

The Birth, Early Years, and Future of Interventional Radiology

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Abbreviations: AGIB = acute gastrointestinal bleeding, PTA = percutaneous transluminal angioplasty, SFA = superficial femoral artery, SIR = Society of Interventional Radiology, SK = streptokinase, TIPS = transjugular intrahepatic portosystemic shunt

THE Society of Interventional Radiology (SIR) celebrates its 30th anniversary this year. During these 30 years, SIR has grown from a closed club with fewer than 100 members to an open society with 4,000 members. The history of the Society and its exciting growth is detailed on the SIR web site, www.sirweb.org. This issue of *JVIR* also contains commemorative articles of some founding members on the formative years of SIR, its transition to an open society, perspectives for its future, and the history of nonvascular interventions. However, only a few SIR members remember the birth and early years of interventional radiology. It is our intention to bring these days back to you by recounting how interventional radiology was born and how it grew, particularly in the area of vascular interventions.

This article is a remembrance, a collection of the highlights of our memories of events that happened 25–40 years ago, documented by historic pictures. Fortunately, the human memory has the most generous and merciful nature; it encrypts in the mind exciting and memorable events while repressing unemotional or disturbing occasions or at least permitting us to look at them differently. Many of the mo-

mentous events associated with the birth and early years of interventional radiology are still as fresh in our memory as if they occurred yesterday. But, because the human memory is also quite subjective, our memories could be somewhat biased as we take you back into the exciting early years of interventional radiology.

THE BIRTH OF INTERVENTIONAL RADIOLOGY

Interventional radiology developed from diagnostic angiography and from the innovative minds and technical skills of many angiographers. Charles Dotter (**Fig 1**) (1) conceived interventional radiology in the early 1960s and first officially spoke about it on June 19, 1963, at the Czechoslovak Radiological Congress in Karlovy Vary. In his more than 1 hour presentation, “Cardiac catheterization and angiographic techniques of the future,” he discussed, among other topics, catheter biopsy, controlled exit catheterization, occlusion catheterization for various purposes, and the rationale of catheter endarterectomy (2). After his conclusion stating that “[t]he angiographic catheter can be more than a tool for passive means for diagnostic observation; used with imagination, it can become an important surgical instrument,” Charles received a standing ovation from more than 300 attendees, including many prominent European angiographers. For those of us in the audience, it was like a bomb had been dropped. At that time, all

angiographers had only one thing in mind, to deliver an exact diagnosis to our referring clinical colleagues, internists and surgeons, thereby allowing them to select proper treatment. Until then, none of us had even thought that we might be able to treat patients ourselves percutaneously with use of catheters and guide wires. Also, none of us present at the congress realized or even dreamed that Dotter’s words would soon become reality.

Interventional radiology was born January 16, 1964, when Dotter percutaneously dilated a tight, localized stenosis of the superficial femoral artery (SFA) in an 82-year-old woman with painful leg ischemia and gangrene who refused leg amputation. After successful dilation of the stenosis with a guide wire and coaxial Teflon catheters, the circulation returned to her leg (**Fig 2**) (3). Charles told us that his skeptical surgical colleagues kept the patient in the hospital under observation for several weeks expecting the dilated artery to thrombose. Instead, her pain ceased, she started walking, and three irreversibly gangrenous toes spontaneously sloughed. She left the hospital on her feet—both of them. The dilated artery stayed open until her death from pneumonia 2.5 years later.

Encouraged by this success, Dotter not only continued to dilate SFA stenoses, but also began treatment of SFA occlusions. In his first paper on this subject published in the November 1964 issue of *Circulation* (3), Dotter—with Melvin Judkins, developer of transfemoral coronary catheterization

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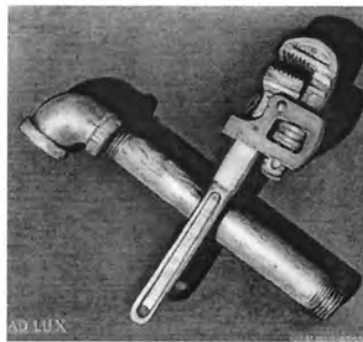
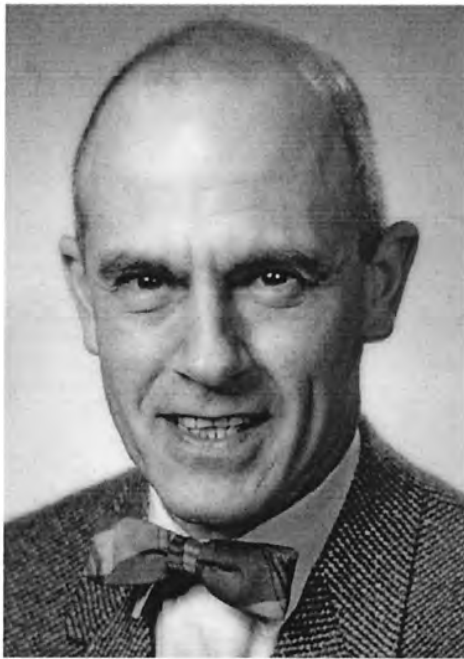


Figure 1. Charles Dotter and his trademark (trademark drawing reprinted with permission from reference 1).

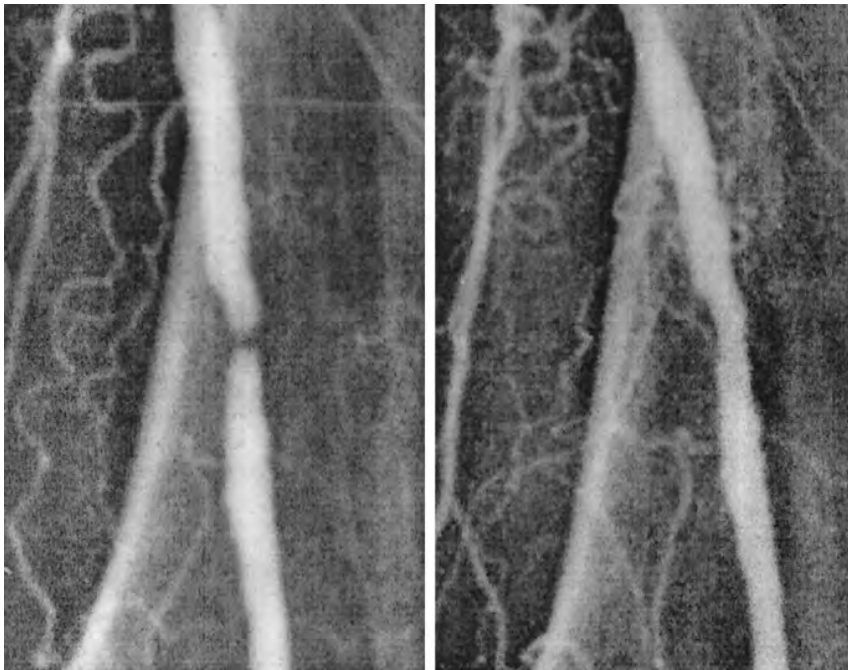


Figure 2. The first percutaneous transluminal angioplasty, performed January 16, 1964 (reprinted with permission from reference 3).

technique (Fig 3)—summarized their 5-month experience with angioplasty. They reported treatment of 11 extrem-

with short SFA occlusions and four with long SFA occlusions. The treatment of occlusions was not always

tions were averted in these patients. In the description of the technique, Dotter recommended “passing guide wires through the lesions more by the application of judgment than of force, even when both are often needed for subsequent dilation.” Force was indeed often necessary when passing the 15-F outer diameter dilation catheter over the first 9-F catheter. Dotter’s experience rapidly grew, and in May 1966, he reported treatment of 82 lesions in 74 patients, including six iliac artery stenoses. This report also mentioned the first use of braided mesh reinforced latex balloon dilation catheters (3A).

Dotter refined his technique and decreased the size of coaxial dilation catheters to 8 F and 12 F and improved the taper of their tips. In 1968, 4 years after his first case, he reported on 217 dilations of 153 lesions in 127 patients (4). Dotter considered himself a “body plumber” and, to avoid reference to his technique as “reaming out,” he drew and published a picture of his concept of the basic mechanism of transluminal dilation in which nothing is removed except for the obstruction. Dotter, for a long time, called his technique “percutaneous transfemoral catheter dilatation,” but later changed it to the presently known “percutaneous transluminal angioplasty” (PTA).

The term “interventional radiology” was coined by Alexander Margulis in his editorial in the March 1967 issue of the *American Journal of Roentgenology* (5). In the mid 1960s, occasional reports were published on treatment with radiologic techniques other than PTA or on new manipulative diagnostic radiologic procedures. These included treatment of rigid shoulders by joint distention during arthrography, abscess drainages, intrauterine transfusion of the fetus under fluoroscopic guidance, removal of plugs from a T-tube by fluoroscopically controlled catheter manipulation, pulmonary and liver biopsy, catheter placements for intraarterial chemotherapy, and transjugular cholangiography. Margulis, a gastrointestinal radiologist and educator, realized that a new trend and new specialty was developing in radiology. In his editorial, he not only defined interventional radiology, but also set requirements for its performance that are still valid today.



Figure 3.
Melvin Judkins
with his coronary
catheters.

manipulative procedures controlled and followed under fluoroscopic guidance that may be predominantly therapeutic or primarily diagnostic. Margulis emphasized the need for special training, technical skills, clinical knowledge, ability to care for patients before, during, and after the procedure, and close cooperation with surgeons and internists as requirements for performance of interventional radiologic procedures. He also raised questions of obligatory training of interventional radiologists in surgical techniques. High-quality radiologic imaging equipment was another of his basic requirements for performance of interventional radiologic procedures (6).

Dotter was not enthusiastic about the term “interventional,” calling it imperfect. His main reservation about the term “interventional” was its lack of definition of our work. He believed that this term leads to confusion about what we do among the lay public and many physicians. Dotter himself defined interventional radiology as a variety of percutaneous image-guided alternatives or aids to surgery. However, he realized that generalized use of the term “interventional radiology” allowed definition of a new subspe-

cialty from general radiology and its other subspecialties.

THE EARLY YEARS OF INTERVENTIONAL RADIOLOGY

The most exciting years of our professional lives were from the late 1960s to the mid 1980s. Dotter’s papers, his lectures, and, later, daily work with him were constant inspirations to us that changed our orientation from diagnostic angiographers to interventionalists. We can still hear his voice telling us that, whenever examining the patient, we must not only concentrate on improving diagnoses, but we must also always think about potential ways to percutaneously treat whatever we find. We and many other interventional pioneers worked hard at it. In the earlier years, new techniques were often introduced as treatments in patients without experimental testing, particularly when no other options were available. Emergencies found us prepared to innovate. In our department, introduction of PTA and arterial embolization of upper gastrointestinal bleeding were introduced in this manner. Applications of our experience and techniques in one organ system to

structure led to new indications for interventional procedures. Examples include our introduction of selective arterial thrombolysis and fallopian tube recanalization. More recent devices and techniques such as stents, stent-grafts, transjugular intrahepatic portosystemic shunt (TIPS) creation, and direct intrahepatic portal systemic shunt creation underwent detailed experimental testing in animals and were introduced for clinical use with approval of the institutional review board.

Departments in other institutions were developing devices and techniques in a similar fashion. Interventional treatment that started with opening vascular obstructions expanded to creating therapeutic vascular occlusions and shunts and treating tumors. Its application also expanded from the vascular system to the pulmonary, biliary, gastrointestinal, genitourinary, and central nervous systems. There were many pioneers who introduced new methods of interventional treatment. We will highlight some of them and concentrate mainly on interventional treatment related to the vascular system, particularly PTA, local thrombolysis, stent development, treatment of acute gastrointestinal bleeding, and TIPS creation.

EARLY HIGHLIGHTS IN PERCUTANEOUS TRANSLUMINAL ANGIOPLASTY

After a few successful procedures, Dotter started an aggressive campaign to recruit patients and gain recognition for PTA. His referrals were mainly from general practitioners and occasionally from internists. Surgeons were not interested in nonsurgical treatment of atheromatous disease and were adamantly opposed to PTA. Dotter’s articles in local newspapers and his radio and TV interviews were effective in attracting patients interested in this new procedure. These patients were admitted to the hospital on the radiology service under Dotter’s name and radiology residents or fellows, with varying degrees of enthusiasm, worked them up and prepared for the procedure.

Patient recruitment was greatly enhanced on a national level with a *Life*

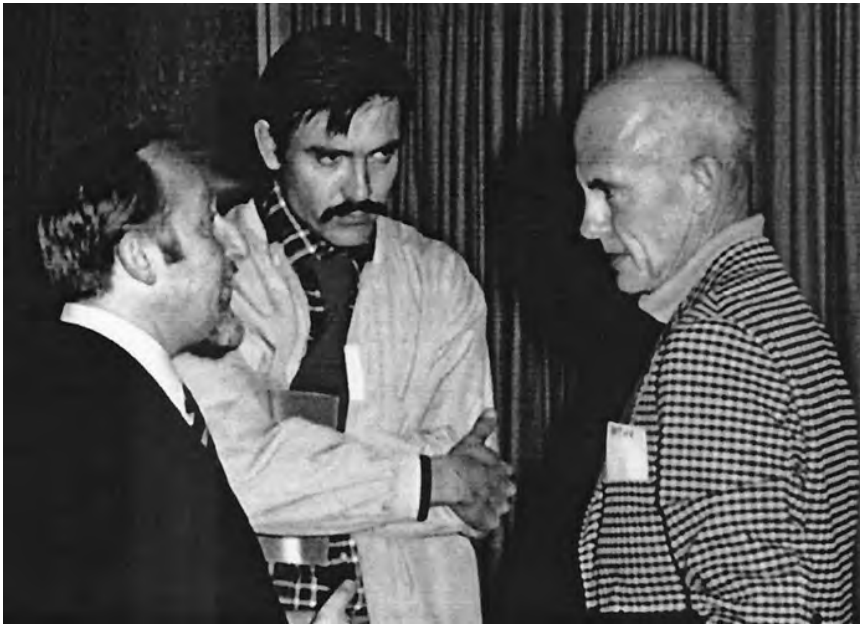


Figure 4. From left to right, Eberhardt Zeitler, Andreas Grüntzig, and Charles Dotter in 1975 discussing angioplasty techniques at the symposium in Cologne, Germany.

Reporters visiting Oregon Health and Science University to write about the Starr-Edward cardiac valve were told about a new procedure, PTA. They insisted on catching Dotter in action. Charles' emotions and reactions to various stages of the procedure were successfully captured in pictures. The article, when published, resulted in tremendous exposure for Charles and PTA and also earned him the nickname of "Crazy Charlie." This national publicity attracted a wealthy VIP patient, the wife of the owner of a large international company in New York City. Dotter flew to New York with his team and successfully treated this patient's SFA stenosis. Afterwards, the thankful patient donated \$500,000 to the Oregon Health and Science University radiology department. Dotter used this grant to purchase up-to-date angiographic equipment that allowed him to perform PTA and other angiographic procedures very efficiently. The remaining funds Dotter used for publicity for PTA, lectures abroad, and to support a 1-year research fellowship in Portland for Josef Rösch, whom he had met at the 1963 Czechoslovak Radiological Congress.

However, general recognition of PTA progressed slowly. In particular,

for a long time. Even though Dotter published 17 papers on PTA in the first 4 years—seven in radiology journals, four in surgery journals, one in a cardiology journal, and five in general journals—PTA procedures in the United States were performed almost exclusively in Portland. Angiographers at other US institutions did not share Dotter's idea of "catheter therapy." They continued to concentrate only on diagnosis. However, European angiographers were more progressive at that time and demonstrated a desire to change and expand their work. Werner Porstmann, a good friend of Dotter from Berlin, started performing PTA in the mid 1960s and published his first experience in 1967 (6). Van Andel from The Netherlands modified the dilation catheters. However, the greatest credit for disseminating PTA throughout Europe belongs to Eberhart Zeitler from Germany (Fig 4). Thanks to his work, many European angiographers accepted PTA and began "Dottering" diseased arteries (7,8).

The Europeans also made critical steps in PTA development by introduction of clinically applicable balloon catheters. The first "caged" or "corset" balloon catheter described by Ports-

loon inside a Teflon catheter with longitudinal slits (9). This device did not find wide application. However, a balloon catheter made of polyvinyl chloride introduced by German cardiologist Andreas Grüntzig in 1974 revolutionized PTA (Fig 4) (10). Realizing the potential of these balloons, medical device manufacturers rapidly placed them into production and balloon PTA took off. Favorable experience with Grüntzig balloon catheters in femoropopliteal and iliac arteries opened the way for balloon PTA of other vessels. Grüntzig performed the first successful balloon dilations of coronary arteries in 1976 (11).

Success of PTA in Europe ignited the interest of the new generation of angiographers in the United States. Some went to Europe to see Grüntzig at work at live case demonstrations he organized, and some even stayed with him for fellowships. Upon returning, they brought the improved PTA procedure back to the United States, where it originated approximately 15 years before. Enthusiastic work of these pioneers, including Barry Katzen, David Kumpe, Amir Motarjeme, Ernie Ring, Don Schwarten, Tom Sos, Charles Tegtmeier, and others, helped with the rapid dissemination of balloon PTA in the United States, where it soon became the most commonly performed interventional procedure (Fig 5).

LOCAL THROMBOLYSIS

Dotter introduced catheter-directed thrombolysis in 1972 at the annual meeting of the Radiological Society of North America in Chicago. The origins of the procedure were the treatment of complications of angiography and PTA. Thrombotic occlusions occasionally occurred at the catheter entrance or dilation sites because of the large size of diagnostic coronary catheters (8 F) and coaxial dilation catheters (12 F). Dotter wanted to treat these complications with interventional techniques rather than have the patient undergo surgery. In our department, we were familiar with thrombolysis because of randomized studies comparing systemic application of streptokinase (SK) and heparin for treatment of pulmonary embolism and acute deep venous thrombosis. We



Figure 5. The pioneers of balloon PTA in the United States. From left to right, upper row: Barry Katzen, David Kumpe, Amir Motarjeme, Ernie Ring. Lower row: Donald Schwarten, Thomas Sos, Charles Tegtmeier.

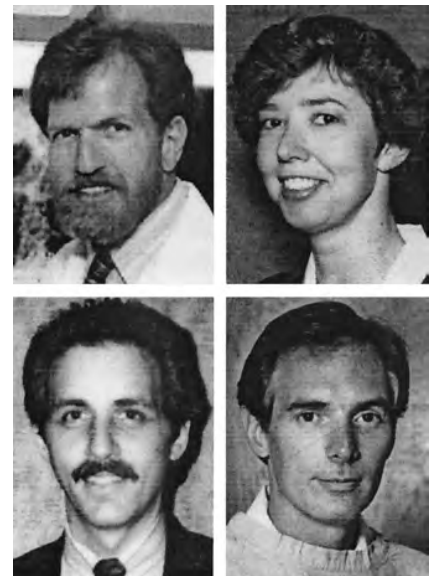


Figure 7. Dotter's early followers in local thrombolysis. From left to right, upper row: Barry Katzen, Arina Van Breda. Lower row: Gary Becker, Thomas McNamara.

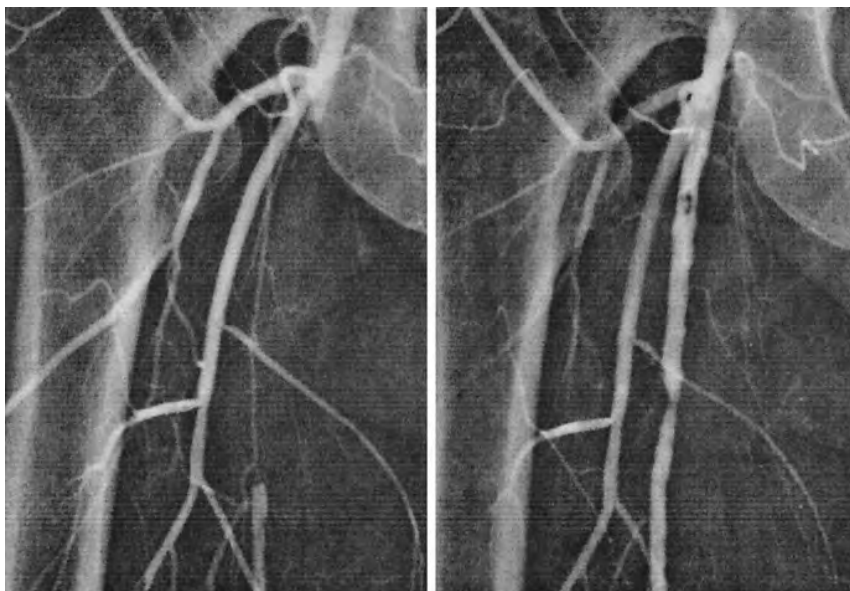


Figure 6. One of the first cases of local thrombolysis performed in June 1972 (reprinted with permission from reference 12).

man, an experienced hematologist in this area. In addition, we had extensive experience with local arterial infusion therapy, mainly with vasopressin infusions for control of arterial and variceal gastrointestinal bleeding and chemotherapy infusions for treatment of tumors.

as the complication was recognized, an end-hole catheter was placed just above a short thrombus or a multiple-side hole catheter was thrust into a long thrombus in the angiography room. Continuous SK infusion was then performed in the intensive care unit. The dose of SK most often used

femoral arteries, approximately 5% of the usual systemic dose. Portable angiograms at 12- or 24-hour intervals were used to monitor the progress of fibrinolysis. In the first six patients with acute thrombosis, 18–112-hour infusions (mean, 47 hours) were needed for complete clot lysis (Fig 6) (12). Encouraged by good results with acute thromboses, Dotter explored local SK infusions in chronic arterial occlusions, but found only minimal benefit for this indication. Therefore, we continued local thrombolysis for our occasional complications. Sometimes we used thrombolysis before PTA when there was clinical suspicion of acute or subacute thrombosis superimposed on chronic arterial obstruction.

Our publication on this technique in April 1974 did not generate enthusiasm for local thrombolysis among interventionalists. The need for hospitalization in the intensive care unit, the antigenic nature of SK, and some bleeding complications were probably the main factors for the limited acceptance of this technique. Barry Katzen and Arina Van Breda were the first followers in the United States and, in 1981, they published their experience

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