Cleveland Clinic surgeons perform some of the most complex aortic procedures in the world. They achieve excellent outcomes through the combination of experience and use of the most advanced conventional, minimally invasive, and endovascular techniques to treat all sections of the aorta. Over the past 20 years, thoracic aorta surgical volumes have increased by 6 times, and the program is now the largest in the world.

**Aortic Surgery**

**Volume and Type**

<table>
<thead>
<tr>
<th>Year</th>
<th>Volume</th>
<th>2015 Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1173</td>
<td>Open ascending/arch repair (N = 718)</td>
</tr>
<tr>
<td>2012</td>
<td>1194</td>
<td>Open descending/thoracoabdominal repair (N = 66)</td>
</tr>
<tr>
<td>2013</td>
<td>1219</td>
<td>Endovascular descending/thoracoabdominal repair (N = 216)</td>
</tr>
<tr>
<td>2014</td>
<td>1230</td>
<td>Open abdominal repair (N = 85)</td>
</tr>
<tr>
<td>2015</td>
<td>1185</td>
<td>Endovascular abdominal repair (N = 93)</td>
</tr>
<tr>
<td></td>
<td>1185</td>
<td>Endovascular ascending aorta repair (N = 7)</td>
</tr>
</tbody>
</table>

**In-Hospital Mortality (N = 1185)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td></td>
</tr>
</tbody>
</table>

AAA = abdominal aortic aneurysm, TAAA = thoracoabdominal aortic aneurysm

Source: Data from the Vizient Clinical Data Base/Resource Manager™ used by permission of Vizient. All rights reserved.
Aortic Disease

Guidelines Clarification for Aneurysm Repair in Patients With a Bicuspid Aortic Valve

A recent guidelines clarification statement by ACC/AHA/STS recommends more aggressive replacement of the ascending aorta for some patients, provided the surgery center has documented excellent outcomes for elective ascending aorta replacement surgery. This recommendation applies to those with an aortic diameter > 5 cm or a maximum aortic area-to-height ratio > 10 and risk factors such as a family history or hypertension in the setting of a bicuspid aortic valve.\(^1\)\(^2\)

This clarification statement was, in part, based on research published by Cleveland Clinic’s Aorta Center.

References


Cleveland Clinic surgeons performed 215 emergency open repairs of the ascending aorta and aortic arch in 2015, including acute aortic dissections and ruptures. These procedures are particularly urgent and challenging. The in-hospital mortality rate was 7.4% in 2015.

Ascending Aorta Stent Grafting

Surgeons at Cleveland Clinic’s Aorta Center have pioneered and become world leaders in performing less invasive transcatheter repairs of the ascending aorta. To date, they have performed more than 30 procedures. These techniques offer the highest-risk patients a safe treatment option, when there previously had been no safe alternative.1 The image to the right is from an 85-year-old man who had a large pseudoaneurysm behind the sternum. Early feasibility trials with newer devices designed specifically for this indication will begin in the coming months.

Reference

Aortic Disease

An increasing number of patients with connective tissue disorders such as Marfan syndrome and Loeys-Dietz syndrome are being diagnosed with aortic aneurysms. Up to 2% of the population is born with a bicuspid aortic valve that is commonly associated with thoracic aortic aneurysm.

Valve-Preserving Operations
Cleveland Clinic surgeons are among the most experienced in the world at performing valve-preserving aortic root aneurysm repairs (modified David’s valve reimplantation procedure). They have performed 569 of these procedures, including 62 in 2015 (0% in-hospital mortality). In a recently published analysis of 178 patients with connective tissue disorder, freedom from reoperation at 6 years was 92%. Cleveland Clinic surgeons are also using this technique more often to stabilize the aortic root in patients who have bicuspid aortic valves (intraoperative photograph shown).¹

Modified David’s Valve Reimplantation Procedure

<table>
<thead>
<tr>
<th>Year</th>
<th>Volume</th>
<th>In-hospital mortality (%)</th>
<th>Expected (%)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>62</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reference

Less Invasive Endovascular Treatment for Aortic Arch Disease
Because the vessels that supply the brain originate from the aortic arch, outcomes after surgery involving this segment are particularly dependent on experience. Even at high-volume centers, some high-risk patients may benefit from an alternative treatment. Cleveland Clinic aortic surgeons helped develop totally endovascular techniques to repair the arch. Both double-branched endovascular devices (left) and single-branched devices (right) are being investigated in trials at Cleveland Clinic.¹²

References

Aortic Arch Aneurysm Repairs

Elective Aortic Arch Aneurysm Open Surgery Volume, Stroke Rate, and In-Hospital Mortality
2011 – 2015

At Cleveland Clinic in 2015, 116 patients had elective surgery to repair the aortic arch. The in-hospital mortality rate was 3.4%, compared with the expected rate of 5.1%.

Emergency Aortic Arch Aneurysm Open Surgery Volume, Stroke Rate, and In-Hospital Mortality
2011 – 2015

A total of 93 Cleveland Clinic patients had emergency open procedures to repair the aortic arch in 2015.

Novel Hybrid Arch Repair

Hybrid aortic surgery involves the use of multiple techniques and tools, including cardiopulmonary bypass, active cooling, continuous direct blood flow to the brain, and direct placement of stent graft devices for extended repair in patients with complex disease involving the aortic arch. Cleveland Clinic aortic surgeons have developed new techniques to perform a modified branched frozen elephant trunk procedure to reduce the time and risk associated with conventional extended open repair.
Physicians and surgeons in Cleveland Clinic’s Aorta Center have the largest single-center experience in the US for treating patients with aortic dissection involving the descending aorta. Up to half of these patients go on to have thoracic endovascular aortic repair during the acute or chronic phase of follow-up. Cleveland Clinic uses a prospectively collected database to track these patients and better understand the natural history and outcome of their care.

**Descending Thoracic Aortic Disease**

Aortic dissections and ruptured aneurysms commonly occur in the descending thoracic aorta (DTA). Patients with these conditions need prompt evaluation and treatment. Cleveland Clinic surgeons use open and endovascular repair techniques with excellent outcomes, and they tailor the choice to each patient’s needs.

**DTA Repair Volume and Type (N = 882)**

2011 – 2015

- 10% open emergency (N = 89)
- 21% open elective (N = 185)
- 23% endovascular emergency (N = 203)
- 46% endovascular elective (N = 405)

The majority of the 882 DTA repairs performed at Cleveland Clinic from 2011 through 2015 were done using an endovascular approach.

**DTA Repair In-Hospital Mortality (N = 882)**

2011 – 2015

- Emergency: 0%
- Elective: 0%

Extensive experience with both open and endovascular treatment options for patients with descending thoracic aortic disease results in lifesaving therapy for patients. This includes even those who require high-risk emergency treatment.
**Lifelong Disease Management**

Patients with aortic dissection and/or aortic aneurysm often have multiple segments of their aorta affected by the disease at any one time and may develop new aneurysms or further degeneration during long-term follow-up. The Aorta Team at Cleveland Clinic’s Aorta Center provides comprehensive management of all patients with aortic disease, including lifelong follow-up in the dedicated aorta clinic. After patients survive an emergency event or if they are fortunate enough to have their aortic disease discovered before an emergency, their regularly scheduled visits will typically include a visit with both a surgeon and a cardiologist. Dedicated heart and vascular imaging specialists ensure that imaging studies such as CT scans or MRIs are done as safely and accurately as possible by tailoring the data acquisition to each patient’s condition.

**Outpatient Aortic Visits**

**2013 – 2015**

![Volume chart showing visits by specialty from 2013 to 2015](image)

<table>
<thead>
<tr>
<th>Year</th>
<th>Cardiovascular medicine</th>
<th>Cardiac &amp; thoracic surgery</th>
<th>Vascular surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>4386</td>
<td>1000</td>
<td>500</td>
</tr>
<tr>
<td>2014</td>
<td>4584</td>
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<tr>
<td>2015</td>
<td>4629</td>
<td>1000</td>
<td>500</td>
</tr>
</tbody>
</table>

**Continuing the Legacy of Innovative Endovascular Aneurysm Repair**

Cleveland Clinic surgeons have been intimately involved in the development of endografts for the treatment of patients with aortic disease. The first endografts for abdominal aortic aneurysms were used at Cleveland Clinic in 1995. Since then, Cleveland Clinic physicians have been actively involved in device development and trials and have helped lead the evaluation of new systems and treatment approaches.
Thoracoabdominal Aortic Aneurysm Surgeries (N = 656)
The most challenging aortic procedures involve patients with thoracoabdominal aortic aneurysms (TAAAs). Cleveland Clinic surgeons have extensive experience using both open and endovascular techniques to treat these patients.

TAAA Surgeries by Crawford Classification of Aortic Aneurysms
2011 – 2015

Thoracic Endovascular Repair First for Extensive Aortic Disease: The Staged Hybrid Approach
Open and endovascular approaches to aortic repair are complementary. Patients with the most extensive disease such as those with chronic aortic dissection or connective tissue disorders often require multiple operations staged over time. By combining open and endovascular procedures to completely replace the aorta, the overall risk can be lessened.¹²

References
The complex nature of TAAA procedures is associated with a greater risk of death. Cleveland Clinic continuously strives to maintain the lowest mortality rates possible.

Branched Aortic Endografts for Inoperable Patients With Extensive Aneurysms

Fenestrated and branched endografts allow treatment of patients with complex aortic disease that involves the visceral and renal vessels of the aorta. Cleveland Clinic surgeons started developing and using this technology in 2001. The endografts can safely be used to treat patients with the most extensive aneurysmal disease that affects the aorta, including those deemed unfit for conventional open surgery.

Despite the complexity of these type II and III thoracoabdominal aortic aneurysms and the increased risks for these patients, the mortality rate was only 4.8%, and preservation of blood flow to the visceral vessels was achieved in more than 98% of the branches.\(^1\)

Reference

Aortic Disease

Abdominal Aortic Aneurysms

The abdominal aorta is second to the ascending aorta for aneurysm repair volume at Cleveland Clinic. Surgeons treat patients with abdominal aortic aneurysms (AAAs) both below and adjacent to the renal arteries using both open and endovascular repair procedures.

AAA Procedure Volume and Type (N = 843)

Cleveland Clinic surgeons performed 843 AAA repairs from 2011 through 2015. Outcomes at Cleveland Clinic are excellent for both types of surgery.

Preservation of Pelvic Flow

Over the past decade, Cleveland Clinic physicians helped pioneer the use of branched aortic endografts designed to preserve blood flow to the internal iliac arteries during repair of aortoiliac artery aneurysms. The use of this technology can help preserve blood flow in the pelvis following aneurysm repair, which can prevent complications such as pain, spinal cord ischemia, and bowel ischemia. Because of their experience, Cleveland Clinic physicians have helped lead enrollment in national trials that resulted in FDA approval of the endografts.

Open AAA Repair Volume and Type (N = 392)

Cleveland Clinic surgeons performed 392 open AAA repairs from 2011 through 2015. The majority of these procedures were elective.
Cleveland Clinic surgeons performed 451 endovascular AAA repair procedures from 2011 through 2015. A total of 37 fenestrated grafts were used to repair juxtarenal aneurysms.

In 2015, Cleveland Clinic surgeons achieved a 0% in-hospital mortality rate for elective open AAA repairs.

EVAR Failures Require Both Open and Endovascular Expertise

Endovascular aneurysm repair (EVAR) is not always durable, and some patients require additional repair after several years. Cleveland Clinic surgeons have developed innovative methods to safely and effectively remove failed aortic endografts. In addition, Cleveland Clinic surgeons have the most experience among US doctors in salvaging these repairs using fenestrated endografts, allowing for a less invasive approach.