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THE AORTIC VALVE

Mano Thubrikar

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PREFACE

The aortic valve is a fascinating structure. It opens and closes about 103,000 times a day. Its dynamics are quite demanding because they are traumatic. The aortic valve sustains variable pressure, undergoes complete reversal of curvature, and is subjected to a large amount of flexion for billions of cycles and still survives. No man-made structure can boast this achievement. In understanding this structure lies enhancement of our knowledge. A vivid picture of the aortic valve can be created by simply imagining three flaps moving back and forth in a swing-and-pause motion, constantly opening and closing the valve.

The book probes step-by-step into various aspects of this structure. The geometry is considered and the principles of valve design are revealed. The tissue composition is described as well as how the tissue is best suited for the valve function. The dynamic motion, which describes the very function of the valve, is considered. The mechanism of valve opening and changes in the leaflet shape are considered. The blood flow, for the control of which the valve exists, is described. The mechanism of closure and how the flow governs the leaflet position is described. The mechanical properties of the tissue and the stresses that develop in the functioning valve are described. Throughout these descriptions a link is maintained between the geometry, tissue, motion, flow, and mechanics.

The echocardiographic studies are described to relate the clinical findings with the experimental observations. The mechanism of second heart sound production is described. The diseaes of the valve are described and theories for valvular stenosis explained. Finally, mechanical and bioprosthetic valves are described. A broad perspective is developed in dealing with normal, pathologic, and bioprosthetic valves by exploring the commonality between them through comparisons of their design, dynamics, properties, function, and outcome. Interrelationships between several different aspects of the valve are constantly pointed out so as to develop a complete cohesive understanding of how the valve works.

At the present time there is a compelling reason to bring together the knowledge of the aortic valve. Most bioprosthetic valves implanted in humans fail in 8 to 16 years and, therefore, the search for a better valve continues. The information contained in this book will help in developing a better bioprosthesis. Theories of calcific stenosis in the natural aortic and bioprosthetic valves can be understood with the help of this book. The book enhances our ability to interpret angiographic and echocardiographic images of the aortic valve. Owing to technical developments during the last 15 years, new fundamental information was discovered about the aortic valve. This book brings newly discovered information together and presents it in such a way that the subject can be understood comprehensively. Each chapter in the book was reviewed by two or three outside and internal experts in the field, which has imparted an unusually high quality to the text. The book is also an example of how interdisciplinary work can achieve results that are otherwise impossible to obtain.

The book will be useful to cardiovascular surgeons, cardiologists, and cardiac pathologists, since it describes normal and abnormal geometries of the aortic valve, valvular pathology, replacement valves, angiography, and ultrasonography. It will be useful to anatomists in relating structure of the valve to function. It will be useful to manufacturers of mechanical and bioprosthetic valves. The book will be useful to students in physiology and biomedical engineering because it describes the principles of physiology and engineering and illustrates their applications to the aortic valve. It brings medicine and engineering disciplines together using the aortic valve as an example and therefore serves as a unique source of teaching and interdisciplinary approaches. From this book both the medical and engineering students can benefit by learning how to study the problems in medicine and how to discover scientific explanations for them. With the help of the book many researchers will be able to expand their research to include interdisciplinary approaches.

THE AUTHOR

Mano Thubrikar, Ph.D., is Associate Professor in the Department of Surgery and Director of Surgical Research at the University of Virginia Health Sciences Center at Charlottesville, Virginia.

Dr. Thubrikar obtained his B.E. degree (first in the Order of Merit) in 1969 in Metallurgy and Materials Science from Nagpur University, India. From New York University he obtained his M.S. in 1971 in the same field and his Ph.D. in 1975 in Biomedical Engineering. He served as a Research Instructor and as a Research Assistant Professor from 1975 to 1982 in the Department of Surgery at the University of Virginia, where he also assumed his present position in 1982.

Dr. Thubrikar is a member of the American Association of University Professors, Alliance of Engineering in Medicine and Biology Society, American Society of Artificial Internal Organs, Biomedical Engineering Society, International Association for Cardiac Biological Implants, and Council on Arteriosclerosis.

He has been the recipient of the Research Career Development Award (1980—1985) from the National Institutes of Health and the Certificate of Merit awarded by the New York Academy of Medicine. He has been the recipient of research grants from the National Institutes of Health, the Diabetes Research Center of the University of Virginia, and private industries.

He has published more than 68 papers and presented 29 lectures at national and international meetings. He has been an invited speaker at several international symposiums. He has been a consultant to private industries and has developed collaborative programs between universities. His current research interests are in natural, pathologic, and bioprosthetic aortic valves and the mechanism of atherosclerosis.

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