Perspective

Best surgical option for thoracoabdominal aneurysm repair - the open approach

John W. Fehrenbacher, Joel S. Corvera

Indiana University Health Cardiovascular Surgeons and the Division of Cardiothoracic Surgery, the Indiana University School of Medicine, Indianapolis, Indiana, USA

Corresponding to: Joel S. Corvera, M.D. Indiana University Health Cardiovascular Surgeons and the Division of Cardiothoracic Surgery, the Indiana University School of Medicine, Indianapolis, IN, USA. Email: jcorvera@iuhealth.org.

Submitted Jul 20, 2012. Accepted for publication Aug 21, 2012.
DOI: 10.3978/j.issn.2225-319X.2012.08.10

Open thoracoabdominal aneurysm (TAAA) repair is a complex surgical procedure that requires efficient replacement of diseased aorta, limitation of ischemia to the various and multiple vascular beds, and intraoperative protection of the heart, central nervous system and abdominal viscera in a patient population with multiple comorbidities. Techniques of TAAA repair have evolved from the original "clamp and sew" technique to modern perfusion-assisted techniques with varying degrees of hypothermia. In experienced aortic centers, the morbidity and mortality of TAAA repair is quite good with mortality 5.0% to 8.0%, paralysis 2.3% to 3.8%, and renal failure requiring hemodialysis 1.5% to 5.6%. Open repair is durable and the long-term survival is well-defined and acceptable. In our hands, the 10 year survival of open descending thoracic and thoracoabdominal aneurysm repair is 53.5%. The applicability of open TAAA repair to the myriad of aortic pathologies, anatomy and connective tissue disorders (CTDs) is *unlimited*.

Thoracic endovascular aortic repair (TEVAR) is a less invasive method for repairing descending thoracic and thoracoabdominal aneurysms. Currently, the approved indication is repair of descending thoracic atherosclerotic aneurysms with adequate proximal and distal landing zones, although these devices are used to treat all aortic pathologies. The applicability of TEVAR to the transverse arch and visceral abdominal aorta has been extended using extraanatomical bypasses (hybrid techniques) or branched and/or fenestrated devices. Long-term durability of these repairs extended beyond the descending thoracic aorta is unknown. Furthermore, the application of TEVAR in patients with CTDs is not recommended in the STS guidelines for thoracic and thoracoabdominal aneurysm repair. As the next generation of devices become available (some with FDA indications other than atherosclerotic descending thoracic aneurysm) and as more data accumulates regarding the long-term efficacy of TEVAR, we may gain more insight into the specific clinical scenarios in which TEVAR may be superior to open repair.

Currently, we believe that open repair in the hands of experienced surgeons is superior to TEVAR for thoracoabdominal aneurysms in a variety of aortic pathologies including: chronic aortic dissection, aortic aneurysm or dissection in patients with CTDs, mycotic pseudoaneurysm and infected aortic grafts. TEVAR has distinct advantages in other aortic pathologies, including acute complicated type B aortic dissection, blunt traumatic aortic injury (BTAI) and anatomically suitable ruptured descending thoracic aneurysm.

Intimate knowledge of and facility in applying both techniques is paramount in deciding how to intervene in specific patient scenarios. The remainder of this commentary will discuss our opinion on open *vs.* endovascular repair of specific pathologies of the thoracoabdominal aorta.

Atherosclerotic thoracoabdominal aneurysms

Open repair has been the "gold standard" for over 50 years. Technical improvements in the conduct of the operation and improvements in postoperative care have demonstrated excellent results in the short and long-term. Complications of paraplegia, renal failure and stroke have significantly improved from the original reports of Crawford. The rate of reintervention after open repair is low and the durability of the repair is not in question. The treatment of aorto-iliac ischemic disease and chronic mesenteric ischemia can be performed at the time of open repair by using bypass techniques. The patient's aortic anatomy does not limit application of open repair, however the patient's comorbid status can. In particular in our hands, octogenarians have the highest mortality rate, 16%. However, advanced age, chronic lung disease, chronic kidney disease and systolic heart failure are not contraindications to open repair. Frailty and an inability to rehabilitate after surgery can be contraindications to open repair.

TEVAR for thoracoabdominal atherosclerotic aneurysms requires either extraanatomic bypass for coverage of the paravisceral abdominal aorta or fenestrations and/or branched grafts for revascularization of these branches. The morbidity and mortality of hybrid thoracoabdominal debranching and endograft repair has exceeded that of traditional open thoracoabdominal repair at centers of excellence. Most institutions have abandoned this approach. The morbidity of the "open" portion of this hybrid approach does not justify the "minimally-invasive" second-stage endograft procedure. The use of this technique should be limited to centers with experience and acceptable results and specific patient scenarios.

Fenestrated endografts can be self-made (on the OR back table) or custom made to suit each patient's specific anatomy. Branched endografts are also custom made for each patient (although a few constructs may be applicable to a certain percentage of patients). As reported by the Cleveland Clinic group, procedural mortality and post-operative complications are low and similar to open repair in experienced aortic surgery centers. The long-term durability of the repair and patency of the visceral branches remains to be seen. Endoleaks and reintervention are common. Although this technology is not yet widely available, it may be best applicable to the high-risk patient who cannot tolerate an open repair.

Chronic aortic dissection

Open repair for chronic aortic dissection has a historical mortality of 10%. Our recent series has shown improved outcomes with mortality of 2.2%, as our understanding of the pathology and our surgical techniques have improved. Usually the patients are younger and the aorta is generally without significant atheromatous disease reducing the risk of stroke or atheroembolization. A majority of intercostal arteries are patent and may come off either true or false lumen. With a large number of patent intercostal arteries, strategies for spinal cord protection can include intercostal and lumbar artery revascularization, cerebrospinal fluid drainage and hypothermia.

Generally, only the aneurysmal portion of the thoracoabdominal aorta need be replaced; the entire dissection does not need to be resected if there is non-aneurysmal distal aorta. Therefore, the extent of the TAAA repair is best limited to the dilated aorta and distal operations are performed when and if the distal aorta grows.

Important technical points to open repair of chronic aortic dissection include fenestration of the distal anastomosis to provide flow to both true and false lumens, intercostal artery bypass using a small diameter looped graft (10 mm, to reduce wall tension on a weakened aortic wall), and either creating small visceral island patches or individually bypassing visceral vessels. We have advocated closure of the false lumen for branches of the aorta to prevent late dilatation. Fortunately, we have not encountered malperfusion syndrome from this technique.

Although there is great enthusiasm for the endovascular repair of chronic aortic dissection, the long-term results are lacking and treatment failure as high as 40%. The success of endovascular repair is dependent upon the thrombosis of the false lumen which is variable at the level of the device and unreliable distal to the device. Additionally, there is sufficient evidence to suggest that partial thrombosis of the false lumen leads to increased adverse outcome, even compared to a patent false lumen. It is our opinion that until our endovascular devices become sophisticated enough to address the countless permutations and combinations of flow dynamics caused by aortic dissection and multiple points of reentry, they should only be used for *limited* chronic aortic dissection where all entry and reentry points can be successfully excluded.

Acute complicated type B aortic dissection

Open repair for a complicated acute type B aortic dissection can be a very difficult operation. The surgical tenets are the same for repair of an acute type A aortic dissection: resection of the entry tear and reapproximation of the intima and adventitia of the aorta to close the false lumen. Aortic replacement can be limited to the proximal and mid descending thoracic aorta, however investigation of the distal aorta looking for malperfusion may be difficult to do unless the operation is performed in a hybrid operating suite. Evidence of distal malperfusion requires either open extension of the repair or endovascular fenestration and/or stenting of the distal aorta and its branches.

We believe that for acute complicated type B aortic dissection, endovascular repair has many advantages. Not only can the surgeon exclude the entry tear, but also interrogate the entire thoracoabdominal aorta using intravascular ultrasound and angiography to assess fate of the true lumen in the distal aorta. Adjunctive procedures to address malperfusion are easily done at the same setting. The incidence of retrograde type A aortic dissection may be higher in treating this pathology, so the choice of endovascular device is ideally one without proximal bare springs or barbs and with lower radial strength. The opportunity to promote "aortic remodeling" or obliteration of the false lumen is greatest in acute dissection, however it is common to see continued perfusion of the false lumen distal to the device and in particular in the abdominal aorta. The application of bare metal stents with low radial force may allow more consistent aortic remodeling distally into the abdominal aorta without compromise of the visceral branches.

Blunt traumatic aortic injury

Open repair for BTAI is a procedure that is becoming less and less common as endovascular repair has been reported to be used in 80% of operative BTAI repairs. The current devices have size constraints for the distal arch and descending thoracic aorta that are small, <16 mm. The incidence of device infolding is rare with the newer generation devices which conform to inner curve of the arch more easily and are not oversized. Reintervention for endoleak or device failure is much less common than initial reports using first generation and oversized devices. For the multiply injured patient (young or old) who is too ill for open surgery, endovascular repair, if anatomically feasible, is ideal and preferred. The overall operative mortality and morbidity of TEVAR for BTAI is lower than that of open repair. We have found that coverage of the left subclavian artery is needed in over 50% of endovascular repairs for BTAI and it has been our practice to revascularize the left subclavian artery with extraanatomic bypass or chimney stenting.

For the young patient who does *not* have other major injuries, open repair in centers with aortic surgical experience may be the better procedure. Open repair can be accomplished with low morbidity and mortality. Spinal cord ischemia is 1% using distal aortic perfusion. Heparin need not be administered using a partial bypass circuit (left atrio-femoral) which may be advantageous in the trauma patient with bleeding risk. Yearly CT scans can be avoided reducing the potentially large burden of lifetime radiation exposure.

Follow up for endovascular repair of BTAI is approximately 32%. Therefore 2 out of 3 patients do not have surveillance imaging of the device. Follow up examination of the traumatically-injured patient has always been and will continue to be a challenge. And it is possible that the placement endovascular devices in these young patients may pose future aortic problems that will largely be undetected.

Penetrating aortic ulcers

Penetrating aortic ulcers (PAUs) seem to be an ideal application for endovascular repair since the pathology appears to be limited and focal. However in open repair of PAUs, it is readily apparent that the atherosclerotic process leading to PAUs is anything but limited and focal. Whereas single PAUs are seen radiographically, multiple PAUs are found intraoperatively during open repair. Local therapy for an extensive pathology will be successful only in the short-term for both open and endovascular repair.

PAUs are a difficult pathology to predict and to treat. An approach that weighs the benefits of open versus endovascular repair for the individual patient may be prudent. Furthermore, the extent of aortic treatment should be individualized to the patient's comorbid status.

Mycotic pseudoaneurysms

Open repair is the only definitive solution to the problem of mycotic aortic pseudoaneurysm. Following the basic surgical tenets of removal of infected fluid and debridement of all infected tissue are imperative. Unfortunately for the thoracic or thoracoabdominal aorta, extraanatomical bypass options are limited and usually the conduit must traverse the infected field. The use of cryopreserved allografts, bovine pericardial conduits or antibiotic impregnated prosthetic grafts with viable soft tissue coverage are the most common solutions to this very difficult surgical problem.

There have been few, very small series of patients who have undergone endovascular repair of a primarily infected aortic pseudoaneurysm with extremely limited long-term results. The patients are placed on intravenous antibiotic therapy for several weeks and suppressive antibiotic therapy for a lifetime. Endovascular repair for mycotic aneurysms of the aorta should *not* be performed except in the most extenuating of circumstances. Endovascular repair has utility in stopping immediate hemorrhage for stabilization and resuscitation of the patient before definitive open repair when the device is explanted.

Infected thoracoabdominal grafts and endografts

Reoperative open repair is the only definitive surgical solution to this very difficult problem. The basic surgical principles of graft excision and debridement of infected tissue with in situ arterial reconstruction with cryopreserved allografts, bovine pericardium or antibiotic impregnated Dacron grafts with soft tissue coverage must be followed for a successful outcome. TEVAR can be used as a temporary measure to contain rupture in preparation for open repair, but should not be used as definitive repair.

Extraanatomical bypass with axillo-femoral bypass will not provide enough flow to the lower body and abdominal viscera. Ascending aorta to abdominal aorta bypass using a large Dacron graft placed outside of the infected field may provide sufficient flow, however.

Aortic fistulae

Aorto-esophageal fistulae are highly fatal problems. Definitive repair demands primary repair of the esophageal perforation or resection and diversion with replacement of the thoracic or thoracoabdominal aorta with cryopreserved allografts, bovine pericardium or antibiotic impregnated Dacron grafts with soft tissue coverage. Thoracic endografts can be used as a temporary measure to control hemorrhage, but should not be used as a definitive repair. Our experience with primary repair of the esophageal perforation and replacement of the aorta with cryopreserved allografts in aorto-esophageal fistulae has a high rate or reintervention for pseudoaneurysm or early suture line rupture. Esophageal resection and diversion may be necessary to protect the allograft from ongoing infection and contamination.

Aorto-bronchial fistulae appear to have less bacterial contamination than aorto-esophageal fistulae. Thoracic endograft exclusion with multiple weeks of intravenous antibiotics followed by lifetime suppressive antibiotics appears to have reasonable early results, although the long-term outcomes are not known. Open repair using Dacron grafts with or without long-term antibiotics is also a durable solution to aorto-bronchial fistulae.

Connective tissue disorders

Patients with Marfan, Loeys-Dietz or Ehlers-Danlos syndrome should be repaired with open thoracoabdominal surgery. Removal of aortic tissue from systemic circulation is imperative with bypasses to all important branches. Multiple operations are usually necessary over the lifetime of these patients to achieve total aortic replacement.

Thoracic endografts should not be used for primary repair in patients with CTDs. Until there is long-term data regarding the durability of endograft repair in patients with CTDs, open repair remains the only safe and durable surgical solution. The radial strength of endograft devices may cause aneurysm formation or rupture at the landing zones. It is reasonable to place an endograft if the landing zones are within prior Dacron grafts in these patients.

Ruptured descending thoracic or thoracoabdominal aneurysm

Open repair of a ruptured thoracoabdominal aneurysm is a large undertaking with high morbidity and mortality, especially if the patient is in extremis. For contained rupture, rapid placement of the patient on partial or full cardiopulmonary bypass is imperative, followed by expeditious repair. In the setting of uncontained rupture, our preferred method of deep hypothermia and circulatory arrest is difficult to employ. Thoracic endograft repair is a significantly less physiological insult if anatomically feasible (i.e. those confined to the descending thoracic aorta with adequate proximal and distal landing zones).

Although there is no long-term survival data regarding open *vs*. endovascular ruptured thoracic or thoracoabdominal aneurysm repair, there is long-term survival data regarding open *vs*. endovascular ruptured infrarenal abdominal aortic aneurysm repair. While mortality is less in the short-term with endovascular repair of ruptured infrarenal aneurysms, the long-term survival is similar between open and endovascular repair. We suspect that the same is probably true for open *vs*. endovascular repair of ruptured thoracic aneurysms confined to the descending thoracic aorta. Emergent totally endovascular thoracoabdominal aneurysm repair is not widely applicable due to the lack of "off-the-shelf" fenestrated or branched endografts.

Summary

Open thoracoabdominal aneurysm repair in centers of aortic surgery excellence has very good early results and long-term outcomes. With open repair, there are no aorta-specific anatomical constraints as seen with endograft repair. The durability of open repair is not in question. All aortic pathologies can be repaired, however several specific pathological entities we believe are best served by open repair, including chronic aortic dissection, infectious aneurysms, infected grafts and CTDs. Devices for thoracic and thoracoabdominal endovascular repair are improving, however still have significant limitations and shortcomings to promote wide application of the technique to all patients and pathologies.

Cite this article as: Fehrenbacher JW, Corvera JS. Best surgical option for thoracoabdominal aneurysm repair - the open approach. Ann Cardiothorac Surg 2012;1(3):334-338. DOI: 10.3978/j.issn.2225-319X.2012.08.10

Acknowledgements

Disclosure: The authors declare no conflict of interest.

