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 treatment options, including conventional, minimally invasive, and endovascular techniques. Surgeons use a multidisciplinary, comprehensive approach to treat patients with diseases involving all sections of the aorta, from the aortic root to the blood supply and pelvic vasculature. 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

#### 2014 Volume (N = 1230)

<table>
<thead>
<tr>
<th>Year</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>762</td>
</tr>
<tr>
<td>2011</td>
<td>88</td>
</tr>
<tr>
<td>2012</td>
<td>200</td>
</tr>
<tr>
<td>2013</td>
<td>94</td>
</tr>
<tr>
<td>2014</td>
<td>1230</td>
</tr>
</tbody>
</table>

#### 2014 Totals

- Open ascending/arch repair (N = 762)
- Open descending/thoracoabdominal repair (N = 88)
- Endovascular descending/thoracoabdominal repair (N = 200)
- Open abdominal repair (N = 86)
- Endovascular abdominal repair (N = 94)

### Aortic Surgery In-Hospital Mortality (N = 1230)

<table>
<thead>
<tr>
<th>Type</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elective</td>
<td></td>
</tr>
<tr>
<td>Expected</td>
<td></td>
</tr>
<tr>
<td>Emergency</td>
<td></td>
</tr>
</tbody>
</table>

Open/Endovascular

Abbreviations: AAA = abdominal aortic aneurysm, TAAA = thoraco-abdominal aortic aneurysm

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

Aneurysm Repair in Patients with Bicuspid Aortic Valves
2011 – 2013

Cleveland Clinic surgeons performed 281 aortic aneurysm repairs for patients with bicuspid aortic valves in 2014.

Up to 2% of the population is born with a bicuspid aortic valve. It is estimated that 30%-50% of those patients are prone to develop an aneurysm of the proximal aorta including the root, ascending, and arch to varying degrees. In a recent analysis of more than 800 patients with bicuspid valves undergoing both elective and emergency surgery at Cleveland Clinic, mortality was 0.25% and the stroke rate was 0.7%.


In 2014, Cleveland Clinic surgeons performed 762 open procedures to repair the ascending aorta.

Elective Ascending Aorta and Aortic Arch Open Surgery Volume, Stroke Rate, and In-Hospital Mortality 2014 Volume (N = 550) 2010 – 2014

In 2014, Cleveland Clinic surgeons performed 550 elective open procedures to repair the ascending aorta and aortic arch. The in-hospital mortality rate was 1.6%, which was lower than the expected rate of 3%. The rate of stroke was 1.1% at Cleveland Clinic.

Source: Data from the UHC Clinical Data Base/Resource Manager™ used by permission of UHC. All rights reserved.
Emergency Ascending Aorta and Aortic Arch Open Surgery Volume and In-Hospital Mortality
2014 Volume (N = 212)
2010 – 2014

Cleveland Clinic surgeons performed 212 emergency open repairs of the ascending aorta and aortic arch in 2014, including acute aortic dissections and ruptures. These procedures are particularly urgent and challenging, yet in-hospital mortality was low at 7.5%, compared with the expected rate of 8.9%.

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

Ascending Stent Grafting

Over the past 8 years, aortic surgeons at Cleveland Clinic have pioneered and become world leaders in the use of stent grafts for ascending aorta repair to treat high-risk patients. Indications have included acute type A dissection, intramural hematoma, pseudoaneurysm, and chronic dissection. The use of these novel techniques has saved the lives of many patients.

An increasing number of patients with connective tissue disorders like 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-Sparing Operations**
Cleveland Clinic surgeons are among the most experienced in the world for valve-sparing aortic root aneurysm repairs (“modified David’s valve reimplantation procedure”). They have performed 507 of these procedures, including 71 in 2014 (0% 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.

**Modified David’s Valve Reimplantation Procedure**
**2014 Volume (N = 71)**
2010 – 2014

![Graph showing volume from 2010 to 2014]


**Less Invasive Endovascular Treatment for Aortic Arch Disease**
Aneurysmal disease of the aortic arch remains a surgical challenge. Conventional surgery has limitations for high-risk patients and presents the need for alternative treatment. Cleveland Clinic surgeons have been intimately involved in the development of endograft techniques to repair these types of aneurysms. This includes participation in an international assessment of this procedure to demonstrate the safety and improved outcomes with the use of these techniques.

Aortic Arch Aneurysm Repairs

Elective Aortic Arch, Open Surgery Volume, Stroke Rate, and In-Hospital Mortality
2014 Volume (N = 149)
2010 – 2014
At Cleveland Clinic in 2014, a total of 149 patients had elective surgery to repair the aortic arch. The in-hospital mortality rate was 3.4% compared with the expected rate of 4%, and the stroke rate was 2.7%.

Brain Protection Strategies
Cleveland Clinic surgeons, anesthesiologists, and perfusionists perform more than 400 cases per year using hypothermic circulatory arrest and have mastered the techniques of brain protection. Cleveland Clinic surgeons were the first to demonstrate the benefits of axillary artery cannulation to reduce stroke during complex aortic surgery. In a recently published randomized controlled trial comparing adjunctive brain protection strategies, the rate of stroke was 0.8% and important nuances about cognitive impairment were elucidated.

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Emergency Aortic Arch Aneurysm Open Surgery Volume, Stroke Rate, and In-Hospital Mortality
2014 Volume (N = 71)
2010 – 2014
A total of 71 Cleveland Clinic patients had emergency open procedures to repair the aortic arch in 2014. The stroke rate was reduced to 1.4%.

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Aortic Disease (continued)

**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 both open and endovascular repair techniques with excellent outcomes, and tailor the choice to each patient’s needs.

**DTA Repair Volume and Type (N = 845)**

2010 – 2014

- 8% Open emergency (N = 67)
- 16% Open elective (N = 139)
- 25% Endovascular emergency (N = 213)
- 51% Endovascular elective (N = 426)

The majority of the 845 DTA repairs performed at Cleveland Clinic from 2010 through 2014 were done using an endovascular approach.

**DTA Repair In-Hospital Mortality (N = 845)**

2010 – 2014

<table>
<thead>
<tr>
<th>Type</th>
<th>2010-2013</th>
<th>2014</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Emergency</td>
<td></td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Open Elective</td>
<td>16%</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Endovascular</td>
<td>10%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Endovascular</td>
<td></td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

Extensive experience with both open and endovascular treatment options for patients with descending thoracic aortic disease allows us to offer lifesaving therapy to patients. This includes even those who require high-risk emergency treatment. For elective repairs, the in-hospital mortality rate was low at 3.7% for open repairs and 1% for endovascular repairs in 2014.
Thoracic Endovascular Aortic Repair (TEVAR) for Acute Descending Dissections

In a recent analysis of 520 patients treated at Cleveland Clinic since 2005 for acute aortic syndrome, 238 (48%) required aortic intervention. A detailed analysis of CT scans demonstrated that several important findings predicted both early and late death or need for intervention.


Permanent Spinal Cord Ischemia Rates Reduced to 0% Following Staged Endovascular Repair

Neurologic dysfunction, in particular spinal cord ischemia (SCI), is a devastating complication after thoracoabdominal aortic aneurysm (TAAA) surgery. Cleveland Clinic surgeons have demonstrated that performing endovascular TAAA repairs in a staged fashion reduces the incidence and severity of SCI. The rate of permanent SCI among patients who had staged repair was 0%, compared with 17% among those who had a single procedure.


Permanent Paraplegia and Paraparesis Reduced by Papaverine

In a study conducted at Cleveland Clinic, the use of intrathecal papaverine during descending thoracic aneurysm and thoracoabdominal aortic aneurysm repair halved the risk of paraplegia and reduced the risk of paraparesis to one quarter the rate.

**Outcomes 2014**

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**TAAA Surgeries**
The most challenging aortic procedures involve patients with thoraco-abdominal 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**

2010 – 2014

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**Cleveland Clinic Approach to Treating Patients With Thoracoabdominal Aortic Aneurysms**

Cleveland Clinic uses a team approach to treat patients with thoracoabdominal aortic aneurysms (TAAAs). This strategy enables individualized care tailored to each patient’s needs, anatomy, and medical conditions. This multidisciplinary approach includes early and long-term considerations to ensure patient safety.
The complex nature of TAAA procedures is associated with a greater risk of mortality. Cleveland Clinic continuously strives to maintain the lowest mortality rates possible. In 2014, the in-hospital mortality rate for endovascular branch vessel procedures was 1.47%. The rate for open elective repairs was 0%. Emergency repairs require open surgery. The mortality rate for these procedures was 6.25%.
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 = 857)
2010 – 2014

Cleveland Clinic surgeons performed 857 AAA repairs from 2010 through 2014. The majority of these were endovascular procedures, which are associated with less risk. However, outcomes at Cleveland Clinic are excellent for both types of surgery.

Open AAA Repair Volume and Type (N = 387)
2010 – 2014

Cleveland Clinic surgeons performed 387 open AAA repairs from 2010 through 2014. The majority of these procedures were elective.
Cleveland Clinic surgeons performed 470 endovascular AAA repair procedures from 2010 through 2014. A total of 35 fenestrated grafts were used to repair juxtarenal aneurysms.

In 2014, Cleveland Clinic surgeons achieved a 0% in-hospital mortality rate for elective open AAA repairs.

Cleveland Clinic surgeons achieved 0% in-hospital mortality rates for both elective and emergency endovascular AAA repair in 2014.