The status of endovascular surgery in aortic aneurysms

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Abdominal Aortic Aneurysms (AAA)

Professor of Anatomy and Surgery Andreas Vesalius first described the entity of Abdominal Aortic Aneurysm (AAA) during the 16th century in "Fabrica, Epitome" [1]. Since then, AAA repair poses a great challenge for every vascular surgeon due to the well described natural history of the disease, which is devastating if left untreated. Prof. of Surgery Rudolph Matas in Tulane University of Louisiana (1860-1957) was the first to introduce "Endoaneurysmorrhaphy" in 1903. Twenty years later he also performed the first successful AAA "ligation" in 1923[2,3]. In 1949, Nissen used the "Wrapping technique with cellophane" to treat symptomatic AAA of Albert Einstein who survived 6 years before rupture[4]. On the 29th of March 1951, the French surgeon Charles Dubost performed the first resection and arterial homograft interposition through a retroperitoneal approach[5,6]. Finally, Creech in 1956, introduced the current procedure of AAA repair "Endoaneurysmorrhaphy and graft interposition", which was popularized by De Bakey[7]. This procedure proved satisfactory short and long term results and become the "gold standard" for AAA repair for many years.

The next revolutionary approach in AAA treatment was with the advent of endovascular techniques in early 90s'. Parodi et al in 1991 first implanted a physician-fabricated **aortoaortic tube endograft** comprised of a balloon-expandable stent and a Dacron graft.[8] Three of the first five procedures eventually failed because the graft was only fixated proximally. Blood-reflux around the distal end of the Dacron graft, which was not attached to the aorta, led to persistent sack perfusion. The graft design was modified to include a second distal Palmaz stent to accomplish fixating of the Dacron graft in the terminal aorta, so success was achieved in excluding the AAA from the arterial circulation. Soon afterwards **aortouniiliac grafts** (AUI) were used in conjunction with femoro-femoral crossover grafts, but tube configuration remained a mainstay of endovascular AAA treatment for the first years due to the advantage of being more straightforward in its deployment, with a limited potential for graft twisting or kinking.[9] Parodi and colleagues deployed 51 aortoaortic tube endografts (in a total of 109 patients) and reported no increase in early endograft failure or any adverse events at that time.[9] During the following years, other investigators, reported that tube grafts may not provide effective long-term exclusion of AAAs.[10] Secondary type I distal endoleaks, despite an apparent adequate length of the distal neck, were reported in sporadic cohorts.[10-14] In addition, growth of the inferior aneurysm neck and recontouring that appeared to be unrelated to endoleaks was also reported and correlated to morphological alterations of the abdominal aorta after EVAR.[15] So, the need for a **bifurcated endograft** fixated distally to the common iliac arteries was more than obvious in order to overcome the defects of "tube" and "AUI"

endoprostheses. From 1993 to 1997 many articles were published showing the initial results of custom made bifurcated endoprostheses in Australia, USA and Europe.[16-25] As the technique evolved, experience was gained and gradually many commercial – industrial modular bifurcated endografts were released in the market. EVAR soon become popular proving equal or even superior results versus open AAA repair.[17-32] At the same time, complications, pitfalls, defects and special considerations regarding this new technique became apparent (endoleak, migration, material fatigue, sack enlargement, leg dislocation or thrombosis, reinterventions etc.). The vascular community soon reached consensus and agreed that modular bifurcated endografts should be first choice implants in AAA.

Descending Thoracic Aortic Aneurysms (DTAA)

Diseases of the descending thoracic aorta pose a challenging problem for cardiovascular surgeons. Thoracic aortic aneurysms (TAAs), Stanford type B dissections, penetrating ulcers, and traumatic aortic tears, all are potentially morbid entities with an increasing incidence in the latest years. The incidence of TAAs is estimated to be as high as 10 cases per 100,000 people per year, with thirty to forty percent of these aneurysms occurring exclusively in the descending thoracic aorta (DTA), when aortic dissection is affecting 9000 patients per year in the United States alone. [33-37] The natural history of these diseases, if left untreated, is devastating, usually leading to aortic expansion, rupture, vital organ ischemia and cardiopulmonary collapse due to blood exsanguination and ultimately death. Actuarial 1- and 5-year survivals for patients with DTAA, not operated on, are 60% and 20%, respectively. [38] The annual risk of rupture, dissection, or death in a patient with a thoracic aneurysm 6 cm in diameter is over 14%. [39] Quite similar, slightly more benign, is the course of untreated type B aortic dissections, with branch ischemia being the most devastating complication. Penetrating ulcers are a much more rare clinical entity, with high risk for rupture if left untreated, [40,41] while traumatic aortic tears, affect usually young people, and are encountered in up to 18% of motor vehicle accidents, with mortality rates of 90% in the field, and 40% to 70% in those who survive the initial shock, due to adjacent injuries. [42,43]

Traditional open surgical repair of DTAAs (aortic graft replacement via a left thoracotomy) has been found to improve survival when compared with medical therapy alone.[44] But since the first resection of descending thoracic aortic aneurysm and graft interposition in 1953 was performed,[45] little progress has been achieved regarding mortality and morbidity after conventional open repair of this aortic pathology. Even with the advent of cardiopulmonary bypass, profound hypothermia, circulatory arrest, spinal cord protection and ICU support, the results slightly improved. [46-49] Operative mortality rates from centers of excellence are reported between 8% and 20% for elective cases and up to 60% for ruptures. On the other hand morbidity rates still remain unexpectedly as high as up to 50% related to renal, intestinal, and spinal cord ischemia, so recent 5-year survival rates are suppressed to no more than 60% to 70%.

With the advent of endovascular stent-grafts and the first successful treatment of AAA by Parodi in 1991, many vascular surgeons were enthusiastic and embraced the idea of repairing descending thoracic aortic pathology with a minimal invasive technique, without thoracotomy or aortic cross-clambing, especially in high risk patients. So, Volodos was the pioneer in 1991 with his relative publication regarding endovascular treatment of DTA as well as AAA.[50] Soon afterwards Dake et al in 1992 investigated the endoluminal repair thoracic aortic aneurysms, using homemade

devices that combined polyester grafts and modified Gianturco Z-stents with promising results.[51] Since then, many studies have shown the technical feasibility and effectiveness of descending thoracic aortic aneurysms endovascular repair, as well as the potential complications.[52-77] Similarly, many publications report interesting results regarding Stanford type B dissections. According to all these publications, advantages of the endovascular approach of descending thoracic aortic pathologies are: avoidance of major thoracic or thoracoabdominal incisions, decreased need for general anesthesia, shorter operative time, minimal blood lose and need for transfusions, lack of aortic crossclamping, avoidance of cardiopulmonary bypass, less postoperative pain, shorter hospital and ICU stays and quicker recuperation. Moreover 30-day mortality from these cohorts for endovascular repair of DTAs is estimated to be from 0 to 25% with most centers reporting around 10%,[52-77] while conventional open repair of DTAs, even from centers of excellence, comes with reported mortality of 8-20% for elective cases. Morbidity of this entity is as high as 50 % for conventional open repair of DTAs while in the endoluminal approach ranges from 0 to 25%, with most centers reporting less than 10 %, with paraplegia being usually 0% (only 7 out of 25 reports with approximately 5% paraplegia).[52-77] On the contrary open surgery is often complicated with paraplegia, ranging from 8 to 30 %. As far as Stanford type B dissection is concerned, similar short-term outcomes in favour of the endovascular approach is documented: for the acute phase 30-day mortality rates of 20% for medically treated patients is reported, 35% for surgically repaired patients, and over 50% for operative patients presenting with end-organ ischemia. On the contrary, endoluminal repair minimizes early mortality to approximately 5% (0-20%) with morbidity ranging from 0 to 28% (usually less than 15%) and paraplegia usually being absent, while open surgery comes with morbidity of 47%.

In our department we have gained experience concerning EVAR from year 2000 with more than 1000 endovascular abdominal aortic repairs using various endografts and techniques. [78-82]. From 2004 we have also implanted many thoracic aortic endoprostheses for various pathologies, mainly DTAAs, using various endografts and techniques [83,84].

Conclusively, the comparison of short-term results between open and endovascular repair of abdominal and descending thoracic aortic pathology, is in favour of the second, but unfortunately no prospective multicenter randomized trial is yet offered to draw safer conclusions for long term results. Endoleak, migration, material fatigue and sac pressurization are all potential complications of aortic pathology endografting, which should be dealt with caution and special consideration, making strict follow-up mandatory. We believe that sooner or later EVAR and TEVAR will become the gold standard for treating aortic aneurysms.

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