italy/Greece
1997 -1999	<b>Janssen-Cilag Limited, UK</b> Head of Clinical Research and Senior Medical Advisor
1993 - 1997	<b>R.W. Johnson Pharmaceutical Research Institute</b> Spring House, PA 1995-1997 Associate Director, Clinical Research 1993-1995 Assistant Director, Clinical Research
1992 - 1993	<b>Presbyterian Medical Center</b> Philadelphia, PA Attending Physician, Division of Infectious Diseases
1986 - 1993	<b>Medical College of Pennsylvania</b> Philadelphia, PA 1990-1993 Fellow, Division of Infectious Diseases 1989-1990 Medical Director (half time)

1986-1989 Internship/Residency Internal Medicine

1989 - 1990 **Philadelphia Department of Health**  
Philadelphia, PA  
Medical Director, Sexually Transmitted Diseases Clinic (half time)

**ACADEMIC APPOINTMENT :**

**John Radcliffe Hospital, Oxford, UK**

1999-2000 Honorary SHO, Dept of Clinical Pharmacology

**Medical College of Pennsylvania, Philadelphia, USA**

1994 - Clinical Assistant Professor, Department of Medicine

1991 - 1993 Instructor in Medicine

**CERTIFICATION:**

Diplomat, A.B.I.M.  
Internal Medicine, 1989  
Infectious Diseases, 1992  
Limited GMC registration, 1999

**EMPLOYMENT-RELATED ACTIVITIES/COMMITTEES:**

RWJ-PRI Continuous Process Improvement Committee	1995-1996
Johnson & Johnson Signature of Quality submission	1997 and 1999
JJ PRD New Product Development Committee Implementation Team	2002-2003
Ikaria Opportunity Review Team	2007-present

**PUBLICATIONS:**

1. Levison M E and Baldassarre J S: Intra-Abdominal Infections. *Current Practice of Medicine* 1993.
2. Baldassarre J S and Abrutyn E: Antibiotic-Resistant Streptococcus pneumoniae. *Infectious Disease Practice* 1993; 17 (9).
3. Baldassarre J S and Abrutyn E: Genital Ulcer Disease. *Infectious Disease Practice* 1992; 16 (9); 1-7.
4. Levison M E and Baldassarre J S: Community Acquired Pneumonia: Time to Reassess Treatment Strategies. *Modern Med* 1992; 60:12 86-91.
5. Levison M E and Baldassarre J S: Community Acquired Pneumonia: Keys to Making the Diagnosis. *Modern Med* 1992; 60: 11 42-58.
6. Baldassarre J S, Ingerman M J, Nansteel J, and Santoro J: Development of Listeria Meningitis during Vancomycin Therapy: A Case Report. *J Infect Dis* 1991; 164: 221-222.
7. Baldassarre J S, Update on the Management of Sexually Transmitted Diseases. *Phila Med* 1991; 87-5 230-233.
8. Baldassarre J S and Kaye D: Special Problems in Urinary Tract Infection in the Elderly. *Med Clin North Am* 1991; 75:2 375-390.
9. Baldassarre J S, Johnson CC and Levison M E: Peritonitis: Update on Pathophysiology, Clinical Manifestations and Management. *Clinical Infectious Diseases* 1997; 24(6); 1035-47.

10. Baldassarre JS and Levison ME: Intra-abdominal Infections *Current Practice of Medicine* 1999, vol 2 (4):591-605
11. Baldassarre JS and Pledger GW Clinical Trial Design for New Antiepileptic Drugs: Determination of Dose and Titration Schedules *Rev Contemp Pharmacother* 1999; 10
12. E. Potapov, D. Meyer, M. Swaminathan, M. Ramsay, A. El Banayosy, C. Diehl et al. Use of Inhaled Nitric Oxide After Left Ventricular Assist Device Placement: Results of a Prospective, Randomized, Double-Blind, Multicenter, Placebo-Controlled Trial *J Heart Lung Transplant* 2010 accepted
13. Mercier JC, Hummler H, Durrmeyer X, Sanchez-Luna M, Carnielli V, Field D, Greenough A, Van Overmeire B, Jonsson B, Hallman M, Baldassarre J; EUNO Study Group. Inhaled nitric oxide for prevention of bronchopulmonary dysplasia in premature babies (EUNO): a randomised controlled trial. *Lancet*. 2010 Jul 31;376(9738):346-54.
14. Barst RJ, Agnoletti G, Fraisse A, Baldassarre J, Wessel DL; NO Diagnostic Study Group. Vasodilator testing with nitric oxide and/or oxygen in pediatric pulmonary hypertension *Pediatr Cardiol*. 2010 Jul;31(5):598-606.

#### Book Chapters

Baldassarre J S and Kaye D: Principles and Overview of Antibiotic Use in Infective Endocarditis. In: Kaye D (ed) *Infective Endocarditis* 2nd ed. New York: Raven Press, 1992; 169-190.

#### Abstracts

1. Baldassarre J S and Stull T L: Cytosol-Mediated Ulcerogenesis in *Haemophilus ducreyi*. 1993 Annual Meeting of the Infectious Diseases Society of America, Abst #19, Oct. 16 and 17, 1993.
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4. Fontinella E, Dorfman M, Baldassarre J, Kaye D and Murasko D: Immune Response to Influenza Immunization in an Elderly Community Dwelling Africa American Population. FASEB J 1991 5: A1373 Abst 5814.
5. Doose DR, Walker SA, Baldassarre J. The effect of food on the oral bioavailability of topiramate from an investigational paediatric sprinkle formulation. *Epilepsia* 1997; 38(suppl 3):147.
6. Glauser TA, Olberding L, Clark P, Reife R, Baldassarre J, Conover D. Topiramate monotherapy substitution in children with partial epilepsy. *Epilepsia* 1996; 37(suppl 4):98.
7. JC Mercier, H. Hummler, X Durrmeyer, M. Sanchez-Luna, V Carnielli, D Field, A. Greenough, B. Van Overmeire, B Jonsson, M Hallman, J Baldassarre, for the EUNO Study Group. The effects of inhaled nitric oxide on the development of bronchopulmonary dysplasia (BPD) in preterm infants: the 'EUNO' multicentre randomised clinical trial. European Academy of Pediatrics; Nice, France October 2008
8. RJ Barst, G Agnoletti, A Fraisse, J Baldassarre, DL Wessel. Nitric Oxide in Combination with Oxygen Versus Either Oxygen Alone or Nitric Oxide Alone for Acute Vasodilator Testing in Children with Pulmonary Hypertension; A Multicenter, Randomized Study. Pediatric Academic Societies Scientific Meeting, Baltimore Md; May 2009 [3861.195]
9. EV Potapov; D Meyer; M Swaminathan; M Ramsay; A El Banayosy; C Diehl; B Veynovich; ID Gregoric; J Baldassarre; M J Zucker; R Hetzer Use of Inhaled Nitric Oxide After Left Ventricular

Assist Device Placement: Results of a Prospective, Randomized, Double-Blind, Multicenter,  
Placebo-Controlled Trial. American Heart Association Scientific Sessions Orlando, FL; Nov 2009  
[3663]



# EXHIBIT 10

# INOMax<sup>®</sup> (nitric oxide) for inhalation

## HIGHLIGHTS OF PRESCRIBING INFORMATION

These highlights do not include all the information needed to use INOMax safely and effectively. See full prescribing information for INOMax.

**INOMax (nitric oxide) for inhalation**  
**Initial U.S. Approval: 1999**

### RECENT MAJOR CHANGES

Warnings and Precautions, Heart Failure (5.4) 8/2009

### INDICATIONS AND USAGE

INOMax is a vasodilator, which, in conjunction with ventilatory support and other appropriate agents, is indicated for the treatment of term and near-term (>34 weeks gestation) neonates with hypoxic respiratory failure associated with clinical or echocardiographic evidence of pulmonary hypertension, where it improves oxygenation and reduces the need for extracorporeal membrane oxygenation (1.1).

Monitor for PaO<sub>2</sub>, methemoglobin, and inspired NO<sub>2</sub> during INOMax administration (1.1).

Utilize additional therapies to maximize oxygen delivery (1.1).

### DOSAGE AND ADMINISTRATION

**Dosage:** The recommended dose of INOMax is 20 ppm, maintained for up to 14 days or until the underlying oxygen desaturation has resolved (2.1).

**Administration:**

- INOMax must be delivered via a system which does not cause generation of excessive inhaled nitrogen dioxide (2.2).
- Do not discontinue INOMax abruptly (2.2).

### DOSAGE FORMS AND STRENGTHS

INOMax (nitric oxide) is a gas available in 100 ppm and 800 ppm concentrations.

### CONTRAINDICATIONS

Neonates known to be dependent on right-to-left shunting of blood (4).

### WARNINGS AND PRECAUTIONS

**Rebound:** Abrupt discontinuation of INOMax may lead to worsening oxygenation and increasing pulmonary artery pressure (5.1).

**Methemoglobinemia:** Methemoglobin increases with the dose of nitric oxide; following discontinuation or reduction of nitric oxide, methemoglobin levels return to baseline over a period of hours (5.2).

**Elevated NO<sub>2</sub> Levels:** NO<sub>2</sub> levels should be monitored (5.3).

**Heart Failure:** In patients with pre-existing left ventricular dysfunction, inhaled nitric oxide may increase pulmonary capillary wedge pressure leading to pulmonary edema (5.4).

### ADVERSE REACTIONS

Methemoglobinemia and elevated NO<sub>2</sub> levels are dose dependent adverse events. Worsening oxygenation and increasing pulmonary artery pressure occur if INOMax is discontinued abruptly. Other adverse reactions that occurred in more than 5% of patients receiving INOMax in the CINRGI study were: thrombocytopenia, hypokalemia, bilirubinemia, atelectasis, and hypotension (6).

To report SUSPECTED ADVERSE REACTIONS, contact INO Therapeutics at 1-877-666-9466 and <http://www.inomax.com/> or FDA at 1-800-FDA-1088 or [www.fda.gov/medwatch](http://www.fda.gov/medwatch).

### DRUG INTERACTIONS

**Nitric oxide donor agents:** Nitric oxide donor compounds, such as prilocaine, sodium nitroprusside, and nitroglycerin, when administered as oral, parenteral, or topical formulations, may have an additive effect with INOMax on the risk of developing methemoglobinemia (7).

Revised: August 2009

## FULL PRESCRIBING INFORMATION: CONTENTS\*

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2. DOSAGE AND ADMINISTRATION
  - 2.1 Dosage
  - 2.2 Administration
3. DOSAGE FORMS AND STRENGTHS
4. CONTRAINDICATIONS
5. WARNINGS AND PRECAUTIONS
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  - 5.2 Methemoglobinemia
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\*Sections or subsections omitted from the full prescribing information are not listed.

## FULL PRESCRIBING INFORMATION

### 1 INDICATIONS AND USAGE

#### 1.1 Treatment of Hypoxic Respiratory Failure

INOMax® is a vasodilator, which, in conjunction with ventilatory support and other appropriate agents, is indicated for the treatment of term and near-term (>34 weeks) neonates with hypoxic respiratory failure associated with clinical or echocardiographic evidence of pulmonary hypertension, where it improves oxygenation and reduces the need for extracorporeal membrane oxygenation.

Utilize additional therapies to maximize oxygen delivery. In patients with collapsed alveoli, additional therapies might include surfactant and high-frequency oscillatory ventilation.

The safety and effectiveness of inhaled nitric oxide have been established in a population receiving other therapies for hypoxic respiratory failure, including vasodilators, intravenous fluids, bicarbonate therapy, and mechanical ventilation. Different dose regimens for nitric oxide were used in the clinical studies [see Clinical Studies (14)].

Monitor for PaO<sub>2</sub>, methemoglobin, and inspired NO<sub>2</sub> during INOMax administration.

### 2 DOSAGE AND ADMINISTRATION

#### 2.1 Dosage

##### Term and near-term neonates with hypoxic respiratory failure

The recommended dose of INOMax is 20 ppm. Treatment should be maintained up to 14 days or until the underlying oxygen desaturation has resolved and the neonate is ready to be weaned from INOMax therapy.

An initial dose of 20 ppm was used in the NINOS and CINRGI trials. In CINRGI, patients whose oxygenation improved with 20 ppm were dose-reduced to 5 ppm as tolerated at the end of 4 hours of treatment. In the NINOS trial, patients whose oxygenation failed to improve on 20 ppm could be increased to 80 ppm, but those patients did not then improve on the higher dose. As the risk of methemoglobinemia and elevated NO<sub>2</sub> levels increases significantly when INOMax is administered at doses >20 ppm, doses above this level ordinarily should not be used.

#### 2.2 Administration

The nitric oxide delivery systems used in the clinical trials provided operator-determined concentrations of nitric oxide in the breathing gas, and the concentration was constant throughout the respiratory cycle. INOMax must be delivered through a system with these characteristics and which does not cause generation of excessive inhaled nitrogen dioxide. The INOvent® system and other systems meeting these criteria were used in the clinical trials. In the ventilated neonate, precise monitoring of inspired nitric oxide and NO<sub>2</sub> should be instituted, using a properly calibrated analysis device with alarms. The system should be calibrated using a precisely defined calibration mixture of nitric oxide and nitrogen dioxide, such as INOCAL®. Sample gas for analysis should be drawn before the Y-piece, proximal to the patient. Oxygen levels should also be measured.

In the event of a system failure or a wall-outlet power failure, a backup battery power supply and reserve nitric oxide delivery system should be available.

Do not discontinue INOMax abruptly, as it may result in an increase in pulmonary artery pressure (PAP) and/or worsening of blood oxygenation (PaO<sub>2</sub>). Deterioration in oxygenation and elevation in PAP may also occur in children with no apparent response to INOMax. Discontinue/wean cautiously.

### 3 DOSAGE FORMS AND STRENGTHS

Nitric oxide is a gas available in 100 ppm and 800 ppm concentrations.

### 4 CONTRAINDICATIONS

INOMax is contraindicated in the treatment of neonates known to be dependent on right-to-left shunting of blood.

### 5 WARNINGS AND PRECAUTIONS

#### 5.1 Rebound

Abrupt discontinuation of INOMax may lead to worsening oxygenation and increasing pulmonary artery pressure.

#### 5.2 Methemoglobinemia

Methemoglobinemia increases with the dose of nitric oxide. In clinical trials, maximum methemoglobin levels usually were reached

approximately 8 hours after initiation of inhalation, although methemoglobin levels have peaked as late as 40 hours following initiation of INOMax therapy. In one study, 13 of 37 (35%) of neonates treated with INOMax 80 ppm had methemoglobin levels exceeding 7%. Following discontinuation or reduction of nitric oxide, the methemoglobin levels returned to baseline over a period of hours.

#### 5.3 Elevated NO<sub>2</sub> Levels

In one study, NO<sub>2</sub> levels were <0.5 ppm when neonates were treated with placebo, 5 ppm, and 20 ppm nitric oxide over the first 48 hours. The 80 ppm group had a mean peak NO<sub>2</sub> level of 2.6 ppm.

#### 5.4 Heart Failure

Patients who had pre-existing left ventricular dysfunction treated with inhaled nitric oxide, even for short durations, experienced serious adverse events (e.g., pulmonary edema).

### 6 ADVERSE REACTIONS

Because clinical trials are conducted under widely varying conditions, adverse reaction rates observed in the clinical trials of a drug cannot be directly compared to rates in the clinical trials of another drug and may not reflect the rates observed in practice. The adverse reaction information from the clinical studies does, however, provide a basis for identifying the adverse events that appear to be related to drug use and for approximating rates.

#### 6.1 Clinical Trials Experience

Controlled studies have included 325 patients on INOMax doses of 5 to 80 ppm and 251 patients on placebo. Total mortality in the pooled trials was 11% on placebo and 9% on INOMax, a result adequate to exclude INOMax mortality being more than 40% worse than placebo.

In both the NINOS and CINRGI studies, the duration of hospitalization was similar in INOMax and placebo-treated groups.

From all controlled studies, at least 6 months of follow-up is available for 278 patients who received INOMax and 212 patients who received placebo. Among these patients, there was no evidence of an adverse effect of treatment on the need for rehospitalization, special medical services, pulmonary disease, or neurological sequelae.

In the NINOS study, treatment groups were similar with respect to the incidence and severity of intracranial hemorrhage, Grade IV hemorrhage, periventricular leukomalacia, cerebral infarction, seizures requiring anticonvulsant therapy, pulmonary hemorrhage, or gastrointestinal hemorrhage.

The table below shows adverse reactions that occurred in at least 5% of patients receiving INOMax in the CINRGI study with event rates >5% and greater than placebo event rates. None of the differences in these adverse reactions were statistically significant when inhaled nitric oxide patients were compared to patients receiving placebo.

Table 1:  
Adverse Reactions in the CINRGI Study

Adverse Event	Placebo (n=89)	Inhaled NO (n=97)
Hypotension	9 (10%)	13 (13%)
Withdrawal	9 (10%)	12 (12%)
Atelectasis	8 (9%)	9 (9%)
Hematuria	5 (6%)	8 (8%)
Hyperglycemia	6 (7%)	8 (8%)
Sepsis	2 (2%)	7 (7%)
Infection	3 (3%)	6 (6%)
Stridor	3 (3%)	5 (5%)
Cellulitis	0 (0%)	5 (5%)

#### 6.2 Post-Marketing Experience

The following adverse reactions have been identified during post-approval use of INOMax. Because these reactions are reported voluntarily from a population of uncertain size, it is not always possible to estimate their frequency reliably or to establish a causal relationship to drug exposure. The listing is alphabetical; dose errors associated with the delivery system; headaches associated with environmental exposure of INOMax in hospital staff; hypotension associated with acute withdrawal of the drug; hypoxemia associated with acute withdrawal of the drug; pulmonary edema in patients with CREST syndrome.

## 7 DRUG INTERACTIONS

No formal drug-interaction studies have been performed, and a clinically significant interaction with other medications used in the treatment of hypoxic respiratory failure cannot be excluded based on the available data. INOmax has been administered with tolazoline, dopamine, dobutamine, steroids, surfactant, and high-frequency ventilation. Although there are no study data to evaluate the possibility, nitric oxide donor compounds, including sodium nitroprusside and nitroglycerin, may have an additive effect with INOmax on the risk of developing methemoglobinemia. An association between prilocaine and an increased risk of methemoglobinemia, particularly in infants, has specifically been described in a literature case report. This risk is present whether the drugs are administered as oral, parenteral, or topical formulations.

## 8 USE IN SPECIFIC POPULATIONS

### 8.1 Pregnancy

Pregnancy Category C

Animal reproduction studies have not been conducted with INOmax. It is not known if INOmax can cause fetal harm when administered to a pregnant woman or can affect reproductive capacity. INOmax is not intended for adults.

### 8.2 Labor and Delivery

The effect of INOmax on labor and delivery in humans is unknown.

### 8.3 Nursing Mothers

Nitric oxide is not indicated for use in the adult population, including nursing mothers. It is not known whether nitric oxide is excreted in human milk.

### 8.4 Pediatric Use

Nitric oxide for inhalation has been studied in a neonatal population (up to 14 days of age). No information about its effectiveness in other age populations is available.

### 8.5 Geriatric Use

Nitric oxide is not indicated for use in the adult population.

## 10 OVERDOSAGE

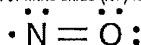
Overdosage with INOmax will be manifest by elevations in methemoglobin and pulmonary toxicities associated with inspired NO<sub>2</sub>. Elevated NO<sub>2</sub> may cause acute lung injury. Elevations in methemoglobinemia reduce the oxygen delivery capacity of the circulation. In clinical studies, NO<sub>2</sub> levels >3 ppm or methemoglobin levels >7% were treated by reducing the dose of, or discontinuing, INOmax.

Methemoglobinemia that does not resolve after reduction or discontinuation of therapy can be treated with intravenous vitamin C, intravenous methylene blue, or blood transfusion, based upon the clinical situation.

## 11 DESCRIPTION

INOmax (nitric oxide gas) is a drug administered by inhalation. Nitric oxide, the active substance in INOmax, is a pulmonary vasodilator. INOmax is a gaseous blend of nitric oxide and nitrogen (0.08% and 99.92%, respectively for 800 ppm; 0.01% and 99.99%, respectively for 100 ppm). INOmax is supplied in aluminum cylinders as a compressed gas under high pressure (2000 pounds per square inch gauge [psig]).

The structural formula of nitric oxide (NO) is shown below:



## 12 CLINICAL PHARMACOLOGY

### 12.1 Mechanism of Action

Nitric oxide is a compound produced by many cells of the body. It relaxes vascular smooth muscle by binding to the heme moiety of cytosolic guanylate cyclase, activating guanylate cyclase and increasing intracellular levels of cyclic guanosine 3',5'-monophosphate, which then leads to vasodilation. When inhaled, nitric oxide selectively dilates the pulmonary vasculature, and because of efficient scavenging by hemoglobin, has minimal effect on the systemic vasculature.

INOmax appears to increase the partial pressure of arterial oxygen (PaO<sub>2</sub>) by dilating pulmonary vessels in better ventilated areas of the lung, redistributing pulmonary blood flow away from lung regions with low ventilation/perfusion (V/Q) ratios toward regions with normal ratios.

### 12.2 Pharmacodynamics

#### Effects on Pulmonary Vascular Tone in PPHN

Persistent pulmonary hypertension of the newborn (PPHN) occurs as a primary developmental defect or as a condition secondary to other diseases such as meconium aspiration syndrome (MAS), pneumonia, sepsis, hyaline membrane disease, congenital diaphragmatic hernia (CDH), and pulmonary hypoplasia. In these states, pulmonary vascular resistance (PVR) is high, which results in hypoxemia secondary to right-to-left shunting of blood through the patent ductus arteriosus and foramen ovale. In neonates with PPHN, INOmax improves oxygenation (as indicated by significant increases in PaO<sub>2</sub>).

### 12.3 Pharmacokinetics

The pharmacokinetics of nitric oxide has been studied in adults.

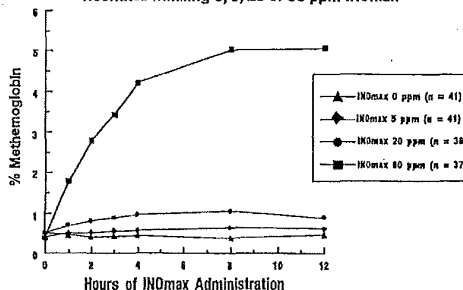
### 12.4 Pharmacokinetics: Uptake and Distribution

Nitric oxide is absorbed systemically after inhalation. Most of it traverses the pulmonary capillary bed where it combines with hemoglobin that is 60% to 100% oxygen-saturated. At this level of oxygen saturation, nitric oxide combines predominantly with oxyhemoglobin to produce methemoglobin and nitrate. At low oxygen saturation, nitric oxide can combine with deoxyhemoglobin to transiently form nitrosylhemoglobin, which is converted to nitrogen oxides and methemoglobin upon exposure to oxygen. Within the pulmonary system, nitric oxide can combine with oxygen and water to produce nitrogen dioxide and nitrite, respectively, which interact with oxyhemoglobin to produce methemoglobin and nitrate. Thus, the end products of nitric oxide that enter the systemic circulation are predominantly methemoglobin and nitrate.

### 12.5 Pharmacokinetics: Metabolism

Methemoglobin disposition has been investigated as a function of time and nitric oxide exposure concentration in neonates with respiratory failure. The methemoglobin (MetHb) concentration-time profiles during the first 12 hours of exposure to 0, 5, 20, and 80 ppm INOmax are shown in Figure 1.

Figure 1:  
Methemoglobin Concentration – Time Profiles  
Neonates Inhaling 0, 5, 20 or 80 ppm INOmax



Methemoglobin concentrations increased during the first 8 hours of nitric oxide exposure. The mean methemoglobin level remained below 1% in the placebo group and in the 5 ppm and 20 ppm INOmax groups, but reached approximately 5% in the 80 ppm INOmax group. Methemoglobin levels >7% were attained only in patients receiving 80 ppm, where they comprised 35% of the group. The average time to reach peak methemoglobin was  $10 \pm 9$  (SD) hours (median, 8 hours) in these 13 patients, but one patient did not exceed 7% until 40 hours.

### 12.6 Pharmacokinetics: Elimination

Nitrate has been identified as the predominant nitric oxide metabolite excreted in the urine, accounting for >70% of the nitric oxide dose inhaled. Nitrate is cleared from the plasma by the kidney at rates approaching the rate of glomerular filtration.

## 13 NONCLINICAL TOXICOLOGY

### 13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility

No evidence of a carcinogenic effect was apparent, at inhalation exposures up to the recommended dose (20 ppm), in rats for 20 hr/day for up to two years. Higher exposures have not been investigated.

Nitric oxide has demonstrated genotoxicity in Salmonella (Ames Test), human lymphocytes, and after *in vivo* exposure in rats. There are no animal or human studies to evaluate nitric oxide for effects on fertility.

#### 14 CLINICAL STUDIES

##### 14.1 Treatment of Hypoxic Respiratory Failure (HRF)

The efficacy of INOmax has been investigated in term and near-term newborns with hypoxic respiratory failure resulting from a variety of etiologies. Inhalation of INOmax reduces the oxygenation index (OI = mean airway pressure in cm H<sub>2</sub>O × fraction of inspired oxygen concentration [FIO<sub>2</sub>] × 100 divided by systemic arterial concentration in mm Hg [PaO<sub>2</sub>]) and increases PaO<sub>2</sub> [see *Clinical Pharmacology* (12.1)].

##### NINOS Study

The Neonatal Inhaled Nitric Oxide Study (NINOS) group conducted a double-blind, randomized, placebo-controlled, multicenter trial in 235 neonates with hypoxic respiratory failure. The objective of the study was to determine whether inhaled nitric oxide would reduce the occurrence of death and/or initiation of extracorporeal membrane oxygenation (ECMO) in a prospectively defined cohort of term or near-term neonates with hypoxic respiratory failure unresponsive to conventional therapy. Hypoxic respiratory failure was caused by meconium aspiration syndrome (MAS; 49%), pneumonia/sepsis (21%), idiopathic primary pulmonary hypertension of the newborn (PPHN; 17%), or respiratory distress syndrome (RDS; 11%). Infants ≤14 days of age (mean, 1.7 days) with a mean PaO<sub>2</sub> of 46 mm Hg and a mean oxygenation index (OI) of 43 cm H<sub>2</sub>O / mm Hg were initially randomized to receive 100% O<sub>2</sub> with (n=114) or without (n=121) 20 ppm nitric oxide for up to 14 days. Response to study drug was defined as a change from baseline in PaO<sub>2</sub> 30 minutes after starting treatment (full response = >20 mm Hg, partial = 10–20 mm Hg, no response = <10 mm Hg). Neonates with a less than full response were evaluated for a response to 80 ppm nitric oxide or control gas. The primary results from the NINOS study are presented in Table 2.

Table 2:  
Summary of Clinical Results from NINOS Study

	Control (n=121)	NO (n=114)	P value
Death or ECMO*†	77 (64%)	52 (46%)	0.006
Death	20 (17%)	16 (14%)	0.60
ECMO	66 (55%)	44 (39%)	0.014

\* Extracorporeal membrane oxygenation

† Death or need for ECMO was the study's primary end point

Although the incidence of death by 120 days of age was similar in both groups (NO, 14%; control, 17%), significantly fewer infants in the nitric oxide group required ECMO compared with controls (39% vs. 55%, p = 0.014). The combined incidence of death and/or initiation of ECMO showed a significant advantage for the nitric oxide treated group (46% vs. 64%, p = 0.006). The nitric oxide group also had significantly greater increases in PaO<sub>2</sub> and greater decreases in the OI and the alveolar-arterial oxygen gradient than the control group (p<0.001 for all parameters). Significantly more patients had at least a partial response to the initial administration of study drug in the nitric oxide group (66%) than the control group (26%, p<0.001). Of the 125 infants who did not respond to 20 ppm nitric oxide or control, similar percentages of NO-treated (18%) and control (20%) patients had at least a partial response to 80 ppm nitric oxide for inhalation or control drug, suggesting a lack of additional benefit for the higher dose of nitric oxide. No infant had study drug discontinued for toxicity. Inhaled nitric oxide had no detectable effect on mortality. The adverse events collected in the NINOS trial occurred at similar incidence rates in both treatment groups [see *Adverse Reactions* (6.1)]. Follow-up exams were performed at 18–24 months for the infants enrolled in this trial. In the infants with available follow-up, the two treatment groups were similar with respect to their mental, motor, audiological, or neurologic evaluations.

##### CINRGI Study

This study was a double-blind, randomized, placebo-controlled, multicenter trial of 186 term and near-term neonates with pulmonary hypertension and hypoxic respiratory failure. The primary objective of the study was to determine whether INOmax would reduce the receipt

of ECMO in these patients. Hypoxic respiratory failure was caused by MAS (35%), idiopathic PPHN (30%), pneumonia/sepsis (24%), or RDS (8%). Patients with a mean PaO<sub>2</sub> of 54 mm Hg and a mean OI of 44 cm H<sub>2</sub>O / mm Hg were randomly assigned to receive either 20 ppm INOmax (n=97) or nitrogen gas (placebo; n=89) in addition to their ventilatory support. Patients who exhibited a PaO<sub>2</sub> >60 mm Hg and a pH < 7.55 were weaned to 5 ppm INOmax or placebo. The primary results from the CINRGI study are presented in Table 3.

Table 3:  
Summary of Clinical Results from CINRGI Study

	Placebo	INOmax	P value
ECMO*†	51/89 (57%)	30/97 (31%)	<0.001
Death	5/89 (6%)	3/97 (3%)	0.48

\* Extracorporeal membrane oxygenation

† ECMO was the primary end point of this study

Significantly fewer neonates in the INOmax group required ECMO compared to the control group (31% vs. 57%, p<0.001). While the number of deaths were similar in both groups (INOmax, 3%; placebo, 6%), the combined incidence of death and/or receipt of ECMO was decreased in the INOmax group (33% vs. 58%, p<0.001).

In addition, the INOmax group had significantly improved oxygenation as measured by PaO<sub>2</sub>, OI, and alveolar-arterial gradient (p<0.001 for all parameters). Of the 97 patients treated with INOmax, 2 (2%) were withdrawn from study drug due to methemoglobin levels >4%. The frequency and number of adverse events reported were similar in the two study groups [see *Adverse Reactions* (6.1)].

##### 14.2 Ineffective in Adult Respiratory Distress Syndrome (ARDS) ARDS Study

In a randomized, double-blind, parallel, multicenter study, 385 patients with adult respiratory distress syndrome (ARDS) associated with pneumonia (46%), surgery (33%), multiple trauma (26%), aspiration (23%), pulmonary contusion (18%), and other causes, with PaO<sub>2</sub>/FIO<sub>2</sub> <250 mm Hg despite optimal oxygenation and ventilation, received placebo (n=193) or INOmax (n=192), 5 ppm, for 4 hours to 28 days or until weaned because of improvements in oxygenation. Despite acute improvements in oxygenation, there was no effect of INOmax on the primary endpoint of days alive and off ventilator support. These results were consistent with outcome data from a smaller dose ranging study of nitric oxide (1.25 to 80 ppm). INOmax is not indicated for use in ARDS.

#### 16 HOW SUPPLIED/STORAGE AND HANDLING

INOmax (nitric oxide) is available in the following sizes:

Size D	Portable aluminum cylinders containing 353 liters at STP of nitric oxide gas in 800 ppm concentration in nitrogen (delivered volume 344 liters) (NDC 64693-002-01)
Size D	Portable aluminum cylinders containing 353 liters at STP of nitric oxide gas in 100 ppm concentration in nitrogen (delivered volume 344 liters) (NDC 64693-001-01)
Size 88	Aluminum cylinders containing 1963 liters at STP of nitric oxide gas in 800 ppm concentration in nitrogen (delivered volume 1918 liters) (NDC 64693-002-02)
Size 88	Aluminum cylinders containing 1963 liters at STP of nitric oxide gas in 100 ppm concentration in nitrogen (delivered volume 1918 liters) (NDC 64693-001-02)

Store at 25°C (77°F) with excursions permitted between 15–30°C (59–86°F) [see USP Controlled Room Temperature].

##### **Occupational Exposure**

The exposure limit set by the Occupational Safety and Health Administration (OSHA) for nitric oxide is 25 ppm, and for NO<sub>2</sub> the limit is 5 ppm.

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SPC-0303 V:4.0

# EXHIBIT 11

## Acute pulmonary hypertension in infants and children: cGMP-related drugs

Alain Fraisse, MD, PhD; David L. Wessel, MD

Pharmacologic strategies to reduce pulmonary vascular tone and to treat pulmonary hypertension originally aimed to enrich vascular smooth muscle cyclic adenosine monophosphate levels. Alternatively, increasing cyclic guanosine monophosphate (cGMP) also reduces pulmonary vascular tone. Inhaled nitric oxide is extremely efficacious in increasing cGMP and selectively reducing mean pulmonary arterial pressure in pediatric cardiac patients. It is considered standard treatment in most centers. However, not all patients respond to inhaled nitric oxide and withdrawal is sometimes problematic. This has prompted investigation of alternative methods to increase intracellular vascular smooth muscle cGMP. Phosphodiesterase type 5 is particularly abundant in the lung vasculature of patients with severe pulmonary hypertension. Its inhibition with the sildenafil class of drugs is now commonplace. Drugs that affect cGMP metabolism in children with acute pulmonary hypertension are the subject of this review and consensus statement. Oral sildenafil is recommended in postopera-

tive pulmonary hypertension after failed withdrawal of inhaled NO (class I, level of evidence B). The effectiveness of prolonged treatment with sildenafil in documented postoperative pulmonary hypertension is not well established (class IIb, level of evidence C). Sildenafil is indicated in idiopathic pulmonary hypertension, although data have been extrapolated mainly from adult trial (class I, level of evidence A, extrapolated). Recently, completed pediatric trials have seemed to support this recommendation. Longer-acting and intravenous forms of phosphodiesterase type 5 inhibitors, brain natriuretic peptides, and direct soluble guanylate cyclase activators all have appeal, but there is insufficient experience in children with acute pulmonary hypertensive disorders for recommendations on treatment. (*Pediatr Crit Care Med* 2010; 11[Suppl.]:S37-S40)

**KEY WORDS:** inhaled nitric oxide; sildenafil; congenital heart disease; postoperative pulmonary hypertension.

**I**n children with pulmonary arterial hypertension (PAH), endothelial dysfunction results in an imbalance of endogenous vasoconstrictors (e.g., endothelin-1) and vasodilators (e.g., nitric oxide [NO]), leading to vascular constriction, *in situ* thrombosis, and vascular remodeling (1-3). Postoperative PAH and endothelial dysfunction are further exacerbated by the effects of cardiopulmonary bypass.

Strategies to reduce pulmonary vascular tone aim to enrich vascular smooth muscle cyclic adenosine monophosphate levels through  $\beta$  agonists (isoproterenol) or with phosphodiesterase type III inhibitors (e.g., milrinone). Alternatively, increasing cyclic guanosine monophos-

phate (cGMP) with nitro-vasodilators (sodium nitroprusside, nitroglycerin, inhaled NO) also reduces pulmonary vascular tone. Inhaled NO is extremely efficacious in selectively reducing mean pulmonary arterial pressure (PAP) in cardiac patients and is considered standard treatment in most centers. However, not all patients respond to inhaled NO. Its application is limited as it is cumbersome and expensive to consider administering chronically and there is a withdrawal response seen in some postoperative patients. Withdrawal of inhaled NO can lead to significant rebound PAH.

Sildenafil and other phosphodiesterase type 5 (PDE5) inhibitors may play a role in the management of PAH as an alternative or adjunct to current therapies by preferentially inhibiting PDE5. Sildenafil acts by inhibiting the breakdown of cGMP through PDE5, an enzyme that metabolizes intracellular cGMP to inactive 5'-GMP. Other cGMP-related drugs may act through direct guanylate cyclase activation.

### Pharmacology of Sildenafil

PDE5 is particularly abundant in the lung vasculature of patients with severe PAH. The main pharmacologic mecha-

nism by which sildenafil achieves its clinical effect is by preferential inhibition of PDE5 that is present in penile tissue, platelets, skeletal muscle, and vascular and visceral smooth muscle, thereby slowing the degradation of cGMP, resulting in lower levels of intracellular calcium and relaxation of vascular smooth muscle. In PAH, this results ultimately in a reduction of PAP and pulmonary vascular resistance (3). However, other factors may play a significant role, such as atrial natriuretic peptide and NO up-regulation (4). One potential contraindication for sildenafil therapy is postcapillary hypertension. When left atrial pressure is elevated, sildenafil could worsen heart failure by increasing pulmonary blood flow through its vasodilator effect, as has been reported with inhaled NO. Although with sildenafil, this might be counterbalanced by its peripheral vasodilator properties (5). Furthermore, sildenafil may be an important regulator for contraction and stress remodeling pathways. Studies in surgical specimens and in rat hypertrophied right ventricular myocardium demonstrated that PDE5 is markedly up-regulated there. Consequently, administration of PDE5 inhibitors increases right

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Dr. Wessel is currently a consultant to IKARIA Holdings, Inc. Dr. Fraisse has not disclosed any potential conflicts of interest.

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ventricular inotropy and decreases right ventricular afterload, making them potentially ideal for the treatment of diseases affecting the right ventricle like PAH (6).

### Clinical Studies With Oral Sildenafil in Adult PAH

Four randomized, controlled trials have been performed to evaluate sildenafil in patients with "chronic" PAH (7–10), with inclusion of few pediatric patients in one (10). They all reported positive results, primarily based on improvement with exercise, using the 6-min walk test. Following the results of the pivotal study from Galis and colleagues, the U.S. Food and Drug Administration approved oral sildenafil for therapy for PAH (7). More recently, combination therapy was evaluated in a double-blind, randomized trial in which either oral sildenafil or placebo was given to patients already receiving intravenous epoprostenol. The primary end point (6-min walk test) significantly improved in treated patients relative to placebo, along with secondary end points (hemodynamics, quality of life, and time to clinical worsening) (11).

Experience is very limited in adults with the use of sildenafil in acute PAH after cardiac surgery. Beside anecdotal case reports of oral sildenafil in cardiac surgical patients, only one small, retrospective study demonstrated significantly decreased mean PAP and pulmonary vascular resistances in eight postoperative patients after mitral valve surgery or left ventricular assist device placement (12).

### Indications and Clinical Applications of Oral Sildenafil in Pediatric PAH

The first human use of sildenafil for the purpose of treating PAH was more than a decade ago in infants with postoperative PAH after failure to wean inhaled NO. The administration of sildenafil blunted rebound PAH during inhaled NO withdrawal (13). From this first experience, there have been growing anecdotal evidence and widespread adoption of the use of sildenafil to treat PAH in pediatric patients. Studies in support of chronic administration of oral sildenafil in children are only now appearing. In a 12-month open-label, clinical trial, Humpl and colleagues

demonstrated significant improvement with hemodynamics and exercise capacity (6-min walk test) in 14 children with idiopathic or secondary PAH (14). More recently, results of a large, prospective, double-blind, placebo-controlled trial in children have been announced (R. J. Barst and D. L. Wessel, personal communication). Improvement in exercise capacity and secondary outcome variables was observed.

In acute PAH, the use of oral sildenafil has been studied during the early postoperative period, mainly to prevent rebound PAH during inhaled NO withdrawal (13, 15). Of particular interest is the prospective, randomized, double-blind, placebo-controlled study of Namachivayam and colleagues. They demonstrated in 15 postoperative infants and children who were receiving inhaled NO after cardiac surgery that a single dose of enteral sildenafil effectively prevented the development of rebound PAH after NO withdrawal, as compared with 14 children allocated to placebo. Sildenafil also reduced the subsequent duration of mechanical ventilation (15). This raises potential interest in the prophylactic administration of sildenafil in such patients with elevated pulmonary vascular resistance and failure to wean inhaled NO. This concept of the prophylactic use of sildenafil to facilitate weaning from NO was further enhanced by Lee and colleagues, who succeeded with oral sildenafil in withdrawing inhaled NO in seven postoperative cardiac children with PAH who had previously failed attempts at inhaled NO weaning (16). In this study, the sildenafil was continued for an average duration of 28 days.

Beside postoperative PAH, sildenafil has been studied in persistent pulmonary hypertension of the newborn, another acute form of PAH. In a placebo-controlled, randomized study in infants >35.5 wks' gestation and <3 days old with severe persistent pulmonary hypertension of the newborn and oxygenation index >25, sildenafil was given at a dose of 1 mg/kg. Oxygenation index improved in all infants within 6 hrs to 30 hrs. All the patients demonstrated a steady improvement in pulse oxygen saturation over time, and none had noticeable effect on blood pressure (17).

Currently, the optimal dose of oral sildenafil in children remains undetermined, but is likely to be in the range of 0.3–1.0 mg/kg three times per day. Bioavailability in a postoperative child may

be significantly impaired. Few serious adverse events have been reported in patients on sildenafil, most frequently dizziness, tachycardia, erythema, and drowsiness (18). Of concern is the report of cases of nonarteritic anterior ischemic optic neuropathy in adult patients using sildenafil for erectile dysfunction. This suggests a possible causal relationship with sildenafil, although such population with erectile dysfunction also often presents with generalized endothelial disease, which also constitutes a risk factor for nonarteritic anterior ischemic optic neuropathy. In children, a single case of ischemic optic neuropathy was reported (19). In pediatric PAH, no significant effect on systemic arterial and central venous pressures was seen after incremental doses of 0.5 mg/kg, 1 mg/kg, 1.5 mg/kg, and 2.0 mg/kg (20). Even accidental ingestions of adult pills of Viagra (Pfizer, New York, NY) did not result in significant nor sustained hemodynamic compromise (21).

Guidelines are as follows:

1. Sildenafil is recommended in postoperative PAH after failed withdrawal of inhaled NO (class I, level of evidence B). There are several case reports and small cohort studies (13, 16) as well as one small prospective, randomized, double-blind, placebo-controlled study in 30 patients (15).
2. The effectiveness of prolonged treatment with sildenafil in documented postoperative PAH is not well established (class IIb, level of evidence C). There are limited data on prolonged use of sildenafil in such indication. In the study by Lee and colleagues, sildenafil was continued for an average duration of 28 days (16). Sildenafil may be reasonable for more prolonged perioperative treatment if PAH is hemodynamically significant. Preliminary review of a large, randomized, pediatric trial suggested a good safety profile and potential mid-term benefit. This will likely raise the class of evidence to IIa.
3. Sildenafil is indicated in idiopathic PAH, although data are extrapolated mainly from adult trials (7–10) (class I, level of evidence A, extrapolated). Completed pediatric trials seem to support this recommendation, but final review and publication are pending.



### Intravenous Sildenafil

When sildenafil is administered enterally, its bioavailability is only about 40% in healthy subjects (22). In critically ill, postoperative children with even more unpredictable enteral absorption, the intravenous form of sildenafil seems more appropriate. Several preliminary studies in children with intravenous sildenafil have reported encouraging results to lower PAP and pulmonary vascular resistances after cardiac surgery or during cardiac catheterization (23–25). In a recent work investigating the pharmacologic properties of three different doses of intravenous sildenafil on postoperative PAH, the use of a bolus followed by maintenance dose for a maximal duration of 72 hrs was specifically designed for treating PAH in the early postoperative course. Beside the ability for the three doses of intravenous sildenafil to decrease PAP effectively, patients experienced a shorter time to extubation and a shorter intensive care unit length of stay compared with placebo (25). This preliminary and underpowered study cannot be used for recommendations regarding this unapproved form of the drug.

Whereas the majority of animal and human studies on intravenous sildenafil did not document any clinically significant hemodynamic and respiratory side effects (25–28), Schulze-Neick and colleagues reported significant intrapulmonary shunting in postoperative children with PAH after cardiac surgery, although no patient experienced significant hypoxemia (23). In another study, systemic hypotension and impaired oxygenation were observed after 0.35 mg/kg IV of sildenafil in postoperative infants at risk but not suffering from PAH (24). In a dose-finding trial of intravenous sildenafil for newborns with persistent pulmonary hypertension of the newborn, the drug was associated with improved oxygenation and, in some patients, may have prevented the need for standard therapy (inhaled NO) (29).

### Second-Generation PDE Inhibitors (Tadalafil, Vardenafil)

With a longer plasma half-life and a more specific and potent PDE inhibition, the new PDE inhibitors are of potential interest in heart failure. To date, no studies in children have been completed and published. In an animal model of persistent pulmonary hypertension of the newborn, tadalafil improves oxygenation (30).

### Direct Soluble Guanylate Cyclase Activators

The limitation of NO donors, such as nitroprusside, includes development of tolerance and lack of selectivity for the pulmonary circulation. This has prompted investigation into a new promising class of compounds that directly activate soluble guanylate cyclase. The so-called BAY compounds (e.g., cinacquat) have been shown to selectively activate the oxidized/heme free enzyme, causing marked vasodilation in diseased organs. Phase II trials are ongoing and no experience in children has been reported.

### Nesiritide

The natriuretic hormone system is an important regulator of neurohormonal activation, cardiac diastolic function, and fluid balance, as well as vascular tone. Furthermore, brain natriuretic peptide seems to be a useful marker to monitor disease severity in pediatric PAH (31). Nesiritide (synthetic B-type natriuretic peptide) may have a hemodynamic profile that is comparable with milrinone as a rather nonspecific pulmonary vasodilator. It reduces PAP in adults and improves diuresis and fluid balance in children after congenital surgery but no study has been conducted in acute PAH children (32).

### Conclusion

Over the last decade, oral sildenafil has played a growing role in the treatment of acute PAH, emerging as an effective first-line therapeutic agent. Selective pulmonary vasodilation and antiremodeling properties played an important role in its clinical efficacy, whereas very few serious adverse events were associated with its administration in children. Future well-designed trials are needed to clarify the efficacy of sildenafil in acute PAH. Other cGMP-related agents are of potential interest but they require more specific studies to provide information on their therapeutic use in acute PAH.

### REFERENCES

1. Wessel DL, Adatia I, Giglia TM, et al: Use of inhaled nitric oxide and acetylcholine in the evaluation of pulmonary hypertension and endothelial function after cardiopulmonary bypass. *Circulation* 1993; 88:2128–2138
2. Rubin LJ: Primary pulmonary hypertension. *N Engl J Med* 1997; 336:111–117
3. Tantini B, Manes A, Fiumana E, et al: Anti-

proliferative effect of sildenafil on human pulmonary artery smooth muscle cells. *Basic Res Cardiol* 2005; 100:131–8

4. Gyurko R, Kuhlencordt P, Fishman MC, et al: Modulation of mouse cardiac function in vivo by eNOS and ANP. *Am J Physiol* 2000; 278: H971–H981
5. Hirata K, Adji A, Vlachopoulos C, et al: Effect of sildenafil on cardiac performance in patients with heart failure. *Am J Cardiol* 2005; 96:436–440
6. Nagendran J, Archer SL, Soliman D, et al: Phosphodiesterase type 5 is highly expressed in the hypertrophied human right ventricle, and acute inhibition of phosphodiesterase type 5 improves contractility. *Circulation* 2007; 116:238–248
7. Galie N, Ghofrani HA, Torbicki A, et al: Sildenafil citrate therapy for pulmonary arterial hypertension. *N Engl J Med* 2005; 352: 2148–2157
8. Sastry BKS, Narasimhan C, Krishna Reddy N, et al: Clinical efficacy of sildenafil in primary pulmonary hypertension. A randomized, placebo-controlled, double-blind, crossover study. *J Am Coll Cardiol* 2004; 43: 1149–1153
9. Bharani A, Mathew V, Sahu A, et al: The efficacy and tolerability of sildenafil in patients with moderate-to-severe pulmonary hypertension. *Indian Heart J* 2003; 55:55–59
10. Singh TP, Rohit M, Grover A, et al: A randomized, placebo-controlled, double-blind, crossover study to evaluate the efficacy of oral sildenafil therapy in severe pulmonary artery hypertension. *Am Heart J* 2006; 151:851.e1–5
11. Simonneau G, Rubin LJ, Galie N, et al: Addition of sildenafil to long-term intravenous epoprostenol therapy in patients with pulmonary arterial hypertension. *Ann Intern Med* 2008; 149:521–530
12. Trachte AL, Lobato EB, Urdaneta F, et al: Oral sildenafil reduces pulmonary hypertension after cardiac surgery. *Ann Thorac Surg* 2005; 79:194–7
13. Alz AM, Wessel D: Sildenafil ameliorates effects of inhaled nitric oxide withdrawal. *Anesthesiology* 1999; 91:307–310
14. Humpl T, Reyes JT, Holtby H, et al: Beneficial effect of oral sildenafil therapy on childhood pulmonary arterial hypertension. *Circulation* 2005; 111:3274–3280
15. Namachivayam P, Theilen U, Butt WW, et al: Sildenafil prevents rebound pulmonary hypertension after withdrawal of nitric oxide in children. *Am J Respir Crit Care Med* 2006; 174:1042–1047
16. Lee JE, Hillier SC, Knoderer CA: Use of sildenafil to facilitate weaning from inhaled nitric oxide in children with pulmonary hypertension following surgery for congenital heart disease. *J Intensive Care Med* 2008; 23:329–234
17. Baquero H, Soliz A, Neira F, et al: Oral sildenafil in infants with persistent pulmonary hypertension of the newborn: A pilot randomized blinded study. *Pediatrics* 2006; 117: 1077–1083

18. Forrester MB, Artalejo L: Pattern of sildenafil calls to Texas poison control centers, 1998–2004. *J Toxicol Environ Health A* 2006; 69:497–503
19. Sivaswamy L, Vanstavern GP: Ischemic optic neuropathy in a child. *Pediatr Neurol* 2007; 37:371–372
20. Raja SG, Danton MD, MacArthur KJ, et al: Effects of escalating doses of sildenafil on hemodynamics and gas exchange in children with pulmonary hypertension and congenital cardiac defects. *J Cardiothorac Vasc Anesth* 2007; 21:203–207
21. Wills BK, Albinson C, Wahl M, et al: Sildenafil citrate ingestion and prolonged priapism and tachycardia in a pediatric patient. *Clin Toxicol* 2007; 45:798–800
22. Zusman RM, Morales A, Glasser DB, et al: Overall cardiovascular profile of sildenafil citrate. *Am J Cardiol* 1999; 83:35C–44C
23. Schulze-Neick I, Hartenstein P, Li J, et al: Intravenous sildenafil is a potent pulmonary vasodilator in children with congenital heart disease. *Circulation* 2003; 108(Suppl II):II-167–II-173
24. Stocker C, Penny DJ, Brizard CP, et al: Intravenous sildenafil and inhaled nitric oxide: A randomised trial in infants after cardiac surgery. *Intensive Care Med* 2003; 29:1996–2003
25. Fraisse A, Butrous G, Taylor MB, et al: Randomized controlled trial of IV sildenafil for postoperative pulmonary hypertension in children with congenital heart disease. *Circulation* 2007; 116:II-350–II-351
26. Ryhammer PK, Shekerdemian LS, Penny DJ, et al: Effect of intravenous sildenafil on pulmonary hemodynamics and gas exchange in the presence and absence of acute lung injury in piglets. *Pediatr Res* 2006; 59:762–766
27. Haase E, Bigam DL, Cravetchi O, et al: Dose response of intravenous sildenafil on systemic and regional hemodynamics in hypoxic neonatal piglets. *Shock* 2006; 26:99–106
28. Bagdyman N, Fleck T, Bitterling B, et al: Influence of intravenous sildenafil on cerebral oxygenation measured by near-infrared spectroscopy in infants after cardiac surgery. *Pediatr Res* 2006; 59:462–465
29. Steinhorn RH, Kinsella JP, Pierce C, et al: Intravenous sildenafil in the treatment of neonates with persistent pulmonary hypertension. *J Pediatr* 2009; 155:841–847.e1
30. Tessler RB, Zadinello M, Fiori H, et al: Tadalafil improves oxygenation in a model of newborn pulmonary hypertension. *Pediatr Crit Care Med* 2008; 9:330–332
31. Bemus A, Wagner BD, Accurso F, et al: Brain natriuretic peptide levels in managing pediatric patients with pulmonary arterial hypertension. *Chest* 2009; 135:745–751
32. Mahle WT, Cuadrado AR, Kirshbom PM, et al: Nesiritide in infants and children with congestive heart failure. *Pediatr Crit Care Med* 2005; 6:543–546

Applicant : James S. Baldassarre et al.  
Serial No. : 12/820,866  
Filed : June 22, 2010  
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Attorney's Docket No.: 26047-0003002

**(x) Related Proceedings Appendix**

There are no decisions in related proceedings.

## Electronic Patent Application Fee Transmittal

<b>Application Number:</b>	12820866			
<b>Filing Date:</b>	22-Jun-2010			
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION			
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre			
<b>Filer:</b>	Janis K. Fraser/Lisa Gray			
<b>Attorney Docket Number:</b>	26047-0003002			
Filed as Large Entity				
<b>Utility under 35 USC 111(a) Filing Fees</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent Appeals-and-Interference:</b>				
Filing a brief in support of an appeal	1402	1	620	620
<b>Post-Allowance-and-Post-Issuance:</b>				
<b>Extension-of-Time:</b>				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
<b>Miscellaneous:</b>				
<b>Total in USD (\$)</b>				<b>620</b>

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	11111696
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	94169
<b>Filer:</b>	Janis K. Fraser/Lisa Gray
<b>Filer Authorized By:</b>	Janis K. Fraser
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1	Appeal Brief Filed	26047-0003002appealbrief.pdf	12505757 42e081bce84737f95c20097cdb5557a8b072d6	no	211
<b>Warnings:</b>					
<b>Information:</b>					
2	Fee Worksheet (SB06)	fee-info.pdf	30717 7fa61065f0c72310f6d36a54ed70979668f3878	no	2
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<p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>  <b>If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</b></p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>  <b>If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</b></p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>  <b>If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</b></p>					



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EXAMINER
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ARNOLD, ERNST V

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PAPER

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The time period for reply, if any, is set in the attached communication.





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**BEFORE THE BOARD OF PATENT APPEALS  
AND INTERFERENCES**

Application Number: 12/820,866  
Filing Date: June 22, 2010  
Appellant(s): BALDASSARRE ET AL.

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Janis Fraser  
For Appellant

**EXAMINER'S ANSWER**

This is in response to the appeal brief filed 10/4/11 appealing from the Office action mailed 8/24/11.

**(1) Real Party in Interest**

The examiner has no comment on the statement, or lack of statement, identifying by name the real party in interest in the brief.

**(2) Related Appeals and Interferences**

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

**(3) Status of Claims**

The following is a list of claims that are rejected and pending in the application:  
28-42.

**(4) Status of Amendments After Final**

The examiner has no comment on the appellant's statement of the status of amendments after final rejection contained in the brief.

**(5) Summary of Claimed Subject Matter**

The examiner has no comment on the summary of claimed subject matter contained in the brief.

**(6) Grounds of Rejection to be Reviewed on Appeal**

The examiner has no comment on the appellant's statement of the grounds of rejection to be reviewed on appeal. Every ground of rejection set forth in the Office action from which the appeal is taken (as modified by any advisory actions) is being maintained by the examiner except for the grounds of rejection (if any) listed under the subheading "WITHDRAWN

REJECTIONS.” New grounds of rejection (if any) are provided under the subheading “NEW GROUNDS OF REJECTION.”

**(7) Claims Appendix**

The examiner has no comment on the copy of the appealed claims contained in the Appendix to the appellant’s brief.

**(8) Evidence Relied Upon**

2007 INOmax insert

Atz & Wessel, Seminars in Perinatology 1997, 21(5), 441-455.

Kinsella et al., The Lancet 1999, 354, 1061-1065.

Loh et al., Circulation 1994, 90, 2780-2785.

**(9) Grounds of Rejection**

The following ground(s) of rejection are applicable to the appealed claims:

***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

Claims 28-42 are rejected under 35 U.S.C. 103(a) as being unpatentable over INOmax® insert (2007; IDS filed on 7/8/11) and Atz et al. (Seminars in Perinatology 1997, 21(5), pp 441-455) and Kinsella et al. (The Lancet 1999, 354, 1061-1065) and Loh et al. (Circulation 1994, 90, 2780-2785).

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

Applicants claims, for example:

28. (New) A method of reducing the risk of occurrence, in a term or near-term neonate patient, of one or more adverse events or serious adverse events associated with a medical treatment comprising inhalation of nitric oxide gas, said method comprising:
  - (a) identifying a term or near-term neonate patient in need of inhaled nitric oxide treatment, wherein the patient is not known to be dependent on right-to-left shunting of blood;
  - (b) determining that the patient identified in (a) has pre-existing left ventricular dysfunction; and
  - (c) excluding the patient from inhaled nitric oxide treatment based on the determination that the patient has pre-existing left ventricular dysfunction.

### **Determination of the scope and content of the prior art**

**(MPEP 2141.01)**

The INOmax® insert teaches that in the NINOS study (page 1, upper right) neonates with hypoxic respiratory failure were treated with inhaled NO (iNO) resulting in fewer deaths than the control (14% vs 20%)(page 1, right column). Adverse events were presented in a Table on page 2 of the insert:

**ADVERSE EVENTS IN THE CINRGI TRIAL**

<b>Adverse Event</b>	<b>Placebo (n=89)</b>	<b>Inhaled NO (n=97)</b>
Hypotension	9 (10%)	13 (13%)
Withdrawal	9 (10%)	12 (12%)
Atelectasis	8 (9%)	9 (9%)
Hematuria	5 (6%)	8 (8%)
Hyperglycemia	6 (7%)	8 (8%)
Sepsis	2 (2%)	7 (7%)
Infection	3 (3%)	6 (6%)
Stridor	3 (3%)	5 (5%)
Cellulitis	0 (0%)	5 (5%)

As can be seen in the Table, there is a higher percentage of Adverse events associated with iNO than the placebo in all categories. In addition, the insert also teaches on page 2, left column:

**in the NINOS study, treatment groups were similar with respect to the incidence and severity of intracranial hemorrhage, Grade IV hemorrhage, periventricular leukomalacia, cerebral infarction, seizures requiring anticonvulsant therapy, pulmonary hemorrhage, or gastrointestinal hemorrhage.**

This teaching fairly suggests that iNO increases the risk of adverse events over a broad variety of events above that of the placebo. Accordingly, the ordinary artisan understands that there is an increased risk of adverse events in administering iNO over that of a placebo. *In other words, the administration of iNO increases the risk of adverse events in neonates and consequently the ordinary artisan understands that by not administering iNO the risk of occurrence of adverse events is reduced as shown by the Table above.* From this piece of art, the Examiner can make the following reasonable conclusion:

**Finding of Fact #1: Administration of iNO is not without risk of adverse events. Inhaled NO increases the risk of adverse events in neonates and the corollary that exclusion of the patient from iNO, the placebo above, has a reduced risk of the the occurrence of adverse events from iNO.**

Atz et al. teach methods using inhaled nitric oxide in the **neonate** with cardiac disease, hence an **identified patient** in need of nitric oxide treatment, (title and Abstract) which intrinsically provides pharmaceutically acceptable NO gas for inhalation to a medical provider to provide to the patient. Atz et al. warn that sudden pulmonary vasodilation may produce **pulmonary edema** (page 452, left column). Atz et al. teach that: “Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension.” (page 452, left column). Since pulmonary hypertension is instantly claimed, then the subject intrinsically has hypoxic respiratory failure. Atz et al. continues with: “Therefore, in newborns with severe left ventricular dysfunction, predominantly left to right shunting at the foramen ovale and exclusively **right to left shunting** at the ductus arteriosus, **NO should be used with extreme caution, if at all.** We and others have reported **adverse outcomes** in this

circumstance.” (page 452, left column) (Examiner added emphasis). Artz et al. thus identify conditions in the patients which is screening of the patient. Thus, Artz et al. fairly teaches excluding patients which include neonates with left ventricular dysfunction from inhaled NO treatment because the Examiner interprets “if at all” to mean no treatment and hence exclusion from treatment. The left ventricular dysfunction is intrinsically pre-existing.

To summarize, the methods disclosed by Artz et al. are interpreted to mean:

- identifying a patient eligible for NO treatment;
- diagnosing/identifying if the patient has left ventricular dysfunction;
- excluding that patient with left ventricular dysfunction from treatment with NO but treating the patient with NO for other conditions discussed by Artz et al. with inhalation of NO thereby reducing the risk of adverse events associated with the medical treatment.

Artz et al. teach neonates with pulmonary hypertension (Abstract and page 442, left column to right column) and it is irrelevant to the Examiner as to how the pulmonary hypertension was diagnosed whether by echocardiographic evidence or clinical evidence. The fact that matters is that the hypertension is diagnosed in the patient population. From this piece of art, the Examiner can make the following reasonable conclusion:

**Finding of Fact #2: Adverse outcomes are known to occur to neonates treated with iNO that have pre-existing left ventricular dysfunction and consequently the art cautions against the use of iNO to such patients.**

Kinsella et al. teach excluding patients (premature neonates) from inhaled nitric oxide treatment if they have fatal congenital anomalies or congenital heart disease (Abstract and page

1062, Methods). Since left ventricular dysfunction is a congenital heart disease, as acknowledged by Applicant, (see specification [0028]), and it would be pre-existing, then the methods of Kinsella et al. intrinsically exclude this patient population from the method. The patients also had pulmonary hypertension which would be associated with the cardiac function (Abstract). Thus, one or more adverse events are reduced in the neonates excluded from the method. The patients are intrinsically identified for nitric oxide inhalation treatment, diagnosed for congenital heart disease which intrinsically includes left ventricular dysfunction, and if the patient meets the criteria than treatment with NO is performed thereby reducing the risk of adverse events associated with the treatment. From this piece of art, the Examiner can make the following reasonable conclusion:

**Finding of Fact #3: Neonates with fatal congenital anomalies or congenital heart disease are excluded from iNO therapy but those neonates who meet the criteria for therapy are provided iNO therapy.**

Loh et al. teach that inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure (Title and Abstract). Loh et al. clearly teaches that patients with pulmonary artery wedge pressure, which is synonymous with the instantly claimed pulmonary capillary wedge pressure, ***of greater than or equal to 18 mm Hg*** had a greater effect of inhaled NO due to the greater degree of reactive pulmonary hypertension present in such patients (page 2784, left column). Loh et al. state: "*Since the degree of reactive pulmonary hypertension is generally related to the severity of hemodynamic compromise in patients with LV failure, it might be anticipated that patients with more severe heart failure will have a more marked hemodynamic response to inhaled NO.*" Loh et al. examined this prediction



further and verified it (page 2784, left column). From this piece of art, the Examiner can make the following reasonable conclusion:

**Finding of Fact #4: Patients with a pulmonary capillary wedge pressure of greater than or equal to 18 mm Hg have a more marked hemodynamic response to inhaled NO which results in the finding that inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure.**

**Ascertainment of the difference between the prior art and the claims**

**(MPEP 2141.02)**

1. The difference between the instant application and INOmax®, Atz et al., Loh et al., and Kinsella et al., is that INOmax®, Atz et al., Loh et al., and Kinsella et al., do not expressly teach the method of reducing the risk of occurrence in a term or near term neonate patient of one or more adverse events or serious adverse events associated with iNO therapy comprising identifying a term or near term neonate patient in need of iNO treatment and is not known to be dependent on right to left shunting of blood, determining if the patient has pre-existing LVD and excluding the patient from iNO treatment if they have pre-existing LVD or administering iNO if they do not have pre-existing LVD of instant claims 28-42. This deficiency in the cited references is cured by the common sense of the ordinary artisan.

**Finding of prima facie obviousness**

**Rational and Motivation (MPEP 2142-2143)**

1. It would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to perform the method of INOmax®, Atz et al., Loh et al., and Kinsella et al., and perform the method steps of instant claims 28-42 and produce the instant invention.

One of ordinary skill in the art would have been motivated to do this because: 1) iNO has risk of adverse events as taught by INOmax®; 2) if the neonate has left ventricular dysfunction (LVD), then Atz et al. clearly teach using extreme caution or not using NO at all in the treatment of patients with LVD which would also render obvious other forms of LVD not known to be dependent on right to left shunting of blood; and 3) the art of Kinsella et al. establishes excluding certain patients (premature neonates) from inhaled nitric oxide treatment if they have fatal congenital anomalies or congenital heart disease. Thus it is simply no stretch of the imagination to exclude patients such as term or near term neonates with LVD and not known to be dependent on right to left shunting of the blood from inhaled nitric oxide therapy in order to avoid adverse outcomes as taught by Atz et al. which intrinsically include all the adverse events recited by Applicant including pulmonary edema as discussed above. The ordinary artisan would err on the side of caution for the benefit of the patient. Identification of a plurality of patients in need of iNO treatment and determining which patient has pre-existing LVD and which does not is simply screening of patients. Administration of iNO to neonates without LVD is already known in the art.

Furthermore, it is already known through the teachings of Loh et al. that a pulmonary capillary wedge pressure (PCWP) of greater than 18 mm Hg serves as a guidepost for alerting the artisan to adverse events from inhaled NO. Thus, it is not inventive to exclude patients with a PCWP of greater than 20 mm Hg when the art already suggests the risk of trouble of treating

patients with a PCWP of 18 mm Hg because inhaled NO increases the wedge pressure as taught by Loh et al. (see entire document).

In summary, it remains the position of the Examiner, which is in alignment with the written opinion of the international search authority, that it is simply not inventive to 'inform' a medical provider that a neonate with LVD is at risk of adverse/serious adverse events from iNO therapy when the art already has established that fact and the ordinary artisan is alerted to this fact. *If the patient has LVD then they are at risk of adverse and/or serious adverse events from iNO therapy and it is not inventive to further identify other secondary conditions/risk factors associated with LVD and provide further warnings for secondary conditions/risk factors that are separate and independent from the first condition/risk factor but nevertheless associated with LVD to the medical provider. Screening for conditions that predispose the patient to adverse/serious adverse effects from medical treatment of iNO is obvious given the teachings above.* Respectfully, the instantly claimed method steps are in the realm of common sense and not in the dominion of invention because it is already known in the art that patients with pre-existing LVD are at risk of adverse effects from iNO. *In other words, not every finding in the scientific kingdom is patentable.* It is obvious to the ordinary artisan that if the neonate has LVD, then in order to avoid the risk of adverse or serious adverse events associated with iNO, to then exclude the neonate from iNO therapy. In other words, given the art as a whole, determination of further conditions/risk factors that would exclude the neonate from iNO therapy is obvious given the teachings in the art as discussed above which direct the artisan to screen neonates about to undergo treatment with NO by inhalation and to exclude those with LVD from such treatment.

In light of the forgoing discussion, the Examiner concludes that the subject matter defined by the instant claims would have been obvious within the meaning of 35 USC 103(a).

From the teachings of the references, it is apparent that one of ordinary skill in the art would have had a reasonable expectation of success in producing the claimed invention. Therefore, the invention as a whole was *prima facie* obvious to one of ordinary skill in the art at the time the invention was made, as evidenced by the references, especially in the absence of evidence to the contrary.

#### ***Double Patenting***

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the “right to exclude” granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting

ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

1. Claims 28-42 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 29-42 of copending Application No. 12/820980. Although the conflicting claims are not identical, they are not patentably distinct from each other because the instant subject matter embraces or is embraced by the subject matter of the copending subject matter. Both applications are drawn to methods of reducing one or more adverse events in a term or near term neonates by excluding from treatment anyone with pre-existing left ventricular dysfunction.

Therefore one of ordinary skill in the art would have recognized the obvious variation of the instant application over the copending application.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

2. Claims 28-42 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 21-30 of copending Application No. 12/821020. Although the conflicting claims are not identical, they are not patentably distinct from each other because the instant subject matter embraces or is embraced by the subject matter of the copending subject matter. Both applications are drawn to methods of reducing one or more

adverse events in a patient population by excluding from treatment anyone with pre-existing left ventricular dysfunction.

The copending application does not expressly teach the intended population as having one or more conditions.

However the copending application is drawn to the same patient population which intrinsically has one or more conditions/risk factors as instantly claimed.

Therefore one of ordinary skill in the art would have recognized the obvious variation of the instant application over the copending application.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

3. Claims 28-42 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 21-29 and 37 of copending Application No. 12/821041. Although the conflicting claims are not identical, they are not patentably distinct from each other because the instant subject matter embraces or is embraced by the subject matter of the copending subject matter. Both applications are drawn to methods of reducing one or more adverse events in a patient population by excluding from treatment anyone with pre-existing left ventricular dysfunction.

The copending application does not expressly teach the intended population as having one or more conditions.

However the copending application is drawn to the same patient population which intrinsically has one or more conditions/risk factors as instantly claimed.

Therefore one of ordinary skill in the art would have recognized the obvious variation of the instant application over the copending application.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

**(10) Response to Argument**

As a first point, it appears that Appellant argues the claims together and not separately.

As a second point, there are about 45 pages of argument in this Appeal Brief where there are multiple arguments over the same points/references. The Examiner has attempted to address all of Appellants arguments in the following response.

Appellant asserts that the Board should reverse the rejection because: i) it is contrary to historical fact and ii) the Examiner provides no analysis based upon the etiology and/or pathophysiology of the various conditions that would explain why a risk of adverse events in the Prior Art Patient Populations would lead one skilled in the art to expect an increased likelihood of adverse events in the Claims Patient Population. Applicant asserts that all the evidence of record is to the contrary and demonstrates that the etiology and pathophysiology of these patient populations are clinically distinct and would not justify any such conclusion. Respectfully, the Examiner strongly disagrees with all of Appellant's arguments for the reasons of record and those following.

The "overwhelming volume of highly pertinent factual evidence" that is supposed to render the claimed subject matter non-obvious is rendered moot by the disclosure of the INOmax

insert which clearly presents inhaled NO (iNO) therapy as having inherent risk of adverse events especially with the neonate target population as discussed in the rejection above. Certainly, all the experts must have been aware of such warnings and therefore knew that iNO therapy carries with it inherent risk of adverse events. It is not as if Applicant discovered some new outcome from the administration of iNO but rather adverse effects are clearly expected from the administration of the iNO therapy. The art of Atz et al. further establishes that neonates with LVD are at increased risk of adverse events. It is therefore no surprise that neonates with pre-existing LVD with right-to-left shunting of blood or not, are at risk of adverse events from iNO therapy because all patients that have iNO therapy are at risk of adverse events. Consequently, it is not inventive to reduce the risk or occurrence of one or more adverse events associated with iNO therapy by excluding that patient from the therapy. In other words:

**No iNO therapy = no risk of adverse events occurring from the iNO therapy.**

This is common sense and not the opinion of the Examiner.

With respect to the etiology and pathophysiology of the claimed patient population, nowhere in the claim language is there positive description(s) of the claimed patient population in terms of their specific etiology and pathophysiology; only that the claimed patient population has LVD which is step (b) in claim 28. The Examiner is examining the claim language and not reading limitations into the claims that are not present.

Appellant appears to be under the impression that just because Appellant noticed increased adverse events due to iNO therapy in a subpopulation of neonates with LVD, which is evidently surprising to the 115+ experts and 5 regulatory authorities despite the warnings on the iNOmax label, that this is patentable subject matter in view of the art as a whole. The Examiner



strongly disagrees for at least the reasons of record and those presented here. While this finding is worthy of publication to inform the public, it does not rise to level of invention based on the preponderance of evidence in the art which was known at the time of the instant invention.

Appellant asks: "...why was the INOT22 Study protocol approved without excluding that population from the study?"

This is an irrelevant question which has no bearing on the patentability of the claims as all patients treated with iNO therapy are under risk of adverse events associated with the therapy.

On page 23 of 56, Appellant asserts that the INOmax insert is both irrelevant and inaccurate. This is incorrect. It must be relevant enough to be on the insert and the Examiner has cut and pasted the relevant sections, which Appellant cannot ignore, in the rejection above.

On page 24 of 56, Appellant asserts that Atz & Wessel are overgeneralized and materially misleading. This is incorrect. Both the INOmax insert and Atz clearly teach adverse events associated with iNO therapy even with neonates with LVD.

On page 24 of 56, Appellant asserts that it is simply false that INOmax should not be administered to patients with congenital anomalies or heart disease. This is incorrect. Kinsella et al. is cited for showing that the art will exclude patients with heart disease from iNO therapy.

On page 24 of 56, Appellant asserts that the fact finding of Loh et al. is a severe overgeneralization and materially misleading. This is incorrect. The art of Loh et al. speaks for itself as discussed in detail previously.

Appellant asserts on page 25 of 56 that the Examiner is simply wrong on the science and the four findings of fact are irrelevant and inaccurate. This is incorrect. The art speaks for itself as discussed in detail previously.

With respect to all of the cited references, please note that the principle of law states that: A reference is good not only for what it teaches by direct anticipation but also for what one of ordinary skill in the art might reasonably infer from the teachings. (*In re Opprecht* 12 USPQ 2d 1235, 1236 (Fed Cir. 1989); *In re Bode* 193 USPQ 12 (CCPA) 1976).

On page 26 of 56, Appellant admits on the record that: “No drug can be said to be “without risk of adverse events.” Given that admission, is it not obvious to exclude a patient from therapy of the drug in order to reduce the risk of adverse events associated with the drug?

On page 26 of 56, Appellant fails to see the connection between the adverse events on the INOmax insert and an understanding that one should avoid giving inhaled NO to the claimed patient population in particular. That is why this is a 103 rejection and not an anticipation rejection. However, given that the instant claims do not require knowledge if the patient has right-to-left shunting of blood, any patient with pre-existing LVD can read on the instant claims when the artisan does not know if they have a dependence on right-to-left shunting of blood and be at risk of the adverse events in the Table.

On page 27 of 56, Appellant attempts to correct the record because it is Appellant’s opinion that the data from the CINRGI table and the NINOS study is superfluous. The Examiner does not find this line of argument persuasive because the table and study were important enough to be put on the insert. Additionally numbers are hard facts and the numbers show an increase in adverse events for the treatment population as shown again below for Appellant's benefit:

**ADVERSE EVENTS IN THE CINRGI TRIAL**

<b>Adverse Event</b>	<b>Placebo (n=89)</b>	<b>Inhaled NO (n=97)</b>
Hypotension	9 (10%)	13 (13%)
Withdrawal	9 (10%)	12 (12%)
Atelectasis	8 (9%)	9 (9%)
Hematuria	5 (6%)	8 (8%)
Hyperglycemia	6 (7%)	8 (8%)
Sepsis	2 (2%)	7 (7%)
Infection	3 (3%)	6 (6%)
Stridor	3 (3%)	5 (5%)
Cellulitis	0 (0%)	5 (5%)

Clearly, for hypotension for example, a 13% adverse event is greater risk of hypotension than for 9% of the placebo. Furthermore, no placebo patients had cellulitis while 5% of the iNO patients did. This is not a trivial difference as asserted by Appellant. This is clearly *an increased risk*. Arguments otherwise are simply unfounded and unsound.

Appellant asserts that the 2007 INOmax supports their position of non-obviousness but the Examiner cannot agree as discussed above.

On pages 29-30 of 56, Appellant asserts that the finding of fact of Atz & Wessel does not accurately represent that teaching and that the reference is directed to adult patients and neonates suffering from LVD that are reliant on right-to-left shunting of blood at the patent ductus arteriosus. To be clear, the citation on page 31 of 56 also states: (Examiner added emphasis) “Therefore, in newborns with severe left ventricular dysfunction, predominantly left to right shunting at the foramen ovale and exclusively right-to-left shunting at the ductus

**arteriosus, NO should be used with extreme caution if at all. We and others have reported adverse outcomes in this circumstance.**” Applicant interprets that the "caution" of the reference is explicitly limited to neonates who present with a combination of three conditions.

Respectfully, the Examiner cannot agree to this narrow interpretation of the reference. The left ventricular dysfunction of the newborn is predominantly left to right shunting at the foramen ovale and exclusively right-to-left shunting at the ductus arteriosus. Thus, the plain and ordinary meaning of the previous sentence is: *mostly or mainly* are left to right shunting at the foramen ovale and *limited to* right to left shunting at the ductus arteriosus. The Examiner does not see how the newborn has to have 3 conditions when only two conditions are discussed which appear to be exclusive of one another. In other words, if the newborn has right to left shunting at the ductus arteriosus that does not necessarily mean the newborn has to also have left to right shunting at the foramen ovale. In any event, the previous teaching that: “*Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension.*” (page 452, left column) trumps all else as patients includes both adults and neonates. The Examiner does not find this argument persuasive.

On pages 32-33 of 56, the physiology is discussed. The Examiner does not dispute the physiology.

On page 33 of 56, Appellant admits on the record that: “It was recognized early on that a particular subset of neonates with pulmonary hypertension may, because of their peculiar cardiac physiology, suffer fatal complications if they receive this therapy.” This admission appears to say that those in the art already knew that neonates with "peculiar cardiac physiology" can suffer fatal consequences if they have iNO therapy. Thus there is nothing surprising here.

It appears that infants that have pulmonary hypertension results in increased blood pressure in the right atrium which results in right to left shunting of blood have blood forced from the right atrium through the still patent ductus arteriosus and directly into the systemic circulation. Blood entering the circulation from the right atrium is partially oxygenated from blood leaking through the patent foramen ovale from the left to the right atrium and mixing with the deoxygenated blood normally in the right atrium. Since the dysfunctional left ventricle in these patients is not able to supply the systemic circulation with blood, the patients rely on this abnormal right to left shunting of blood to supply oxygenated blood systemically. Reducing pulmonary hypertension will redirect blood flow from the right atrium into the lungs and away from the ductus arteriosus, cutting off the right to left shunt on which the patient depends for survival. Thus, iNO therapy which reduces pulmonary hypertension can be fatal to these patients. The Examiner does not dispute this logic.

On page 35 of 56, Appellant asserts that the Examiner has impermissibly picked and chosen only the LVD aspect of Atz & Wessel disclosure. The Examiner cannot agree. The Examiner has applied the appropriate section of the reference and Atz & Wessel do warn others of this problem. Atz et al. teach that: "*Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension.*" (page 452, left column). That is a pretty generic cautionary advisory provided by the reference especially when the patients include both adults and neonates with severe left ventricular dysfunction.

On page 35 of 56, Dr. Wessel is surprised that children with LVD who are not dependent on right to left shunting would be at increased risk of adverse events when administered iNO. The Examiner disagrees. There is nothing surprising here when the art already teaches that there

are inherent risks with iNO therapy and Atz & Wessel already caution against iNO use in neonates with severe LVD. The Examiner does not find this argument persuasive.

On page 37 of 56, Appellant asserts that the Examiner mischaracterizes the disclosure. The Examiner cannot agree for the reasons of record. Kinsella et al. is cited to demonstrate that it is known to exclude patients from studies as discussed above. Thus it is known in the art to exclude patients from therapy. The Examiner does not find this argument persuasive.

On page 40 of 56, Appellant asserts that the Examiner has grossly overgeneralized the reference of Loh et al. because Loh et al. is directed to adults and not neonates. This is not deemed persuasive because Loh et al. provide a guidepost which guides the artisan to the instantly claimed value. The correlation between LVD, PCWP value, iNO and adverse effects is already known in the art. The Examiner does not find this argument persuasive. The Examiner has considered the evidence of record between Adult and the instant populations and not found the evidence to be persuasive in this case.

On page 42 of 56, Appellant asserts that the Examiner's rejection is based on flawed and legally improper reasoning. The Examiner cannot agree. The Examiner has made a sound prima facie case of obviousness and Applicant's arguments are not persuasive for the reasons discussed here and already of record.

On page 42 of 56, Appellant did not understand the Examiner's statement. Let the Examiner clarify: In view of the cited references, there is no patentable subject matter.

On page 43 of 56, Appellant addresses the Examiner's motivation. Appellant re-argues points made previously and the Examiner's response is the same as above.

On page 45 of 56, Appellant asserts that the Examiner has not commented on any of the evidence supplied by Applicant. The Examiner strongly disagrees. The Examiner has thoroughly and thoughtfully considered all evidence supplied by Applicant as evidenced by the multiple Office Actions of record and weighed all the evidence and determined that the evidence is not persuasive for the reasons of record.

On page 46 of 56, Appellant states: "Resolution of this issue [of obviousness] entails a difficult process of turning back the clock to a time when the invention was made and asking **what one of ordinary skill in the art might have thought.**" This is what the Examiner has done. Given that Atz et al. teach that: "*Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension.*" (page 452, left column); and INOmax insert teaches adverse events associated with iNO therapy when administered to neonates, the only reasonable conclusion is that patients with LVD are at risk from adverse events from iNO therapy.

Contrary to Appellant's assertion at no point does the Examiner agree with any of Appellant's arguments.

On page 47 of 56, Appellant asserts that the prima facie case is fundamentally flawed. The Examiner cannot agree. The Examiner has presented the facts as known to the ordinary artisan at the time of the invention.

On page 49 of 56, Appellant makes arguments about what real world doctors would do. This is not relevant to patentability.

Appellant does not traverse the non-statutory obviousness type double patenting rejections (page 4 of 56).

**Summary:**

To bring the state of the art at the time of the invention into perspective:

- Administration of iNO is not without risk of adverse effects (INOmax®).
- Administration of iNO to neonates with LVD, predominantly left to right shunting at the foramen ovale and exclusively right to left shunting at the ductus arteriosus is warned against because of adverse outcomes (Atz et al.); and: \*\*\*“*Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension.*” (page 452, left column of Atz et al.).\*\*\*
- Neonates with congenital heart disease have already been excluded from iNO therapy (Kinsella et al.).
- Inhaled nitric oxide in patients with left ventricular dysfunction may have adverse effects in patients with LV failure (Loh et al.).

**The principles of law state:**

- A reference is good not only for what it teaches by direct anticipation but also for what one of ordinary skill in the art might reasonably infer from the teachings. (*In re Opprecht* 12 USPQ 2d 1235, 1236 (Fed Cir. 1989); *In re Bode* 193 USPQ 12 (CCPA) 1976).
- From MPEP 2141.03 I: “A person of ordinary skill in the art is also a person of ordinary creativity, not an automaton.” *KSR International Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 167 LEd2d 705, 82 USPQ2d 1385, 1397 (2007). “[I]n many cases a person of ordinary skill will be able to fit the teachings of multiple patents



together like pieces of a puzzle.” *Id.* Office personnel may also take into account “the inferences and creative steps that a person of ordinary skill in the art would employ.” *Id.* At 1396, 82 USPQ2d at 1396.

- From MPEP 2141.03 I: “The “hypothetical person having ordinary skill in the art’ to which the claimed subject matter pertains would, of necessity have the capability of understanding the scientific and engineering principles applicable to the pertinent art.” *Ex parte Hiyamizu*, 10 USPQ2d 1393, 1394 (Bd. Pat. App. & Inter. 1988)

Consequently, the art as a whole paints a picture that patients, including neonates, are at risk of adverse events from iNO therapy even if the iNO therapy is beneficial in other aspects and it remains obvious to one of ordinary skill in the art to exclude patients, including neonates, from iNO therapy to reduce the risk of occurrence of such adverse events. While the Examiner acknowledges the instant claims have a real world utility and can perhaps save the lives of neonates, the instant claims do not rise to the level of invention but rather remain on the plane of obvious to the person of ordinary skill in the art based on the art as a whole.

*In conclusion, while Appellant has performed routine research (INOT22 Study) and observed something that is worthy of publication in the medical literature, it does not however impart patentability to the instant method claims given the knowledge in the art as a whole at the time of the invention. In other words, good scientific research and beneficial contributions to the art do not necessarily result in patentability especially when, as is the case here, the prior art*

Art Unit: 1613

provides *specific* guidance and indicates that neonates with LVD are at risk of adverse events from iNO therapy. Respectfully, the Examiner cannot agree with any of Appellants arguments.

**(11) Related Proceeding(s) Appendix**

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner's answer.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

/Ernst V Arnold/

Primary Examiner, Art Unit 1613

Conferees:

1./Brian-Yong S Kwon/

Supervisory Patent Examiner, Art Unit 1613

2./Bennett Celsa/

Primary Examiner, TC1600

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : James S. Baldassarre et al. Art Unit : 1613  
Serial No. : 12/820,866 Examiner : Ernst V. Arnold  
Filed : June 22, 2010 Conf. No. : 2913  
Title : METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING  
HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR  
ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

REQUEST FOR ORAL HEARING

Under the provisions of 37 CFR §41.47(b), appellant respectfully requests an oral hearing in the appeal in this case. This request is being filed within two months after the date the Examiner's Answer was mailed (November 1, 2011). The required fee of \$620 is being paid concurrently herewith. Please apply any other necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: December 16, 2011

/Janis K. Fraser/  
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : James S. Baldassarre et al.                      Art Unit : 1613  
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**Mail Stop Appeal Brief - Patents**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

REPLY BRIEF

Appellant submits this Reply Brief in response to the Examiner's Answer dated November 1, 2011, and within the two-month period for reply specified in 37 CFR § 41.41(a)(1). The subject application is under Accelerated Examination.

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December 16, 2011

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Applicant : James S. Baldassarre et al.  
Serial No. : 12/820,866  
Filed : June 22, 2010  
Page : 2 of 21

Attorney's Docket No.: 26047-0003002 / 3000-US-  
0008CON

**I. Status of Claims**

The claims remain unchanged from the claims described in Appellant's Appeal Brief filed October 4, 2011 (the Appeal Brief). To wit:

Claims 1-27 are canceled.

Claims 28-42 are rejected and under appeal.

The Claims Appendix that was attached to the Appeal Brief as Appendix (viii) incorrectly designated each claim as "New", when in fact the claims should have been designated "Previously presented." In order to correct the record, a revised Claims Appendix with the proper claim designations is attached to this Reply Brief. Appellant apologizes for the error.

## **II. Ground of Rejection To Be Reviewed on Appeal**

The ground of rejection to be reviewed on appeal is as described in the Appeal Brief on page 4. The Examiner's Answer did not raise a new ground of rejection. As noted in the Appeal Brief at pages 4-5, the provisional rejections of the claims for nonstatutory obviousness-type double patenting are not contested insofar as they are applied to the claims as currently written, and will be addressed by the filing of appropriate Terminal Disclaimers if doing so is warranted at the time the present claims are otherwise deemed allowable. Accordingly, the Board of Patent Appeals and Interferences (the "Board") need not address the obviousness-type double patenting rejections at this time.

### **III. Argument**

#### **A. The Rejection ignores overwhelming real-world evidence that the claimed subject matter is non-obvious**

The issue on appeal is whether a person skilled in the art, presented with a patient who is a “term or near-term neonate in need of inhaled nitric oxide,”<sup>1</sup> would have found it obvious at the time of Appellant’s invention to withhold inhaled nitric oxide treatment because the patient was a member of the Claimed Patient Population, i.e., a term or near-term neonate that suffers from pre-existing left ventricular dysfunction (“LVD”) but is not known to be dependent on right-to-left shunting of blood. In the opening brief on appeal, Appellant cited mountains of un rebutted evidence that, for inhaled nitric oxide’s entire history as an approved drug (up to the time of Appellant’s invention), it was *not* the practice in the art to withhold this life-saving drug from the Claimed Patient Population. This evidence is summarized in the Appeal Brief at pages 6-8 and presented in more detail at pages 16-23.

Briefly, the evidence of record demonstrates the following:

1. Over 115 doctors, researchers, and regulatory officials responsible for designing and approving the INOT22 Study for inhaled nitric oxide did not raise any concerns about including the Claimed Patient Population in that study;<sup>2</sup>
2. The head of the committee that designed the protocol for that study (and senior author of the Atz & Wessel reference) did not predict there was any particular risk to the Claimed Patient Population from the administration of inhaled nitric oxide;<sup>3</sup>
3. The FDA did not recognize any risk to the Claimed Patient Population in the original INOmax® prescribing information or the INOT22 Study protocol, though a different risk to a distinct group of neonates (the Shunt-Reliant Population) was recognized by the FDA and prominently featured in the original prescribing information.<sup>4</sup>

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<sup>1</sup> See, e.g., amended claim 28.

<sup>2</sup> Appeal Brief at 6-8, 10-14, 16-19, and 21-22.

<sup>3</sup> *Id.* at 6-7, 17, and 35-36.

<sup>4</sup> *Id.* at 19-23.

The record also includes evidence that inhaled nitric oxide has been administered to hundreds of thousands of patients, and that the standard of care for administration of the drug did not, prior to Appellant's invention, exclude the Claimed Patient Population from receiving the drug on grounds of an increased likelihood of adverse events, or otherwise.<sup>5</sup> It further includes evidence that the FDA and other regulatory agencies around the world recognized the importance of Appellant's invention and modified the label for inhaled nitric oxide as a direct result of the surprising INOT22 Study results.<sup>6</sup>

Notably, the Examiner does not dispute any of the above facts. Rather, he dismisses all of Appellant's evidence on two grounds. First, he takes the remarkable position that real-world evidence need not be considered in evaluating obviousness:

... Appellant makes arguments about what real world doctors would do.  
***This is not relevant to patentability.***<sup>7</sup>

This is clear legal error. Far from being "not relevant to patentability," such evidence is considered highly probative by the courts, as the cases cited in Appellant's Appeal Brief demonstrate.<sup>8</sup> "A critical step in analyzing the patentability of claims pursuant to section 103(a) is casting the mind back to the time of invention, to consider the thinking of one of ordinary skill in the art, guided only by the prior art references ***and the then-accepted wisdom in the field.***"<sup>9</sup> Thus, evidence of what real world doctors did or did not do prior to Appellant's invention is directly probative of non-obviousness in this case. Indeed, objective evidence of non-obviousness "may be the most pertinent, probative, and revealing evidence available to aid in reaching a conclusion on the obvious/nonobvious issue."<sup>10</sup>

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<sup>5</sup> *Id.* at 10, 45 (drug administered to over 300,000 patients; citing a publication showing that inhaled nitric oxide is routinely (and successfully) used to treat neonates who have congenital heart disease in general).

<sup>6</sup> *Id.* at 13-14.

<sup>7</sup> Examiner's Answer at 24 (emphasis added).

<sup>8</sup> See, e.g., *Rosemount, Inc. v. Beckman Instruments, Inc.*, 727 F.2d 1540, 1546 (Fed. Cir. 1984) ("The objective evidence, again composed of real world facts, is worthy of great weight..."); *Panduit Corp. v. Dennison Mfg. Co.*, 774 F.2d 1082, 1099 (Fed. Cir. 1985) ("The human, real world story in evidence...not only reflects the inadequacy of the prior art, but compels a conclusion of nonobviousness of the claimed inventions in suit."). These cases were cited in the Appeal Brief at page 48.

<sup>9</sup> *In re Kotzab*, 217 F.3d 1365, 1369 (Fed. Cir. 2000) (internal citations omitted; emphasis added).

<sup>10</sup> *W.L. Gore & Assocs., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1555 (Fed. Cir. 1983).



Perhaps recognizing that a complete refusal to consider Appellant's objective evidence is contrary to law, the Examiner also presents a second, inconsistent, theory for discounting this evidence. The Examiner states:

Appellant appears to be under the impression that just because Appellant noticed increased adverse events due to iNO therapy in a subpopulation of neonates with LVD, *which is evidently surprising to the 115+ experts and 5 regulatory authorities* despite the warnings on the INOmax label, that this is patentable subject matter in view of the art as a whole. The Examiner strongly disagrees for at least the reasons of record and those presented here. While this finding is worthy of publication to inform the public, it does not rise to level of invention based on the preponderance of evidence in the art which was known at the time of the instant invention.<sup>11</sup>

Notably, the Examiner does not deny that the "115+ experts" described in the Appeal Brief<sup>12</sup> did, in fact, find the present invention to be surprising.<sup>13</sup> Nor is the Examiner arguing that physicians administered inhaled nitric oxide only because they were unaware of the INOmax® label and its table listing the rates of various adverse events. Indeed, the Examiner's Answer candidly admits that the table of adverse events was certainly known to the experts mentioned in Appellant's evidence: **"Certainly, all the experts must have been aware of such warnings<sup>14</sup> [in the table of adverse events in the 2007 INOmax® Insert] and therefore knew that iNO therapy carries with it inherent risk of adverse events."**<sup>15</sup>

Nevertheless, the Examiner persists in the extreme position that all of these experts negligently put the lives of children at risk in conducting the INOT 22 study and, more generally, that the standard of care applied by the entire medical community with respect to administration of inhaled nitric oxide between 1999 (when inhaled nitric oxide was first approved by the FDA)

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<sup>11</sup> Examiner's Answer at 17-18 (emphasis added).

<sup>12</sup> Appeal Brief, *e.g.*, at 13, 18-19, and 50-51.

<sup>13</sup> *See also* Examiner's Answer at 22-23 (citing Dr. Wessel's declaration testimony that he was, *as a matter of fact*, "surprised that children with LVD who are not dependent on right to left shunting would be at increased risk of adverse events when administered iNO" but disagreeing with Dr. Wessel because, in the Examiner's opinion "[t]here is nothing surprising here.").

<sup>14</sup> Although the Examiner characterizes the adverse events table in the 2007 INOmax® Insert as being a "warning," the reference itself does not so characterize it. Instead, the table is in a section titled "ADVERSE REACTIONS." A statement classified as a "warning" on a pharmaceutical label would be a far more serious and pointed statement of danger.

<sup>15</sup> *Id.* at 17 (emphasis added).

and 2009 (when the FDA added a warning to the INO label to educate doctors about Appellant's invention), constituted malpractice. According to the Examiner, all of the world's doctors, researchers, and regulatory officials *should have* read the cited prior art the way he does and *should have* recognized years before Appellant's invention that the Claimed Patient Population was at risk of increased adverse events from inhaled nitric oxide.<sup>16</sup> Put another way, to support a rejection of obviousness, the Examiner, using hindsight reasoning, claims to have identified disclosure within the medical literature that all of the world's doctors, researchers, and regulatory officials allegedly missed, and rejects as "not relevant to patentability" all of the evidence submitted by Appellant demonstrating that those experts did not read the prior art as the Examiner does now.

As discussed below, it is the Examiner who is misreading the cited references and finding in them a warning with respect to the Claimed Patient Population that is simply not there. Moreover, the relevance of the Examiner's view as to how those skilled in the art *should have* read the INOmax® label and the other cited references pales beside the evidence of record establishing how those skilled in the art *did in fact* understand that label and the state of the art generally.<sup>17</sup> This evidence demonstrates that those skilled in the art did not see any particularized warning in the INOmax® label or any other prior art with respect to the Claimed Patient Population and did not view the cited references as teaching that inhaled nitric oxide therapy should be withheld from that population. The Examiner cannot simply substitute his own judgment for that of the 115+ medical experts who clearly did not consider Appellant's invention to be obvious.

**B. The Rejection rests on the irrelevant and incorrect theory that the 2007 INOmax® label renders it obvious to refrain from treating *all* patients with inhaled nitric oxide (regardless how beneficial it might be to them)**

The first reference relied upon by the Examiner is the 2007 INOmax® Insert, the prescribing information for INOmax® nitric oxide gas provided in 2007 to physicians. This

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<sup>16</sup> *Id.* at 18.

<sup>17</sup> *See, e.g.*, Wessel Declaration.

reference says nothing about LVD or anything else pertinent to the Claimed Patient Population, and the Examiner does not assert that it does. Rather, the reference is relied upon for its table reporting rates of various adverse events observed in the so-called “CINRGI” clinical trial of inhaled nitric oxide—events unconnected to any identified subgroup of neonates.<sup>18</sup>

According to the Examiner, “this teaching” makes it obvious to withhold inhaled nitric oxide treatment from **all** patients in need of the treatment, in order to reduce the risk of **all** adverse events:

[T]he administration of iNO increases the risk of adverse events in neonates and consequently the ordinary artisan understands that by not administering iNO the risk of occurrence of adverse events is reduced as shown by the Table above.<sup>19</sup>

Consequently, it is not inventive to reduce the risk or occurrence of one or more adverse events associated with iNO therapy by excluding that patient from the therapy. In other words:

**No iNO therapy = no risk of adverse events occurring from the iNO therapy.**<sup>20</sup>

The Examiner's line of reasoning is flawed for two reasons:

**First**, even if it were correct, this line of reasoning would prove too much, i.e., it would prove that it was obvious to withhold inhaled nitric oxide treatment from **all** patients. But the claims do not call for treatment to be withheld from **all** patients. Rather, they require that the exclusion be deliberately limited to patients that have pre-existing LVD.

This flaw in the Examiner's reasoning is best illustrated by independent claim 37 which recites both **withholding treatment** from a patient who has pre-existing LVD, and **administering treatment** to a second patient who does **not** have pre-existing LVD. Given the Examiner's fundamental assumption that it is obvious to exclude **all** patients (regardless of their condition) from treatment with inhaled nitric oxide in order to avoid **all** risk of adverse events, it is not at all clear why the Examiner also believes that a physician of ordinary skill would have found it obvious to discriminate between patients, treating some and not others.

<sup>18</sup> Examiner's Answer at 6. The Examiner's Answer also cites to and quotes from a second study, the NINOS study. *Id.* at 6-7. It is not clear why the Examiner cites to this study, since it found that treatment with inhaled NO resulted in fewer deaths than control and, thus, contradicts the Examiner's point. *Id.*

<sup>19</sup> *Id.* at 7 (original emphasis omitted).

<sup>20</sup> *Id.* at 17 (emphasis in the original).

**Second**, the Examiner's contention that it would have been obvious to persons skilled in the art to withhold inhaled nitric oxide from all patients fails the logic test and is obviously contrary to fact. The claims all specify that the neonate patient is "in need of inhaled nitric oxide treatment," which typically means the patient is suffering from acute pulmonary hypertension and at risk of dying if that condition is not quickly relieved. A person of ordinary skill in the art would *of course* take the patient's need for this potentially lifesaving treatment into account when deciding whether to treat these very ill neonates or to refrain from doing so because of a desire to eliminate all risk of the relatively minor adverse events listed in the 2007 INOmax® Insert. In weighing and balancing the risks and benefits of inhaled nitric oxide, persons of skill in the art would certainly consider the disclosure in the 2007 INOmax® Insert that fewer neonates with hypoxic respiratory failure in the NINOS trial who were treated with inhaled nitric oxide died, compared with those given a control treatment:<sup>21</sup> *i.e., inhaled nitric oxide improved survival of these very ill newborns*. They would also consider the 2007 INOmax® Insert's disclosure that inhaled nitric oxide treatment reduces the need to place patients on ECMO to save their lives, with its attendant trauma and risk.<sup>22</sup> Given the significant benefits of inhaled nitric oxide to patients in need of such treatment, it is not fair to conclude that a doctor treating a patient would consider it obvious to withhold this lifesaving, ECMO-sparing therapy from all patients merely because the therapy was at some point reported to be associated with a slightly increased rate of an adverse event.<sup>23</sup> This is evident from the fact that real world doctors *do* administer inhaled nitric oxide to patients, despite the risks identified in the INOmax® label. Accordingly, the Examiner's sweeping and conclusory statement that it would have been obvious to withhold nitric oxide therapy from all patients in order to decrease the risk of adverse events is simply incorrect.<sup>24</sup>

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<sup>21</sup> *Id.* at 6.

<sup>22</sup> 2007 INOmax® Insert at 1, column 2 (disclosing data from the NINOS and CINRGI studies proving that treatment with inhaled nitric oxide significantly reduces the need to resort to what had been the standard treatment for life-threatening pulmonary hypertension in neonates, extracorporeal membrane oxygenation, or "ECMO," a highly invasive procedure in which blood is pumped out of the body and oxygenated by a machine).

<sup>23</sup> Appeal Brief at 49.

<sup>24</sup> Examiner's Answer at 26.

Appellant realizes that the Examiner's obviousness rejection is based on multiple references, not just the 2007 INOmax® Insert. However, a fundamental basis for the rejection appears to be the Examiner's assumption that the disclosures in the 2007 INOmax® Insert make it obvious to exclude *all* patients from treatment with inhaled nitric oxide, regardless of what conditions they may have, and regardless of how desperately they need the treatment to survive. *See, e.g.*, the Final Office Action dated August 24, 2011 (the "Final Office Action"), which (tellingly) asserts:

In other words, it does not matter if the neonate has a foot fungus, is polydactyly or has pre-existing left ventricular dysfunction because the risk of occurrence of adverse events from iNO therapy will be reduced if the patient is excluded from iNO therapy.<sup>25</sup>

It cannot, of course, be disputed that one sure way to avoid *all* adverse events from inhaled nitric oxide (or any drug) is to withhold *all* treatment of that drug. But that fact does not make it obvious to withhold the drug from patients "in need of" such treatment and, in any event, has no bearing whatsoever on the patentability of the present claims.

**C. The Examiner's reliance on the Atz & Wessel reference is contrary to both law and fact**

The dispute between Appellant and the Examiner with respect to the Atz & Wessel reference centers on one paragraph, found at page 452, left column of that reference.<sup>26</sup> At pages 29-37 of the Appeal Brief, Appellant discusses this paragraph at length and explains how it relates exclusively to two particular patient populations that are not the subject of the present claims. These are (i) adults with ischemic cardiomyopathy who may experience pulmonary edema when nitric oxide relieves their pulmonary hypertension (referred to in the Appeal Brief as the Adult Population); and (ii) newborns who exhibit a *simultaneous combination of the following three conditions*: severe LVD, predominantly left-to-right shunting at the foramen ovale, and exclusively right-to-left shunting at the ductus arteriosus. The Appeal Brief further

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<sup>25</sup> Final Office Action at 13.

<sup>26</sup> Andrew M. Atz & David L. Wessel, *Inhaled Nitric Oxide in the Neonate with Cardiac Disease*, 21 *Seminars in Perinatology* 441, 452 (Harvard Medical School 1997).

explains in detail how the physiology of each of these two patient populations is entirely distinct from that of the Claimed Patient Population and why the known risks of adverse events in these two patient populations would not lead one of ordinary skill in the art to predict similar adverse events in the Claimed Patient Population.<sup>27</sup>

Based on the Examiner's Answer, it does not appear that the Examiner disputes Appellant's position with respect to those parts of the cited Atz & Wessel paragraph that relate to the adult population. The Examiner does, however, sharply disagree with Appellant's views concerning the remainder of this paragraph. According to the Examiner:

Applicant interprets that the "caution" of the reference is explicitly limited to neonates who present with a combination of three conditions. Respectfully, the Examiner cannot agree to this narrow interpretation of the reference. The left ventricular dysfunction of the newborn is predominantly left to right shunting at the foramen ovale and exclusively right-to-left shunting at the ductus arteriosus. Thus, the plain and ordinary meaning of the previous sentence is: mostly or mainly are left to right shunting at the foramen ovale and limited to right to left shunting at the ductus arteriosus. The Examiner does not see how the newborn has to have 3 conditions when only two conditions are discussed which appear to be exclusive of one another. In other words, if the newborn has right to left shunting at the ductus arteriosus that does not necessarily mean the newborn has to also have left to right shunting at the foramen ovale. In any event, the previous teaching that: "*Caution should be exercised when administering NO to patients with severe left ventricular dysfunction and pulmonary hypertension.*" (page 452, left column) trumps all else as patients includes both adults and neonates.<sup>28</sup>

Thus, the Examiner rejects Appellant's explanation of Atz & Wessel on two grounds. First, the Examiner reads the part of the reference that concerns newborns as disclosing what he (incorrectly) interprets to be two independently-occurring forms of left ventricular dysfunction, "predominantly left-to-right shunting at the foramen ovale" and "exclusively right-to-left shunting at the ductus arteriosus," and as cautioning against the administration of inhaled nitric oxide to patients with either form.<sup>29</sup> Second, the Examiner contends that the above-quoted paragraph's broad introductory sentence (i.e., "Caution should be exercised when administering

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<sup>27</sup> Appeal Brief at 29-34.

<sup>28</sup> *Id.* at 21 (emphasis in original).

<sup>29</sup> *Id.* ("The left ventricular dysfunction of the newborn is predominantly left to right shunting at the foramen ovale and exclusively right-to-left shunting at the ductus arteriosus;" "only two conditions are discussed [in the above-quoted sentence]" (emphasis added))

nitric oxide to patients with severe left ventricular dysfunction and pulmonary hypertension”) would have been understood by those skilled in the art as a general warning that inhaled nitric oxide should be used with caution in *all* patients suffering from left ventricular dysfunction. As discussed below, the Examiner’s first argument is wrong as a matter of fact and his second argument is wrong as both a matter of law and fact.

**(a) The Examiner’s interpretation of Atz & Wessel’s disclosure concerning newborns is wrong as matter of fact.** The Examiner’s contention that Atz & Wessel’s disclosure concerning newborns is directed to *all* newborns with LVD is wrong for at least the following five reasons:

*First*, the plain meaning of the above-quoted language from Atz & Wessel contradicts the Examiner’s view and is consistent with that of Appellant. For example, the reference states:

Therefore, in newborns with severe left ventricular dysfunction, predominantly left to right shunting at the foramen ovale *and* exclusively right to left shunting at the ductus arteriosus, NO should be used with extreme caution, if at all.<sup>30</sup>

Note the emphasized word “and” in the quoted sentence. Choice of this conjunction rather than “or” demonstrates that Atz & Wessel is saying it is the *combination of all three conditions* that results in the newborns’ dependence on the right-to-left shunt at the ductus arteriosus and leaves the newborns at risk of systemic collapse when treated with inhaled nitric oxide. Furthermore, the “therefore” at the beginning of this sentence links (a) the caution expressed for patients with this combination of three conditions to (b) the problems outlined in the preceding two sentences: i.e., that these patients rely on their right-to-left shunt to maintain systemic circulation and that selective vasodilation caused by inhaled nitric oxide may impair that circulation in a newborn who has the combination of all three conditions, which together result in a circulatory system dependent on the right-to-left shunt at the ductus arteriosus. Thus, as Atz & Wessel clearly explains, the crux of the inhaled nitric-oxide-treatment problem for these neonates is not the risk of harmfully augmenting preload in the dysfunctional left ventricle and thereby triggering pulmonary edema (as seen in adults with the adult form of LVD), but

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<sup>30</sup> Atz & Wessel at 452 (emphasis added).

rather is the neonates' precarious dependence on the right-to-left shunt across the patent ductus arteriosus, a shunt that is maintained only as long as the lungs remain vasoconstricted. Using inhaled nitric oxide to dilate the pulmonary vasculature in this set of neonates may redirect the flow of blood to the lungs and away from the ductus arteriosus, reducing the right-to-left shunting of blood on which their systemic circulation relies.<sup>31</sup> This can result in systemic collapse and death.

That Atz & Wessel are referring to a single subpopulation of newborns is further confirmed by the paragraph's final sentence which states:

We and others have reported adverse outcomes *in this circumstance*.<sup>32</sup>

Note the phrasing "in this circumstance." The "circumstance" to which the sentence refers is, of course, the circumstance described in the preceding sentence, i.e., when a newborn who has the combination of all three conditions (and so whose systemic circulation is dependent on maintaining the right-to-left shunt at the ductus arteriosus) is treated with inhaled nitric oxide and suffers an adverse outcome (i.e., collapse of systemic circulation) as a result. If Atz and Wessel had intended to communicate that adverse outcomes were observed in neonates who have any one or two of the three conditions (i.e., in multiple possible circumstances), they would not have used the singular term "this circumstance."

**Second**, The Examiner's reading of Atz & Wessel is contradicted by declaration testimony from that reference's senior author: Dr. David Wessel. Dr. Wessel was so disturbed by what he viewed as the Examiner's misinterpretation of his article as encompassing *all* LVD patients that he provided a declaration to clarify the record regarding what was known in the art and communicated by his article. As explained by Dr. Wessel:

Neither the Atz et al. article that I co-authored [i.e., Atz & Wessel], nor the medical literature or medical experience of which I was aware at the time, predict this risk [i.e., that a child with LVD who is not dependent on right-to-left shunting of blood would be at particular risk when treated with inhaled nitric oxide]. Instead, Atz et al. describes two distinct, independent precautions with respect to the use of iNO. First, with respect to adults, Atz et al. stated that iNO may be more effective in newborns than in older patients, and noted that it should

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<sup>31</sup> Appeal Brief at 33-34; *see also* Examiner's Answer at 22.

<sup>32</sup> Atz & Wessel at 452 (emphasis added).



be used with caution in adults with ischemic cardiomyopathy in whom a risk of pulmonary edema is a consideration (see page 452, left column). Second, with respect to neonates, we stated the well-known contraindication (currently found in the INOMAX® prescribing information) that iNO should not be used in newborns dependent upon right-to-left shunting of blood across a patent ductus arteriosus to avoid circulatory collapse. What we did **not** disclose or predict was that neonatal patients with left ventricular dysfunction who are not dependent on right-to-left shunting of blood would be at greater risk of adverse events.<sup>33</sup>

*Third*, Appellant's understanding of Atz & Wessel is confirmed by the fact that the sole contraindication or other warning appearing on the INOMax® product insert prior to the present invention is limited to the Shunt-Reliant Population: "INOMax should not be used in the treatment of neonates known to be dependent on right-to-left shunting of blood."<sup>34</sup> If Atz & Wessel had in 1997 described a risk to neonates other than the Shunt-Reliant Population, this additional risk would have been made explicit on the product insert long before the point when it was actually added (in 2009, in response to Appellant's invention).<sup>35</sup>

*Fourth*, the Examiner is simply wrong in his apparent assumptions that "predominantly left-to-right shunting at the foramen ovale" and "exclusively right-to-left shunting at the ductus arteriosus" are different examples of LVD and that these two conditions are "exclusive of each other." That his assumption that they are forms of LVD is in error is evident from the fact that neither the foramen ovale nor the ductus arteriosus is part of the left ventricle. As explained in the Appeal Brief, LVD in a newborn means the infant has a soft, overly elastic left ventricle that cannot push blood out, resulting in impaired emptying.<sup>36</sup> In contrast, the two "shunting" conditions mentioned by Atz & Wessel involve structures of the heart separate from the left ventricle, and cannot in any way be characterized as forms of LVD. The foramen ovale is a hole between the left atrium and right atrium of the heart that, when it remains abnormally open after birth, permits blood to flow ("shunt") between the two atria.<sup>37</sup> The ductus arteriosus is a

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<sup>33</sup> Wessel Declaration ¶ 7 (emphasis in original).

<sup>34</sup> 2007 INOMax® Insert at 2, column 1 ("Contraindications"). The risk to the Adult Population is not addressed on the product insert because the only FDA-approved indication is in neonates.

<sup>35</sup> Appeal Brief at 22-23.

<sup>36</sup> *Id.* at 30.

<sup>37</sup> *Id.* at 33.

passageway between the right atrium and the systemic circulation that, when it remains abnormally open after birth, permits blood to flow (“shunt”) from the right atrium directly into the systemic circulation associated with the left side of the heart.<sup>38</sup> The particular foramen ovale condition mentioned in Atz & Wessel involves a flow of blood through the foramen ovale predominantly from the left atrium to the right atrium (i.e., “predominantly left to right”). The ductus arteriosus condition mentioned in the reference involves shunting through the ductus arteriosus that is exclusively in one direction, from the right atrium to the systemic circulation on the left side of the heart (i.e., “exclusively right to left”). Contrary to the Examiner’s position, ***neither shunting condition is a form of LVD***. Furthermore, the two shunting conditions are not “exclusive of each other.” To the contrary, they can and do co-exist, such as in neonates of the Shunt-Reliant Population. As explained in the Appeal Brief at pages 18-19, the two shunts can work in tandem in the Shunt-Reliant Population to create a flow of blood from the left atrium to the right atrium through the foramen ovale, and then from the right atrium to the systemic circulation through the ductus arteriosus.

***Fifth***, Appellant’s interpretation of Atz & Wessel is fully consistent with and confirmed by the detailed technical description of the relevant physiology provided in the Appeal Brief at pages 32-34. The Examiner’s Answer responded to Appellant’s technical description of the physiology of the Shunt Reliant Population with the remark, “The Examiner does not dispute the physiology.”<sup>39</sup> However, the Examiner’s Answer does not explain why the distinct physiology of the Shunt-Reliant Population did not inform the Examiner’s interpretation of Atz & Wessel, nor compel withdrawal of the rejection.

For all of the above reasons, the Examiner’s interpretation of Atz & Wessel as issuing a “caution” for ***all*** neonates who have severe LVD (an interpretation that permeates the entire Examiner’s Answer) is not supported by the facts. Rather, the “caution” regarding newborns expressed by Atz & Wessel relates solely to those presenting with a combination of ***all three*** of the listed conditions. Such newborns are reliant for survival on their right-to-left shunt through

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<sup>38</sup> *Id.*

<sup>39</sup> Examiner’s Answer at 21.

the ductus arteriosus, and so correspond to the “Shunt-Reliant Population” that is excluded from the present claims.

**(b) The Examiner’s attempt to improperly read one sentence of Atz & Wessel’s disclosure out of context is contrary to law and fact.** As noted above, the Examiner takes the position that, regardless of how one interprets Atz & Wessel’s disclosure concerning newborns, Appellant’s claims are nevertheless rendered obvious by that reference because the lead-in sentence that Atz & Wessel uses to introduce a more specific discussion of that population and the Adult Population refers generally to patients with LVD, so “trumps” all else in the reference. This position is contrary to both law and fact.

It is black letter law that a reference must be considered *in its entirety*.<sup>40</sup> “It is impermissible within the framework of section 103 to pick and choose from any one reference only so much of it as will support a given position to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one skilled in the art.”<sup>41</sup>

This black letter law is inconsistent with the Examiner’s assertion that one particular sentence, taken out of the context that explains it, “trumps all else.”<sup>42</sup> The Examiner is not permitted to dismiss all of the teachings of Atz & Wessel that are inconsistent with his “fact finding” as somehow being irrelevant to the question of obviousness. As demonstrated above, a careful reading of Atz & Wessel’s entire disclosure from the perspective of persons skilled in the art demonstrates that this one sentence would not be (and was not) understood as “trumping all else” in the reference and thereby teaching those skilled in the art to withhold inhaled nitric oxide treatment from all neonates with LVD.

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<sup>40</sup> *Bausch & Lomb, Inc. v. Barnes-Hind/Hydrocurve, Inc.*, 796 F.2d 443, 448 (Fed. Cir. 1986) (quoting *In re Wesslau*, 353 F.2d 238, 241 (C.C.P.A. 1965); *Medicis Pharm. Corp. v. Acella Pharms. Inc.*, 2011 WL 5321007 at \*5 n.2 (D. Ariz. Nov. 3, 2011) (“The Court should consider prior art references as a whole to determine their teachings.”) (citing *Bausch & Lomb*, 796 F.2d at 448-49); *Armament Sys. & Procs., Inc. v. Monadnock Lifetime Prods., Inc.*, 1998 WL 537746 at \*8 (Fed. Cir. 1998) (“a reference must be considered as a whole, including the portions that argue against or teach away from the claimed invention.”) (citing *Bausch & Lomb*, 796 F.2d at 448); *Westek Assocs. v. Tri-Lite Elecs., Inc.*, 722 F.Supp. 474, 481 (N.D. Ill. 1989) (same, quoting *Bausch & Lomb*, 796 F.2d at 448); *In re Halley*, 296 F.2d 774, 778 (C.C.P.A. 1961) (“it is proper for this court to study the whole of the various references in the record”).

<sup>41</sup> *Bausch & Lomb*, 796 F.2d at 448 (quoting *In re Wesslau*, 353 F.2d at 241).

<sup>42</sup> Examiner’s Answer at 21.

To the contrary, given the fact that inhaled nitric oxide is a life-saving drug with the potential to spare one's neonate patients a highly invasive alternative treatment such as ECMO, one of skill in the art who is intent on determining who is and isn't at risk from inhaled nitric oxide treatment would have reviewed the entire Atz & Wessel reference *very carefully* to ensure that he or she understood exactly what populations Atz & Wessel were addressing so that inhaled nitric oxide therapy would not be withheld unnecessarily from patients who "are in need of treatment."

As a factual matter, Appellant has already demonstrated beyond any shred of doubt that those skilled in the art *did not* understand the broad introductory sentence relied on by the Examiner as a general caution relating to all patients with LVD. The unrebutted record evidence supporting this conclusion includes the 2007 INOmax® insert, whose warning with respect to neonates was directed only to those dependent on a right-to-left shunt, and declaration testimony regarding the behavior of expert physicians in designing a clinical protocol for inhaled nitric oxide years after Atz & Wessel was published.

It is telling that the Examiner has provided no factual evidence whatsoever to indicate that those of ordinary skill in the art actually interpreted Atz & Wessel's caution as applying to *all* neonates with LVD. Given the importance of safety considerations to physicians who treat neonates, one would suppose that a discovery that inhaled nitric oxide is dangerous to all neonates with LVD would have been pointedly discussed in the literature, or at least mentioned on the product insert for the INOmax® product, within a short time after the Atz & Wessel review appeared in print (in 1997), and would have been taken into account when the 2004 INOT 22 clinical trial protocol for inhaled nitric oxide was designed.<sup>43</sup>

Further, if Atz & Wessel had indeed intended to communicate that *all* patients with LVD were at heightened risk from inhaled nitric oxide treatment, this reference would have explained why neonates who have LVD but are *not* dependent on a right-to-left shunt at the ductus arteriosus are at risk, rather than focusing solely on two other populations: adults with LVD and neonates who are dependent on the right-to-left shunt. The Examiner does not explain why a

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<sup>43</sup> Appeal Brief at 10-14.

single sentence of Atz & Wessel, taken out of context, "trumps" not only all the rest of the reference and all of the evidence of record, but also common sense.

**D. The Examiner's reliance on Kinsella et al. and Loh et al. is without merit**

The Examiner's arguments with respect to the Kinsella et al. and Loh et al. references are the same in the Examiner's Answer as in the Final Office Action and are fully addressed by Appellant in the Appeal Brief. Appellant respectfully directs the Board to pages 37-42 of the Appeal Brief for a discussion of those references.

**CONCLUSION**

As discussed above and in the Appeal Brief, the Examiner's obviousness rejection in this case rests on a number of factual and legal errors. In view of these specific errors of fact and law, Appellant respectfully urges the Board to reverse the Examiner's obviousness rejection.

A revised Claims Appendix is attached.

A request for an oral hearing is being submitted separately.

Please apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: December 16, 2011

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**(viii) Claims Appendix (Revised)**

The claims below are identical to those in the Claims Appendix appended to the Appeal Brief, except that the designations have been changed from “New” to “Previously presented.”

1.-27. (Canceled)

28. (Previously presented) A method of reducing the risk of occurrence, in a term or near-term neonate patient, of one or more adverse events or serious adverse events associated with a medical treatment comprising inhalation of nitric oxide gas, said method comprising:

(a) identifying a term or near-term neonate patient in need of inhaled nitric oxide treatment, wherein the patient is not known to be dependent on right-to-left shunting of blood;

(b) determining that the patient identified in (a) has pre-existing left ventricular dysfunction; and

(c) excluding the patient from inhaled nitric oxide treatment based on the determination that the patient has pre-existing left ventricular dysfunction.

29. (Previously presented) The method of claim 28, wherein the patient has pulmonary hypertension.

30. (Previously presented) The method of claim 28, wherein the patient has a pulmonary capillary wedge pressure that is greater than or equal to 20 mm Hg.

31. (Previously presented) The method of claim 28, wherein the patient is a term neonate.

32. (Previously presented) A method of reducing the risk of occurrence, in a term or near-term neonate patient, of one or more adverse events or serious adverse events associated with a medical treatment comprising inhalation of nitric oxide gas, said method comprising:

- (a) identifying a term or near-term neonate patient in need of inhaled nitric oxide treatment, wherein the patient is not known to be dependent on right-to-left shunting of blood;
- (b) determining by diagnostic screening that the patient identified in (a) has pre-existing left ventricular dysfunction; and
- (c) excluding the patient from treatment with inhaled nitric oxide based on the determination that the patient has pre-existing left ventricular dysfunction.

33. (Previously presented) The method of claim 32, wherein the diagnostic screening comprises echocardiography.

34. (Previously presented) The method of claim 32, wherein the patient has pulmonary hypertension.

35. (Previously presented) The method of claim 32, wherein the patient has a pulmonary capillary wedge pressure that is greater than or equal to 20 mm Hg.

36. (Previously presented) The method of claim 32, wherein the patient is a term neonate.

37. (Previously presented) A method of reducing the risk of occurrence, in a plurality of term or near-term neonate patients, of one or more adverse events or serious adverse events associated with medical treatment comprising inhalation of nitric oxide gas, said method comprising:

- (a) identifying a plurality of term or near-term neonate patients who are in need of inhaled nitric oxide treatment, wherein the patients are not known to be dependent on right-to-left shunting of blood;
- (b) determining that a first patient of the plurality has pre-existing left ventricular dysfunction and a second patient of the plurality does not;
- (c) administering the inhaled nitric oxide treatment to the second patient; and
- (d) excluding the first patient from treatment with inhaled nitric oxide, based on the determination that the first patient has pre-existing left ventricular dysfunction.

38. (Previously presented) The method of claim 37, wherein the first and second patients have pulmonary hypertension.

39. (Previously presented) The method of claim 37, wherein the second patient has congenital heart disease.

40. (Previously presented) The method of claim 37, wherein the first patient has a pulmonary capillary wedge pressure that is greater than or equal to 20 mm Hg.

41. (Previously presented) The method of claim 37, wherein the first and second patients are term neonates.

42. (Previously presented) The method of claim 37, wherein determining that the first patient of the plurality has pre-existing left ventricular dysfunction and the second patient of the plurality does not have pre-existing left ventricular dysfunction comprises diagnostic screening.



## Electronic Patent Application Fee Transmittal

<b>Application Number:</b>	12820866			
<b>Filing Date:</b>	22-Jun-2010			
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION			
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre			
<b>Filer:</b>	Janis K. Fraser/Paul Micele			
<b>Attorney Docket Number:</b>	26047-0003002			
Filed as Small Entity				
<b>Utility under 35 USC 111(a) Filing Fees</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent Appeals-and-Interference:</b>				
Request for oral hearing	2403	1	620	620
<b>Post-Allowance-and-Post-Issuance:</b>				
<b>Extension-of-Time:</b>				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
<b>Miscellaneous:</b>				
<b>Total in USD (\$)</b>				<b>620</b>

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	11642833
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	94169
<b>Filer:</b>	Janis K. Fraser/Stacey Hill
<b>Filer Authorized By:</b>	Janis K. Fraser
<b>Attorney Docket Number:</b>	26047-0003002
<b>Receipt Date:</b>	16-DEC-2011
<b>Filing Date:</b>	22-JUN-2010
<b>Time Stamp:</b>	17:05:28
<b>Application Type:</b>	Utility under 35 USC 111(a)

### Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	\$620
RAM confirmation Number	4328
Deposit Account	061050
Authorized User	

### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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1	Request for Oral Hearing	OralHearing.pdf	42430 5904ddcbf4ac8d06f0ffa20288de139513b12563	no	1
<b>Warnings:</b>					
<b>Information:</b>					
2	Reply Brief Filed	ReplyBrief.pdf	220334 0a7df9274b88a964cd8fb437b28c60645318054a	no	21
<b>Warnings:</b>					
<b>Information:</b>					
3	Fee Worksheet (SB06)	fee-info.pdf	30725 a6b1ee842a0782831fc7168a9abe5498a6ae3e0b	no	2
<b>Warnings:</b>					
<b>Information:</b>					
<b>Total Files Size (in bytes):</b>			293489		
<p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>  <b>If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</b></p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>  <b>If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</b></p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>  <b>If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</b></p>					

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : James S. Baldassarre et al.                      Art Unit : 1613  
Serial No. : 12/820,866    Examiner : Ernst V. Arnold  
Filed : June 22, 2010    Conf. No. : 2913  
Title : METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING  
HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR  
ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION

**Mail Stop Appeal Brief – Patents**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

SUPPLEMENT TO THE REPLY BRIEF

On December 16, 2011, Appellant filed a Reply Brief in response to the Examiner’s Answer dated November 1, 2011. Following submission of that Reply Brief, Appellant became aware that the technical description of neonatal cardiac physiology provided on pages 14-15 of the Reply Brief, and similarly on pages 33-34 of the Appeal Brief filed October 4, 2011, was not entirely accurate. Although the discrepancy does not in any way affect the arguments provided in the Appeal Brief and Reply Brief, Appellant wishes to clarify the record to prevent possible confusion.

The text at issue concerns the description of a neonatal cardiac structure referred to as the “ductus arteriosus,” which was originally described in the Reply Brief and Appeal Brief as being a passageway between the right atrium and the systemic circulation, when in fact it is between the pulmonary artery and the systemic circulation.

The affected text from the Reply Brief filed December 16, 2011, begins with the last (partial) sentence on page 14 (“The ductus arteriosus is a...”) and ends at the end of the first paragraph on page 15. The corrected version follows.

CERTIFICATE OF (A) MAILING BY FIRST CLASS MAIL OR (B) TRANSMISSION  
I hereby certify under 37 CFR §1.8(a) that this correspondence is either (A) addressed as set out in 37 CFR §1.1(a) and being deposited with the United States Postal Service as first class mail with sufficient postage, or (B) being transmitted by facsimile in accordance with 37 CFR § 1.6(d) or via the Office electronic filing system in accordance with 37 CFR § 1.6(a)(4), on the date indicated below.

January 3, 2012

\_\_\_\_\_  
Date of Deposit or Transmission

/Nancy Bechet/

\_\_\_\_\_  
Signature

Nancy Bechet

\_\_\_\_\_  
Typed or Printed Name of Person Signing Certificate

The ductus arteriosus is a passageway between the pulmonary artery exiting the right ventricle and the systemic circulation that, when it remains abnormally open after birth, permits blood to flow (“shunt”) from the right heart directly into the systemic circulation, bypassing the left side of the heart. The particular foramen ovale condition mentioned in Atz & Wessel involves a flow of blood through the foramen ovale predominantly from the left atrium to the right atrium (i.e., “predominantly left to right”). The ductus arteriosus condition mentioned in the reference involves shunting through the ductus arteriosus that is exclusively in one direction, from the pulmonary artery exiting the right side of the heart directly into the systemic circulation exiting the left side of the heart (i.e., “exclusively right to left”). Contrary to the Examiner’s position, ***neither shunting condition is a form of LVD***. Furthermore, the two shunting conditions are not “exclusive of each other.” To the contrary, they can and do co-exist, such as in neonates of the Shunt-Reliant Population. As explained in the Appeal Brief at pages 33-34, the two shunts can work in tandem in the Shunt-Reliant Population to create a flow of blood from the left atrium to the right atrium through the foramen ovale, and then from the right atrium through the right ventricle, which pumps the blood on into the pulmonary artery and from there through the open ductus arteriosus to the systemic circulation.

The affected text from the Appeal Brief filed October 4, 2011, begins at page 33, line 12, and ends at page 34, line 6. The corrected text is as follows:

The First Greene Declaration explains that this condition occurs in neonates who have a particular combination of congenital conditions including, in addition to pulmonary hypertension: (a) an open (or “patent”) ductus arteriosus (a passageway between the pulmonary artery exiting the right ventricle of the heart and the systemic circulation that is supposed to close at birth, when it is no longer needed); (b) a patent foramen ovale (a hole between the right and left atria that, like the ductus arteriosus, is supposed to close shortly after birth, when it is no longer needed); and (c) a dysfunctional left ventricle that is unable to handle its usual role of pumping blood through the systemic circulation. As noted by Dr. Greene, the pulmonary hypertension and resulting high vascular resistance in the lungs of these infants means that the blood pressure in the right side of the heart is kept abnormally high. This forces blood from the pulmonary artery through the still-patent ductus arteriosus and directly into the systemic circulation, a situation known as “right-to-left shunting of blood.” This blood entering the systemic circulation from the

pulmonary artery (via the ductus arteriosus) is partially oxygenated by virtue of oxygenated blood leaking through the patent foramen ovale from the left to the right atrium and mixing with the deoxygenated blood normally in the right atrium. Because the dysfunctional left ventricle in these patients is not able to supply the systemic circulation with blood, the patients end up relying on this abnormal right-to-left shunting of blood to keep a life-sustaining level of partially oxygenated blood flowing through their systemic circulation. *If the right-to-left shunt ceases for any reason, and there is no compensating mechanism to supply blood to the systemic circulation, the result would be catastrophic: total systemic circulatory collapse—and death.* In these infants, reducing pulmonary hypertension by treatment with inhaled nitric oxide will redirect blood flow into the lungs and away from the ductus arteriosus, cutting off the right-to-left shunt on which the patient desperately depends for survival.

Appellant apologizes for the technically inaccurate descriptions provided in the Appeal Brief and Reply Brief as filed.

The deadline for filing a Reply to the Examiner's Answer in this appeal is January 3, 2012 (January 1 and 2, 2012, being a Sunday and a Federal holiday, respectively). This Supplement to the Reply Brief is therefore being filed via EFS prior to that deadline.

Any necessary charges may be applied to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: January 3, 2012

/Janis K. Fraser/

Janis K. Fraser, Ph.D., J.D.  
Reg. No. 34,819

Customer Number 94169  
Fish & Richardson P.C.  
Telephone: (617) 542-5070  
Facsimile: (877) 769-7945

22766597.doc

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	11748717
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	94169
<b>Filer:</b>	Janis K. Fraser/Nancy Bechet
<b>Filer Authorized By:</b>	Janis K. Fraser
<b>Attorney Docket Number:</b>	26047-0003002
<b>Receipt Date:</b>	03-JAN-2012
<b>Filing Date:</b>	22-JUN-2010
<b>Time Stamp:</b>	16:18:16
<b>Application Type:</b>	Utility under 35 USC 111(a)

### Payment information:

Submitted with Payment	no
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### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Supplemental Response or Supplemental Amendment	supplementalreply0003002.pdf	109400 <small>fb942b629f0180d0157b05512fbf1c269b93389</small>	no	3

### Warnings:

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Total Files Size (in bytes):

109400

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**New Applications Under 35 U.S.C. 111**

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/820,866	06/22/2010	James S. Baldassarre	26047-0003002	2913

94169 7590 01/06/2012  
Fish & Richardson PC  
P.O.Box 1022  
minneapolis, MN 55440

EXAMINER
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ARNOLD, ERNST V

ART UNIT	PAPER NUMBER
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1613

MAIL DATE	DELIVERY MODE
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01/06/2012

PAPER

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<b>APPLICATION NO./ CONTROL NO.</b>	<b>FILING DATE</b>	<b>FIRST NAMED INVENTOR / PATENT IN REEXAMINATION</b>	<b>ATTORNEY DOCKET NO.</b>
12/820,866	22 June, 2010	BALDASSARRE ET AL.	26047-0003002

Fish & Richardson PC P.O.Box 1022 minneapolis, MN 55440	<b>EXAMINER</b>	
	ERNST ARNOLD	
	<b>ART UNIT</b>	<b>PAPER</b>
	1613	20120105

DATE MAILED:

**Please find below and/or attached an Office communication concerning this application or proceeding.**

**Commissioner for Patents**

The reply brief filed 12/16/11 has been entered and considered. The application has been forwarded to the Board of Patent Appeals and Interferences for decision on the appeal.

/Ernst V Arnold/  
Primary Examiner, Art Unit 1613



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/820,866	06/22/2010	James S. Baldassarre	26047-0003002	2913

94169                      7590                      01/17/2012  
Fish & Richardson PC  
P.O.Box 1022  
minneapolis, MN 55440

EXAMINER
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ARNOLD, ERNST V

ART UNIT	PAPER NUMBER
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1613

MAIL DATE	DELIVERY MODE
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01/17/2012

PAPER

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FISH & RICHARDSON PC  
P.O. BOX 1022  
MINNEAPOLIS, MN 55440

Appeal No: 2012-003574  
Application: 12/820,866  
Appellant: James S. Baldassarre et al.

**Board of Patent Appeals and Interferences  
Docketing Notice**

Application 12/820,866 was received from the Technology Center at the Board on January 09, 2012 and has been assigned Appeal No: 2012-003574.

In all future communications regarding this appeal, please include both the application number and the appeal number.

The mailing address for the Board is:

BOARD OF PATENT APPEALS AND INTERFERENCES  
UNITED STATES PATENT AND TRADEMARK OFFICE  
P.O. BOX 1450  
ALEXANDRIA, VIRGINIA 22313-1450

The facsimile number of the Board is 571-273-0052. Because of the heightened security in the Washington D.C. area, facsimile communications are recommended. Telephone inquiries can be made by calling 571-272-9797 and referencing the appeal number listed above.

By order of the Board of Patent Appeals and Interferences.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : James S. Baldassarre et al.                      Art Unit : 1613  
Serial No. : 12/820,866    Examiner : Ernst V. Arnold  
Filed : June 22, 2010    Conf. No. : 2913

Title : METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING  
HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR  
ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION

**Mail Stop Express Abandonment**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

EXPRESS ABANDONMENT UNDER 37 CFR §1.138

Applicant hereby expressly abandons application serial number 12/820,866, filed June 22, 2010, in favor of copending application serial number 13/651,660, filed October 15, 2012, which is directed to the same subject matter. This abandonment is made without prejudice and is not intended as an abandonment of the subject matter disclosed and claimed in this application.

Apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: December 3, 2012

/Janis K. Fraser/  
Janis K. Fraser, Ph.D., J.D.  
Reg. No. 34,819

Customer Number 94169  
Fish & Richardson P.C.  
Telephone: (617) 542-5070  
Facsimile: (877) 769-7945

22927229.doc

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I hereby certify under 37 CFR §1.8(a) that this correspondence is either (A) addressed as set out in 37 CFR §1.1(a) and being deposited with the United States Postal Service as first class mail with sufficient postage, or (B) being transmitted by facsimile in accordance with 37 CFR § 1.6(d) or via the Office electronic filing system in accordance with 37 CFR § 1.6(a)(4), on the date indicated below.

December 3, 2012

Date of Deposit or Transmission

/Nancy Bechet/

Signature

Nancy Bechet

Typed or Printed Name of Person Signing Certificate

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	14367117
<b>Application Number:</b>	12820866
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	2913
<b>Title of Invention:</b>	METHODS OF TREATING TERM AND NEAR-TERM NEONATES HAVING HYPOXIC RESPIRATORY FAILURE ASSOCIATED WITH CLINICAL OR ECHOCARDIOGRAPHIC EVIDENCE OF PULMONARY HYPERTENSION
<b>First Named Inventor/Applicant Name:</b>	James S. Baldassarre
<b>Customer Number:</b>	94169
<b>Filer:</b>	Janis K. Fraser/Nancy Bechet
<b>Filer Authorized By:</b>	Janis K. Fraser
<b>Attorney Docket Number:</b>	26047-0003002
<b>Receipt Date:</b>	03-DEC-2012
<b>Filing Date:</b>	22-JUN-2010
<b>Time Stamp:</b>	14:58:24
<b>Application Type:</b>	Utility under 35 USC 111(a)

### Payment information:

Submitted with Payment	no
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### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Letter Express Abandonment of the application	Expressaban26047_0003002.pdf	67912 <small>b0e52440aac94ec950a8cc425d939f15fc630ab5</small>	no	1

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### Information:

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**National Stage of an International Application under 35 U.S.C. 371**

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**New International Application Filed with the USPTO as a Receiving Office**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/820,866	06/22/2010	James S. Baldassarre	26047-0003002	2913

94169 7590 12/17/2012  
Fish & Richardson PC  
P.O.Box 1022  
minneapolis, MN 55440

EXAMINER

ARNOLD, ERNST V

ART UNIT PAPER NUMBER

1613

MAIL DATE DELIVERY MODE

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**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

---

*Ex parte* JAMES S. BALDASSARRE and RALF ROSSKAMP

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Appeal 2012-003574  
Application 12/820,866  
Technology Center 1600

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Before KIMBERLY R. JORDAN, *Division 1 Support Administrator*.

#### ORDER DISMISSING APPEAL

On September 1, 2011, Appellants filed a Notice of Appeal. On December 3, 2012, Appellants filed a communication requesting express abandonment of the application. The request for express abandonment will be treated as a request to withdraw the appeal.

Accordingly, the appeal in this application is dismissed.

The application is being returned to the Examiner for further action as may be appropriate.

Appeal 2012-003574  
Application 12/820,866

If there are any questions pertaining to this Order, please contact the  
Patent Trial and Appeal Board at 571-272-9797.

lp



UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/820,866	06/22/2010	James S. Baldassarre	26047-0003002	2913
94169	7590	12/20/2012	EXAMINER	
Fish & Richardson PC P.O.Box 1022 minneapolis, MN 55440			ARNOLD, ERNST V	
			ART UNIT	PAPER NUMBER
			1613	
			MAIL DATE	DELIVERY MODE
			12/20/2012	PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

**Notice of Abandonment**

<b>Application No.</b> 12/820,866	<b>Applicant(s)</b> James S. Baldassarre, et al	
<b>Examiner</b> Ernst Arnold	<b>Art Unit</b> 1613	

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--**

This application is abandoned in view of:

1.  Applicant's failure to timely file a proper reply to the Office letter mailed on \_\_\_\_\_.
  - (a)  A reply was received on \_\_\_\_\_ (with a Certificate of Mailing or Transmission dated \_\_\_\_\_), which is after the expiration of the period for reply (including a total extension of time of \_\_\_\_\_ month(s)) which expired on \_\_\_\_\_.
  - (b)  A proposed reply was received on \_\_\_\_\_, but it does not constitute a proper reply under 37 CFR 1.113 (a) to the final rejection.  
(A proper reply under 37 CFR 1.113 to a final rejection consists only of: (1) a timely filed amendment which places the application in condition for allowance; (2) a timely filed Notice of Appeal (with appeal fee); or (3) a timely filed Request for Continued Examination (RCE) in compliance with 37 CFR 1.114).
  - (c)  A reply was received on \_\_\_\_\_ but it does not constitute a proper reply, or a bona fide attempt at a proper reply, to the non-final rejection. See 37 CFR 1.85(a) and 1.111. (See explanation in box 7 below).
  - (d)  No reply has been received.
2.  Applicant's failure to timely pay the required issue fee and publication fee, if applicable, within the statutory period of three months from the mailing date of the Notice of Allowance (PTOL-85).
  - (a)  The issue fee and publication fee, if applicable, was received on \_\_\_\_\_ (with a Certificate of Mailing or Transmission dated \_\_\_\_\_), which is after the expiration of the statutory period for payment of the issue fee (and publication fee) set in the Notice of Allowance (PTOL-85).
  - (b)  The submitted fee of \$\_\_\_\_\_ is insufficient. A balance of \$\_\_\_\_\_ is due.  
The issue fee required by 37 CFR 1.18 is \$\_\_\_\_\_. The publication fee, if required by 37 CFR 1.18(d), is \$\_\_\_\_\_.
  - (c)  The issue fee and publication fee, if applicable, has not been received.
3.  Applicant's failure to timely file corrected drawings as required by, and within the three-month period set in, the Notice of Allowability (PTO-37).
  - (a)  Proposed corrected drawings were received on \_\_\_\_\_ (with a Certificate of Mailing or Transmission dated \_\_\_\_\_), which is after the expiration of the period for reply.
  - (b)  No corrected drawings have been received.
4.  The letter of express abandonment which is signed by the attorney or agent of record, the assignee of the entire interest, or all of the applicants.
5.  The letter of express abandonment which is signed by an attorney or agent (acting in a representative capacity under 37 CFR 1.34(a)) upon the filing of a continuing application.
6.  The decision by the Board of Patent Appeals and Interference rendered on \_\_\_\_\_ and because the period for seeking court review of the decision has expired and there are no allowed claims.
7.  The reason(s) below:

Betty J. Powell  
Office of Data Management  
571-272-8665

Petitions to revive under 37 CFR 1.137(a) or (b), or requests to withdraw the holding of abandonment under 37 CFR 1.181, should be promptly filed to minimize any negative effects on patent term.