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Review

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Treatment selection for thoracoabdominal aortic aneurysm repair: open or endovascular?

Akiko Tanaka, Holly N. Smith, Anthony L. Estrera

Department of Cardiothoracic and Vascular Surgery, McGovern Medical School at UTHealth Houston, Houston, TX 77030, USA.

Correspondence to: Prof. Anthony L. Estrera, Department of Cardiothoracic and Vascular Surgery, McGovern Medical School at UTHealth, 6400 Fannin St., Ste. #2850, Houston, TX 77030, USA. E-mail: Anthony.L.Estrera@uth.tmc.edu

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Abstract

Despite advancements in operative techniques and perioperative management, early mortality and morbidity from open thoracoabdominal aortic aneurysm (TAAA) repair remain significant. Endovascular aortic repair (EVAR), with visceral parallel grafts or branched/fenestrated stent grafts, is the less invasive treatment option. However, off-the-shelf, branched/fenestrated stent grafts are currently not readily available on the market. The anatomical complexities of TAAAs, which make open repair difficult, such as the involvement of visceral branches and spinal cord blood supplies, are also challenges to endovascular repair. Open surgical TAAA repair should be considered in patients with connective tissue disorders, younger age (less than 50 years old), and ruptured hemodynamically unstable TAAA. Endovascular TAAA repair should be considered in patients with sarcopenia, advanced age, renal dysfunction, and lung dysfunction, if patients have suitable anatomy. The two approaches should remain complementary. Overall, few data exist on which TAAA patient population would benefit from open *vs.* endovascular approaches. Therefore, this manuscript discusses patient selection for open and endovascular repair of TAAA from a literature review and our institutional experience.

Keywords: Thoracoabdominal aortic aneurysm, TAAA, open repair, endovascular aortic repair, EVAR

BACKGROUND

Seven decades have passed since the first report of open thoracoabdominal aortic aneurysm (TAAA)

repair[1]. Since that time, intraoperative and perioperative management have evolved to improve operative outcomes. The adjunct of distal aortic perfusion, hypothermia, and cerebrospinal fluid drainage have significantly reduced the incidence of spinal cord injury. In addition, visceral blood perfusion and cold crystalloid perfusion of the renal arteries are used to protect the viscera and kidneys[2,3]. However, the early mortality and morbidity rate of this procedure remains significant[2,3]. In the early 1990s, endovascular aortic aneurysm repair (EVAR) emerged as a less-invasive alternative to treat infrarenal abdominal aortic aneurysms[4]. By the late 2000s, EVAR became the first-line treatment option for both infrarenal abdominal and descending thoracic aortic aneurysms (DTAA). However, EVAR has not yet become the gold standard for treating TAAAs.

The anatomical complexities of TAAAs, which make open TAAA repair difficult, such as the involvement of visceral/renal branches and spinal cord blood supplies, are also challenges to EVAR. Hybrid TAAA repair was proposed to solve the anatomical constraints of EVAR with fewer surgical insults than open repairs by sparing thoracotomy. However, outcomes after hybrid TAAA repair were not superior to open repair[5]. Another alternative approach is total endovascular repair, with visceral parallel graft (chimney/snorkel) techniques using off-the-shelf devices. Nevertheless, the use of parallel graft has raised concerns for durability due to the "gutter" leaks[5]. The physician-modified, multi-branched/fenestrated stent graft was introduced in the late 1990s and, currently, off-the-shelf and custom-made branched/fenestrated stent grafts to treat TAAA are under investigational use in the United States[6].

In the recently published 2022 ACC/AHA Guidelines for the aortic disease[7], all the recommendations are derived from nonrandomized and limited data. The use of open repair was Class I recommendation in patients with ruptured TAAA and with intact TAAA in Marfan syndrome, Loeys-Dietz syndrome, and vascular Ehlers-Danlos syndrome. On the other hand, endovascular repair was a Class 2b recommendation but is limited to centers with endovascular expertise and access to appropriate endovascular stent grafts, in patients with both hemodynamically stable ruptured TAAA and intact degenerative TAAA with suitable anatomy.

This manuscript discusses patient selection for open and endovascular repair of TAAA from a literature review and our institutional experience.

METHODS

Because of the technical complexity of both open and endovascular TAAA repairs and low case numbers across the United States, a paucity of data exists on which patient population would benefit most from open and endovascular approaches. A systematic search of the literature was performed using PubMed and Cochrane database with the keywords "thoracoabdominal aortic aneurysm", "open repair or open surgery", "endovascular or stent graft" and "comparative study or trial".

COMPARATIVE STUDIES

There are no direct comparative studies on outcomes after open *vs.* endovascular TAAA repairs. The closest study is our institutional experience in DTAA repairs[8,9]. We found that DTAA patients with sarcopenia are at risk for postoperative adverse events in both open and endovascular approaches, especially sarcopenic patients, who underwent open surgical repair carry significantly increased long-term mortality risk[8]. We have also published that TEVAR reduced mortality fourfold compared to open repair when patients with DTAA had chronic obstructive pulmonary disease, glomerular filtration rate < 60 mL/min, and age > 70 years[9].

There is little doubt that TAAA patients with the four factors - sarcopenia, chronic obstructive pulmonary disease, glomerular filtration rate < 60 mL/min, and age > 70 years - will likely have a higher incidence of adverse outcomes, regardless of the open or endovascular approaches. However, the current meta-analysis demonstrated that the endovascular group was prone to include patients with older age, chronic obstructive pulmonary disease, coronary artery disease, and diabetes[10]. Although current literature has yet to demonstrate a definitive benefit of endovascular treatment in high-risk patients, these high-risk patients would likely benefit more from endovascular repair, given the comparable outcomes between open and endovascular treatment.

In the realm of endovascular treatment, there is a consideration for ensuring an adequate "landing zone" to prevent endoleak, which may result in the treatment area being larger than the actual lesion extent. For instance, a Crawford Extent 3 TAAA may necessitate coverage consistent with an Extent 2 classification. When comparing the outcomes of open repair *vs.* endovascular treatment, there is ongoing debate as to whether comparisons should be based on the extent of the lesion or the extent of the treatment. This discussion is crucial, as it has significant implications for the evaluation of procedural efficacy and the subsequent stratification of treatment outcomes. Further investigation is required to determine the most appropriate metric for comparative analyses in this context.

CONNECTIVE TISSUE DISORDER

A recent review article on TAAA patients with connective tissue disorder (CTD)[11] demonstrated that the rates of early postoperative mortality after open and endovascular repairs were equivalent (8 studies with 458 patients on open repairs; 12 studies with 168 patients on endovascular repair). This is likely due to the young age and minimal comorbidities in this patient population. However, the technical success rate with endovascular repair varied from 38% to 100%, while that of open repair in all the studies was 100%. In addition, stent-graft-related complications in this patient population were high: type I endoleak 8%-30%; type II endoleak 17%-30%; and new dissection 17%.

Because of the young age presentation and fragile aortic wall with CTD, the durability of the repair remains a concern, especially in the long term. In the previously mentioned review[11], the rate of reintervention in the treated aortic segment with open TAAA was 4%-5% due to patch aneurysm. In addition, branch graft patency is nearly 100%. On the contrary, reintervention to the treated aortic segment after endovascular repair was observed in 8%-38%. In addition, in patients with CTD, false lumen may continue to have persistent flow after the repair and cause growth, which was reported in 33%-38% of patients. Additionally, open conversion ranged from 7%-50% in this review. Thus, TAAA patients with CTD should be considered for open surgical repair due to both short-term and long-term benefits.

Two large series reported outcomes after open TAAA repair in patients younger than 50 years of age[12,13]. In both series, incidence of CTD was 53%. Operative mortality is low in these young patients (3%-6%) with a low reintervention rate (< 4% at 10 years in both series). As complex endovascular TAAA repairs have been mostly used in older, high-risk patients, there is no study available to discuss the feasibility of endovascular TAAA repair in the younger population.

In conclusion, younger TAAA patients with CTD should be considered for open surgical repair due to both short-term and long-term benefits.

HOSPITAL/SURGEON CASE VOLUMES

There is a clear relationship between hospital volume and operative mortality after open TAAA repair. A US-based study using Nationwide Inpatient Sample, including 1,542 patients and 20% of US hospitals, demonstrated a near doubling of operative mortality after open TAAA repair at the low-volume hospitals (median annual case: 1) compared to that of high-volume hospitals (median annual case: 12) (27% *vs.* 15%, $P < 0.001$)[14]. This study also showed a similar relationship in surgeon volume-operative mortality (low-volume surgeon: median annual case of 1; high-volume surgeon: median annual case of 7; operative mortality 26% *vs.* 11%, < 0.001)[13].

Similarly, a recent study using the Vascular Quality Initiative database evaluated the impact of hospital volume on operative mortality after endovascular TAAA repair in 2,115 patients from 118 centers[15]. The study demonstrated that centers with low and medium quantile volumes (mean annual case: 3.6 and 9.3) had higher 30-day mortality rates compared to the high-volume hospitals (mean annual case: 22.7) (unadjusted 30-day mortality 5.1%, 6.5%, 2.2%, respectively, $P = 0.002$). Of note, for complex fenestrated-branched EVAR, there is a learning curve, even after 300 cases[16]. Preoperative planning of fenestrations and cannulation of branch vessels represent a significant portion of the learning curve with these devices[17].

Thus, if the patient with TAAA was suitable to be treated by either of the procedures, it may be reasonable to be treated using the approach that the treating institution is more proficient and experienced in. However, if the institution is not well experienced with either open or endovascular aortic repair, stable TAAA patients should be referred to an experienced aortic center for the patient's benefit.

SUMMARY

For patients with stable TAAA, it is recommended to refer them to experienced aortic centers. Open surgical TAAA repair should be considered in patients with connective tissue disorders, younger age (less than 50 years old), and ruptured hemodynamically unstable TAAA. Endovascular TAAA repair should be considered in patients with sarcopenia, advanced age, renal dysfunction, and lung dysfunction, if they have suitable anatomy. The two approaches should remain complementary.

DECLARATIONS

Authors' contributions

Responsible for the overall concept and design of this paper: Tanaka A, Smith HN, Estrera AL
Responsible for writing and research: Tanaka A, Smith HN
Reviewed and approved the final version: All three authors

Availability of data and materials

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Conflicts of interest

Estrera AL is a consultant for WL Gore, CryoLife, Edwards Life Science, and Terumo Aortic.
The other authors have no disclosures.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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