Milestone Cases in Endovascular Trauma Therapy

Recollections of key experiences in the history and development of this life-saving therapy.

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During the Second World War, Michael Debakey demonstrated that lives and limbs could be saved using surgical treatment of vascular injuries.[1] With the development of endovascular techniques, it became evident that some selected cases of vascular trauma could be treated using an endovascular approach. Injuries to the vascular vessels can be penetrating or blunt and can be the result of violence, accidents, or be iatrogenic in origin.

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HISTORICAL BACKGROUND AND CASE PRESENTATIONS

In 1990, the first successful endoluminal treatment of an infrarenal aneurysm was performed in Buenos Aires.[2] A year later, we were the first to successfully treat a subclavian arteriovenous fistula with a covered stent. The patient was a police officer who developed a subclavian arteriovenous fistula after sustaining a gunshot wound during a police operation.

Three months after the injury, the patient presented to the emergency room due to shortness of breath. He had a dilated heart, a hyperdynamic status, and a thrill and bruit over the right clavicle. Dilated subcutaneous veins were evident on the right shoulder. Color duplex imaging showed an arteriovenous fistula with very dilated veins between the subclavian artery and vein.

At the time, we had already gained experience with the endovascular treatment of abdominal aortic aneurysms and had published one case of an infrarenal aortic dissection in the *Annals of Vascular Surgery*.[2]

For the police officer, we used a Palmaz stent (Cordis Corporation) covered with an expanded polytetrafluoroethylene (PTFE) graft. The approach was performed via cutdown of the right brachial artery, and fluoroscopic guidance was used to advance a guidewire to the aortic arch. A 12-F sheath was introduced in the brachial artery and placed exactly where the arteriovenous communication was located. The compressed balloon-expandable stent graft mounted on an 8-mm balloon was advanced through the sheath. The procedure was performed under local anesthesia. Once the stent was deployed, an arteriogram showed coverage of the orifice of the vessels. The patient's heart rate immediately decreased, and he was discharged the next morning. At 1-month follow-up, the heart had decreased to a normal size.

In 1991, Becker et al also reported temporary treatment of an arteriovenous fistula with a silicon-covered stent; however, the procedure was utilized as a bridge to open surgical treatment and thus was not the final treatment.[3]

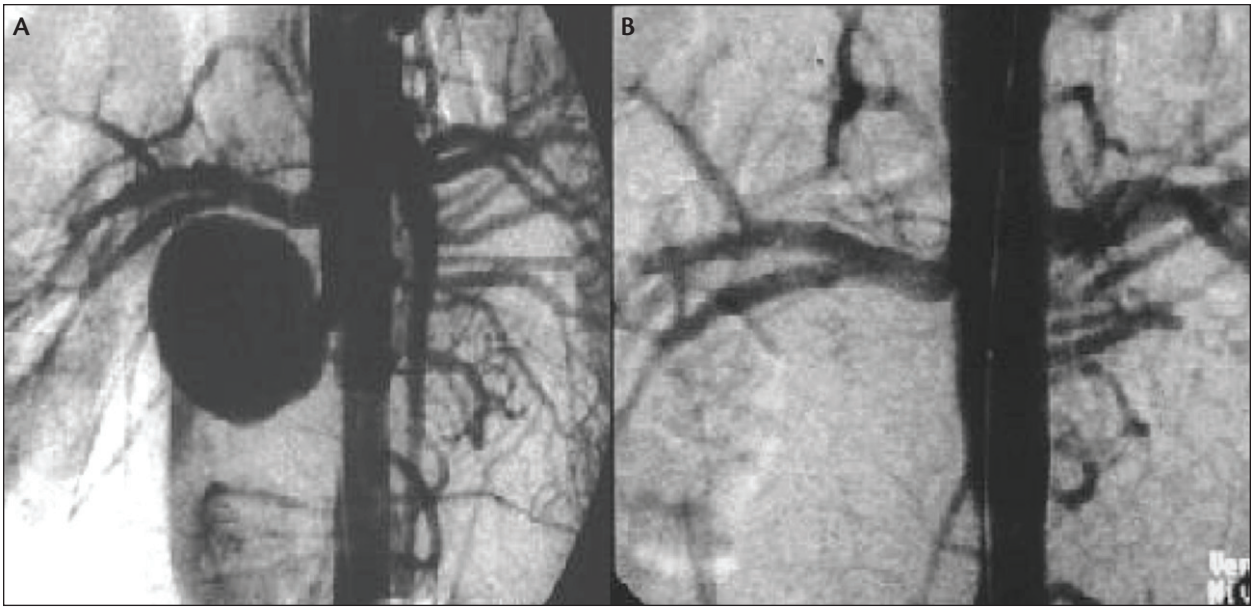

Figure 1. Abdominal aortic false aneurysm and aortocaval fistula before (A) and after (B) treatment with a covered Palmaz stent.

A second patient had an aortic-inferior vena cava fistula resulting from a gunshot wound. A surgical attempt to solve the problem in a city hospital resulted in massive bleeding. The wound was packed, and the patient was transferred to our institution. Under local anesthesia, a covered Palmaz stent was placed at the level of the fistula under fluoroscopic guidance. Packing was removed with minimal requirement of hemostasis. The patient was discharged after 3 days (Figure 1).

A third patient we treated endoluminally was a young patient with a large false aneurysm of the proximal common carotid artery resulting from a gunshot injury. One day, I was performing surgery and received a phone call from the Pentagon. On the line was a colonel who was a staff physician at the Pentagon. His father was 87 years old and had a large abdominal aortic aneurysm. He asked me if I could treat his father with an endograft. I accepted the challenge, and the patient was sent to my hospital in Buenos Aires, where he was successfully treated with an aorto-uni-iliac balloon-expandable endograft, complemented with a common iliac occlusion and a femorofemoral bypass.

After finishing the case, I received a call from the emergency department requesting treatment for a large false aneurysm of the proximal common carotid artery in a young patient who sustained a gunshot wound. The colonel asked to stay in the operating theater to observe the case.

From the groin, we introduced a 12-F-long sheath that ended in the right common carotid artery. We used only local anesthesia. A covered Palmaz stent was sutured to a PTFE graft, which was previously expanded with a balloon. The procedure was uneventful, and the colonel was very impressed; he foresaw the potential use of the technique in military surgery. I was invited to present my experience at the Pentagon in connection with the Walter Reed Hospital and a military hospital in San Antonio, Texas. I presented the initial 10 cases that I had performed at the time of the presentation. That presentation motivated several military surgeons to explore the endovascular treatment method for military application.

Another interesting case was performed in São Paulo, Brazil. A young patient had massive edema of the left lower extremity, dilated superficial veins in the lower abdomen and leg, and a thrill was palpated on the left lower quadrant of the abdomen. He had a history of a gunshot wound 5 years earlier. The patient had congestive heart failure and needed three pillows to sleep due to shortness of breath. An arteriogram depicted an arteriovenous fistula of the common iliac vessels and massive dilation of the veins. The proximal left common iliac was aneurysmatic due to the hyper flow caused by the fistula. After treating the fistula with a covered Palmaz stent, the patient had an amazing recovery; the edema subsided, his congestive heart failure was reversed, and in < 1 month, the patient was able to have a normal life. One of our doubts was the evolution of those extremely dilated veins. We decided to place an inferior vena cava filter due to the presence of thrombus in some of the pelvic veins.

After several successful cases similar to those previously described (including false aneurysms and arteriove-

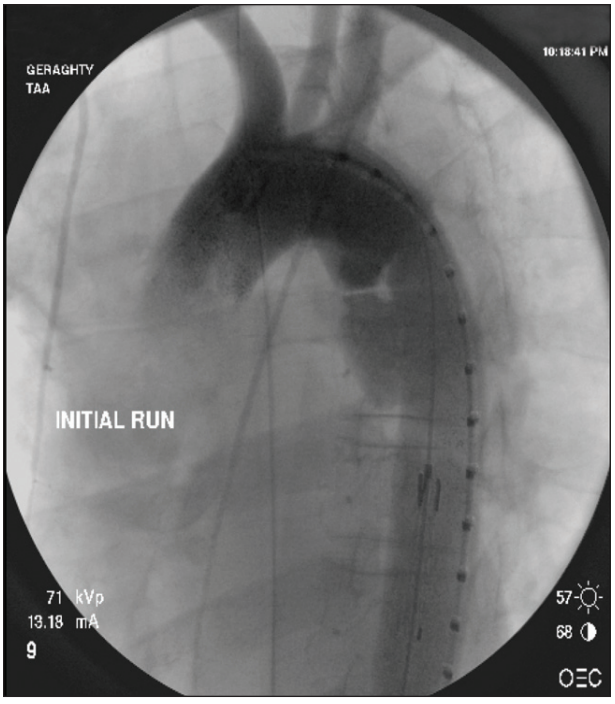

Figure 2. Partial transection of the descending thoracic aorta at the level of the isthmus.

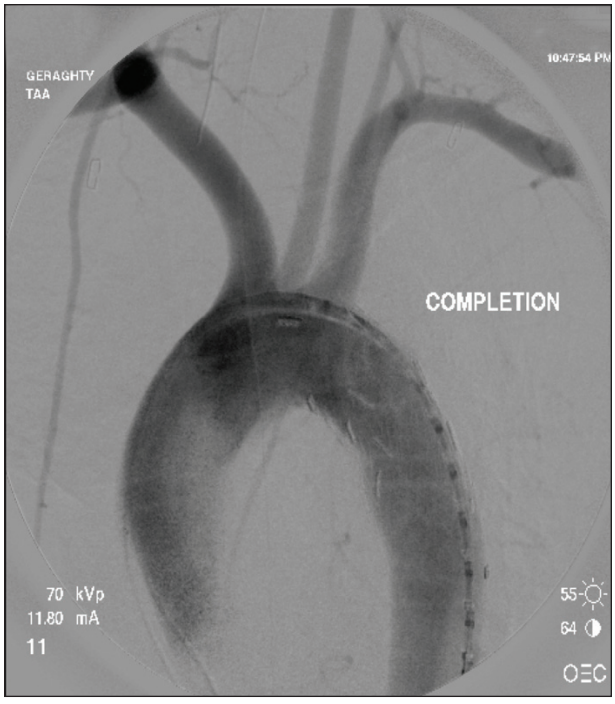

Figure 3. The same lesion as shown in Figure 2 after treatment with two 23-mm-diameter Excluder cuffs.

nous fistulas located in the common carotid artery, iliac artery, and superficial femoral artery), we collaborated in the development of the Corvita device (Boston Scientific Corporation). The idea of covering a Wallstent (Boston Scientific Corporation) originated with Dr. Juan Parodi, seeking to have flexible, self-covered stents available for trauma. The Wallstent was covered by coretane.

Many cases were successfully treated with the Corvita system; Boston Scientific made some device iterations to the Wallgraft after acquiring Corvita, and the Wallgraft was used successfully in many cases.

In our early experience, we used Palmaz stents covered with vein, PTFE, or Dacron; Corvita; and Wallgraft endoprostheses.

One of the most useful developments was endografts to treat blunt aortic trauma with transection of the descending thoracic aorta. Open treatment is invasive and has a significant complication rate. Today, thoracic endografts are almost routinely used to treat thoracic aortic transections. The conformable TAG endograft (Gore & Associates) is currently the only device that is approved by the US Food and Drug Administration for that indication.

Initially, we were using 23-mm-diameter Excluder cuffs in most of our cases because of the often small size of the aorta seen in young patients involved in car accidents. The results of endoluminal treatment of trauma cases involving the thoracic aorta are encouraging (Figures 2 and 3).

OUTCOMES AND COMPLICATIONS

In the follow-up of our treated cases, we observed arterial occlusion and one subclavian endograft fracture without undesirable consequences. One case of a compressed balloon-expandable endograft in the superficial femoral artery indicated that in compressible areas or where flexion is taking place, balloon-expandable endografts should not be used. Wire fractures were seen in the subclavian artery. There are few reports of long-term outcomes of vascular trauma cases treated with endografts.

Today, we have several endografts suitable to be used in trauma cases. Treatment of false aneurysms and arteriovenous fistulas can be done with Viabahn (Gore & Associates), Fluency (Bard Peripheral Vascular, Inc.), or iCast (Maquet Vascular Systems) endografts, and aortic transections can be corrected with the conformable TAG endograft, which is approved by the FDA for this application.

Without question, endografts represent a viable alternative for treating false aneurysms, arteriovenous fistulas, and even acute injuries of the arteries and veins, especially in difficult locations.

Association Between Treatment for Branch and Main Artery Injuries

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occluded with gelfoam, Spongostan (Ferrosan Medical Devices), or coils before placing the endograft in the main artery.

ADVANTAGES OF ENDOLUMINAL TREATMENT OF VASCULAR TRAUMA

One of the most useful applications of endografts in trauma is in cases of aortic transection. In all publications, the complication rate, length of hospital stay, and recovery time were significantly favorable for endoluminal treatment compared with an open procedure.

Patients with associated trauma are better treated with less-invasive procedures. In chronic arteriovenous fistulas, trauma to the dilated and friable veins is prevented, as well as nerve injury. Very often, treatment of false aneurysms and/or arteriovenous fistulas can be facilitated by endoluminal treatment, especially in difficult-to-access locations, such as the proximal common carotid artery, vertebral arteries, thoracic and abdominal aorta, and subclavian arteries.

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