Endovascular Surgery: How We Arrived Here

"...a minimal incision, limited potential for complications, short hospitalization, and rapid recovery are obvious advantages." —Edward B. Diethrich, MD[1]

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Implicit in the question of how we arrived where we are today with endovascular surgery is that first there was vascular surgery, and the ways in which vascular surgery developed can be clearly seen from our 50-year vantage. Many individuals have contributed; a few remain, but most have now passed away. Many concepts and procedures were attempted but, like the surgeons who developed them, most are gone today. Those procedures that remain constitute the practice of open vascular surgery.

The development of vascular surgery in the 20th century was dependent upon four main events: the discovery of heparin, the development of vascular prostheses, the application of transfusion science, and the use of antibiotics.

HEPARIN

First among the necessities of vascular surgery was the discovery of heparin by Jay McLean, MD. The discovery of heparin can be dated to 1916, when McLean was a second-year medical student at Johns Hopkins University and was working in the laboratory of the well-known physiologist, William H. Howell, MD. Dr. Howell claimed credit for the discovery, and Dr. McLean was left forever bitter. Later, in 1933, purification of heparin by Charles Herbert Best, MD, in Toronto cleared the path for its clinical application. Vascular surgery could not have advanced without the discovery of heparin.

TRANSFUSION AND ANTIBIOTICS

Two other elements that contributed to development of vascular surgery were perfection of blood transfusion and development of antibiotics. Again, it can be said that vascular surgery could not have progressed without heparin, blood transfusion, and antibiotics.

PROSTHETIC GRAFTS

Another major element in the development of vascular surgery was the failure of homografts. This chapter is largely forgotten, but its lessons reappear whenever vascular allografts are inserted. Homograft (the term in use at the time) failure was not immediate, so the brief success of the procedure fueled the growth of technical vascular surgery. Ultimately, the development of prosthetic grafts permitted true progress. It was the success of polyester grafts in particular that allowed growth of direct vascular reconstruction.

Although those four elements allowed the phenomenal growth of vascular surgery as a specialty, development of the balloon embolectomy catheter by Thomas Fogarty, MD, which was reported in 1963, began the era of endovascular surgery.[2] Use of the Fogarty catheter was a breakthrough in improving the results of reconstructive arterial surgery. This is well remembered by those who worked in the surgical vineyards at that time. Who would have known in the 1960s that this was the beginning of endovascular surgery, a new subspecialty? When the Fogarty catheter was used for embolectomy, the surgical incision was minimized, anesthesia could be local infiltration, and postoperative convalescence was markedly shortened.[3] These are the hallmarks of endovascular interventions today.

SELDINGER CHANGED THE WORLD

Before the Seldinger technique, arteriography and even aortography was done by direct needle puncture. The volume of contrast injected was severely restricted by the size of the needles, the concentration of contrast at the point of the target was diminished by blood dilution, and the images were imperfect. The single event that changed angiography forever and shaped the course of endovascular interventions was the fantastic idea of replacing the small percutaneous arteriography needle with a larger catheter, which was the idea of Sven-Ivar Seldinger, MD.

Dr. Seldinger presented his idea in June 1952, and his article was published the next year.[4] It was a true breakthrough. It made translumbar arteriography obsolete. It replaced direct carotid artery puncture and eliminated high-power retrograde brachial injections. The catheter, and ultimately future devices, all larger than the needle, could be passed into all of the nooks and crannies of the body through the vascular system.

Sven-Ivar Seldinger (1921-1999) graduated from the Karolinska Institute in 1948 and trained in radiology from 1948 to 1953. His idea was elegant in its simplicity, requiring only a thin-walled introducing needle (Cournand), a wire guide, and a plastic catheter larger than the needle to pass over the wire. Dr. Seldinger made accessing every part of the body via the cardiovascular system routine. He pioneered catheter-based angiography, investigated localization of tumors, performed selective renal angiography, and even percutaneous transhepatic cholangiography. It is an understatement to say that the simplicity of the Seldinger technique revolutionized cardiology and radiology, while serving as a catalyst for innovative applications of the technique in other specialties, such as urology, anesthesiology, and critical care medicine.

PIONEERS

Just as the growth of vascular surgery was dependent on the discovery of heparin, availability of blood transfusions, development of antibiotics, and prosthetic grafts, endovascular therapy flourished with use of the Seldinger technique. It allowed the development of endovascular stents by Julio Palmaz, MD, and others, and ultimately the invention of endovascular grafting by Juan Parodi, MD.

Most would say that discussion of the pioneers in endovascular surgery would be incomplete without a tribute to Charles Dotter, MD. Although he is credited with the birth of interventional radiology, his main contribution was the completely original idea that arterial catheterization could be therapeutic and not merely diagnostic. He said, "The angiographic catheter can be more than a tool for passive means of diagnostic observation; used with imagination, it can become an important surgical instrument."[5]

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Dotter's early work changed radiologists from being purely diagnostic angiographers to becoming interventionists. He was a natural publicist, and his publications included articles in local newspapers, radio spots, and TV interviews. There was even a national article in *Life* magazine. At that time, *Life* was widely distributed and universally read. Dotter's emotional reactions in performance of procedures were captured on film and published widely. His appearance earned him the nickname of "Crazy Charlie." It can be said that the publicity that he sought and achieved was important to early widespread use of the intravascular catheter as a therapeutic tool. Surgeons did not greet Dotter's technique of percutaneous transfemoral catheter dilation to relieve arterial obstruction kindly. In fact, they castigated him. Nevertheless, his appreciation of the power of publicity led directly to the growth of interventional radiology. In fact, he is often erroneously credited with invention of the that term.[6]

Attitudes toward Dr. Dotter's percutaneous transluminal angioplasty changed in 1974, when a cardiologist from Zurich, Andreas Gruentzig, MD, developed the technique of balloon catheter dilation of arteries and described his first five cases of percutaneous coronary angioplasty.[7] That was the turning point. Dr. Dotter's technique of angioplasty was dropped, but his idea of the catheter as a therapeutic tool remained.

THE STENT

Dr. Charles Stent was an English dentist who, in 1856, developed a thermoplastic material for taking impressions of toothless mouths.[8] Stents have been used by several medical disciplines in applications as different from one another as rebuilding the mandible to reconstructing the ureter.[9] Although many individuals contributed to the development of intra-arterial stents, the name that most readily comes to mind is that of Julio Palmaz, MD. Palmaz is a radiologist at the University of Texas Health Science Center in San Antonio, where the Palmaz stent was invented in the 1980s. His first stent was described in 1985 and developed further in 1986.[10,11] Palmaz began his work with stents using a low-power microscope and weaving stainless steel wire into a crisscross tubular pattern. His final stent design became a single stainless steel tube with parallel staggered slots in the wall. When expanded, the slots formed diamond-shaped spaces that resisted arterial collapse. The Palmaz stent became the first stent approved by the FDA for vascular use.

Although several teams of investigators were working out the problems of endovascular grafting, it was the team of Drs. Palmaz and Parodi that made the greatest impact. They took advantage of the fact that after deployment, a stent gets incorporated into the arterial wall by formation of a thrombo-resistent neointima. Using a stent as an anchoring device, they presented the first results of using such a stent graft to the Radiological Society of North America in 1990.[12] It was Parodi's graft that was first used in human application and reported in 1991. Four of five grafts were successful, but the fifth required repair by open operation. In practice, the graft was composed of large Palmaz stents anchored to thin-walled and crimped Dacron. Initially, the anchoring stent was only in the proximal portion of the graft, but Dr. Parodi was quickly convinced that the distal stent should be implanted also.

SUMMARY

Many individuals and many ideas have contributed to the phenomenal growth of endovascular therapy. These address the fundamental problems of vascular disease and allow treatment for many individuals who are prohibitive surgical risks. When reduced to its fundamental elements, the story of how we arrived where we are today is the story of startlingly few individuals, each of whom had very original ideas and made them practical for clinical use. ■

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