Chapter 18
Thoracic Aortic Aneurysm Chapter

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Evaluating Patient

What is a thoracic aortic aneurysm (TAA)?	Localized dilatation of the thoracic aorta greater than 50% of normal. The upper limit of normal caliber for the descending thoracic aorta is 3–3.5 cm.
What are the two major types of aneurysms?	80% are fusiform (uniform and circumferential) and 20% are saccular (localized outpouching).
What chest X-ray findings that should raise suspicion for a thoracic aortic aneurysm?	Widening of the mediastinal silhouette, enlargement of the aortic knob, and tracheal or esophageal deviation

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Which imaging modality is most critical for evaluating thoracic aortic aneurysms?	Computed tomography angiography (CTA) from the thoracic inlet to the femoral artery bifurcations. Non-contrast images help visualize calcifications and intramural hematomas, while arterial-phase angiography provides accurate aneurysm measurements.
What are additional imaging modalities that can be used to further evaluate thoracic aortic aneurysms?	Magnetic resonance angiography (MRA), transesophageal echo (TEE), and intravascular ultrasound (IVUS)
Why is it important to thoroughly assess the femoral and iliac vasculature?	Significant tortuosity, thrombus, or calcification might preclude an endovascular approach. Adequate vessel caliber is essential for accommodating the endograft delivery system.

High Yield History

What is the prevalence of thoracic aortic aneurysms?	6–10 per 100,000
What is the average age of diagnosis?	65 years old, with women presenting approximately 10 years later than men
Is there a gender predominance?	Slightly, with a male-to-female ratio of 1.5:1–1:1
What are the risk factors?	Atherosclerosis, aortic dissection, connective tissue disorders, family history, trauma, infection, and vasculitis

Which connective tissue disorders are associated with TAAs?	Marfan syndrome, Ehlers-Danlos syndrome, Loeys-Dietz syndrome, and Turner syndrome
What are the symptoms of thoracic aortic aneurysms?	Chest discomfort and surrounding organ compression (new onset hoarseness, dysphagia, dyspnea, hemoptysis)
What are the risk factors for aneurysm rupture?	Size > 6 cm, increasing age, and tobacco use
What is the most common complaint associated with rupture or impending rupture?	Acute onset of back and/or chest pain

Indications/Contraindications

What are the methods available for thoracic aortic aneurysm repair?	Aneurysms of the ascending aorta generally require surgical reconstruction, while aneurysms of the descending aorta are addressed with either surgical or endovascular techniques.
What does TEVAR stand for?	*T*horacic *e*ndo*v*ascular *a*ortic *r*epair
TEVAR is approved to treat which medical conditions?	Aortic aneurysmal disease, type B aortic dissection, traumatic aortic transection, and penetrating atherosclerotic ulcer
What are the indications for thoracic aortic aneurysm repair?	1. Size (greater than 5.5 cm) 2. Rapid expansion (greater than 5 mm within 6 months) 3. Symptoms

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What are the advantages of TEVAR over open surgical repair?	Avoidance of thoracotomy or sternotomy, decreased blood loss, reduced spinal cord ischemia, and shorter hospitalizations
What is an endograft "landing zones"?	The landing zones are the sites proximal and distal to the aneurysm where the endograft will "land" during the endovascular repair. In order to ensure stable fixation and adequate seal, there must be 2 cm of healthy, parallel aortic wall both proximal and distal to the aneurysm.
How is the landing zone diameter measured?	From inner wall to inner wall, excluding calcifications but including intraluminal thrombi and plaque
Is unfavorable anatomy an absolute contraindication to TEVAR?	No, various techniques have been developed to overcome these barriers, such as additional cuffs or fenestrated grafts.
Is TEVAR recommended in patients with underlying connective tissue disorders or Takayasu?	No, because the fragile tissue is not suitable for long-term endograft seal.

Relevant Anatomy

What are the three components of the thoracic aorta?	1. Ascending aorta 2. Aortic arch 3. Descending aorta

Where is the most common site of thoracic aortic injury when the body undergoes significant deceleration?	The aortic isthmus is the most common site of origin of aortic dissection. The isthmus is a constriction of the aortic arch just distal to the origin of the left subclavian artery at the site of the ductus arteriosus.
Which vessels supply the anterior spinal cord?	The vertebral arteries
Which vessels supply the posterior spinal cord?	The posterior inferior cerebellar arteries
What is the great radicular artery of Adamkiewicz?	The principal vessel that feeds the lower thoracic, lumbar, and sacral portions of the spinal cord. The vessel most commonly arises between T9 and T12 from a single intercostal artery as the anterior radiculomedullary artery that continues as a hairpin loop, forming the characteristic appearance of the artery of Adamkiewicz. Specifically, the artery arises on the left from the radicular anterior artery of the spinal branch of the posterior intercostal artery. The origin of the artery can occur as high as T6.
Which vessel(s) gives rise to the intercostal arteries?	The subclavian arteries provide the first two intercostal arteries and the descending thoracic aorta provides the remaining nine intercostal arteries.

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Relevant Materials

What are the recommended aortic measurements for stent-graft placement in a descending TAA?	Proximal and distal neck diameter of less than 42 mm is recommended to prevent stent migration. Aneurysm length and total treatment length measurements ensure adequate stent coverage of the aneurysm. Radius of curvature of greater than 35 mm or aortic angulation of less than 60° is recommend to achieve adequate circumferential seal and prevent endoleaks.
For descending TAAs, the stent-graft diameter is generally oversized by how much relative to luminal diameter of the landing zones?	10–20% to select the most correct diameter of the endoprosthesis and to ensure a tight circumferential seal and secure anchoring to prevent migration
An access vessel of what size is necessary for a standard 24 Fr delivery device?	A vessel of at least 8 mm in diameter given 1 Fr is equal to 0.33 mm diameter, and therefore, 24 Fr is equal to 8 mm diameter. In calcified vessels, open surgical cutdown is preferred.

General Step by Step

Why should arterial pressure be continuously monitored during the thoracic stent-graft placement?	In addition to continuous monitoring of vital signs, arterial pressure should be closely monitored to avoid hypotension and decrease the risk of spinal cord ischemia.

What can be used to detect neurologic complications?	Intraoperative somatosensory-evoked potentials (SSEP) and motor-evoked potentials (MEP) help monitor spinal cord function to prevent injury and allow for early treatment if detected. Intervention includes draining CSF if CSF pressure becomes elevated and ensuring adequate spinal cord blood flow by maintaining a minimum distal arterial pressure of 60 mmHg.
What should the achieved activated clotting time be in heparinized patients?	Patients should be anticoagulated throughout the procedure to achieve an activated clotting time of 250–300 s to reduce thromboembolic complications. However, increased activated clotting times > 300 s may increase bleeding complications. Protamine is given for reversal of heparin anticoagulation. Most serious reaction to protamine is anaphylaxis, characterized by circulatory shock, severe bronchospasm, and occasionally cardiac arrest.
What is the preferred arterial access for thoracic stent-graft placement?	Common femoral artery (external iliac or common iliac arteries may also be accessed)
After gaining arterial access in the contralateral common femoral artery for the initial aortogram, what should be done next?	Place a vascular sheath and advance marker pigtail catheter to the proximal aortic arch.

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What injection rate and size marker pigtail catheter should be used for injection in the ascending aorta?	Injection rate of 15 cc/second for a total of 30 cc and 5- to 7-Fr pigtail catheter should be used.
The thoracic stent-graft delivery system should be advanced over what type of wire?	Super stiff 0.035″ guidewire
For the initial aortogram, how should the fluoroscope be positioned?	Left anterior oblique (LAO) to visualize the arch and accurately profile the great vessels
For the thoracic stent-graft deployment, how should the fluoroscope be positioned?	Perpendicular to the proximal landing zone
After advancing the endograft delivery system to the target site, how do you confirm positioning?	Locate the radiopaque markers and expose the first two springs. Ensure the proximal and distal springs are at adequate landing zones of at least 20 mm.
How should the thoracic stent-graft be deployed?	Under continuous fluoroscopic visualization to confirm positioning
What can be done to prevent migration of the thoracic stent-graft during deployment?	Maintain low mean arterial pressure (MAP) (60–70 mmHg) with the use of sodium nitroprusside.

After deployment of the stent graft and careful withdrawal of the delivery catheter, what should be done next?	A completion angiogram to confirm stent-graft placement and absence of endoleak
What is the role of compliant balloon angioplasty?	It helps model the stent graft to the vessel wall to ensure wall apposition and seal
What if additional devices are needed for adequate coverage of the TAA?	Ensure an overlap of a minimum of 30 mm of the stent-graft material. In areas of angulation or curvature, an additional overlap of 50 mm is required with a minimum of 45 mm.

Complications

TAA can cause what types of complications?	Rupture, distal embolization, compression of adjacent structures (trachea, esophagus, pulmonary vein or artery, superior vena cava), stretching of the recurrent laryngeal nerve, fistula (trachea or bronchus, superior vena cava, esophagus), or infection
What are some early and late complications of the thoracic stent-graft placement?	Aortic perforation, endoleaks, stent fracture, and device malposition, migration, or collapse

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What is an endoleak?	An endoleak is the persistent perfusion of the aneurysm sac outside of the stent graft. Endoleak complications may occur up to 25% of the time.
What are the dreaded complications after treatment of a TAA?	Spinal cord ischemia (0.8–3%) resulting in paraparesis or paraplegia, anterior spinal syndrome, and cerebrovascular stroke (2.1–3.6%)
How can you prevent and reverse spinal cord ischemia?	Prophylactic CSF drainage should be considered in patients with prior history of abdominal aortic aneurysm repair, hypotension (mean arterial pressure < 70 mmHg), stent-graft coverage between T8 and L2, and treatment length >20 cm. If detected early, it may be reversed with prompt CSF drainage and maintaining a mean blood pressure between 80 and 90 mmHg.
What are the types of complications that can occur at the vascular access site?	Thrombosis, dissection, rupture, and avulsion
What is postimplantation syndrome?	It is a self-limited early complication of stent-graft placement, which usually resolves within a week. Patients may present with low-grade fever, elevated C-reactive protein, mild leukocytosis, and possible reactive pleural effusion. The symptoms usually resolve within 1 week and are managed with analgesics and anti-inflammatory agents.

Landmark Research

In the VALOR Trial, what was the bottom line of the 5-year follow-up with the Talent Thoracic Stent Graft?	TEVAR using the Talent Thoracic Stent Graft System demonstrated sustained protection from thoracic aortic aneurysm-related mortality, aneurysm rupture, conversion to surgery, and durable stent-graft performance.
What are the results of the VALOR Trial through the 5-year follow-up?	Kaplan-Meier estimates for freedom from all-cause mortality at 1 year and 5 years were 83.9% (standard error [SE] 2.6%) and 58.5% (SE 3.7%), respectively. Estimated freedom from aneurysm-related mortality (ARM) at 1 year and 5 years was 96.9% (SE 1.3%) and 96.1% (SE 1.4%), respectively. Freedom from secondary endovascular procedures was 81.5% (SE 3.3%). 5-year estimate of survival free from aneurysm rupture was 97.1% (SE 1.5%). 5-year estimate of conversion-free survival was 97.1% (SE 1.4%). 5-year estimate of freedom from stroke was 88.2% (SE 6.0%), and spinal cord ischemia (SCI) was 92.3% (SE 4.8%).

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What are the main lessons from the 5-year follow-up for treatment of thoracic aneurysms with TEVAR using the Gore TAG compared with open surgery?	At 5 years, no ruptures, one migration, no collapse, and 20 instances of fracture in 19 patients were noted in the TAG group with authors claiming occurred prior to the Gore TAG revision. Treatment of thoracic aneurysms is superior to surgical repair at 5 years: Aneurysm-related mortality was lower for TAG 2.8% compared with open repair 11.7% ($P = 0.008$). No differences in all-cause mortality between TAG 68% and 67% of open repair ($P = 0.43$). Major adverse events were significantly reduced in the TAG group 57.9% vs open repair 78.7% ($P = 0.001$). Endoleaks in the TAG group decreased from 8.1% at 1 month to 4.3% at 5 years.

What are the 5-year results between open surgical repair and thoracic endovascular aortic repair with Zenith TX2 in the treatment of degenerative aneurysms and ulcers of the descending thoracic aorta?	Similar survival estimates from all-cause mortality for TEVAR were 62.9% and 62.8% for open repair and aneurysm-related mortality with TEVAR 94.1% compared with open repair 88.3%. Kaplan-Meier estimates of freedom from severe morbid events (paraplegia, return to operating room for bleeding, and permanent dialysis) for TEVAR and open repair were 87.3% vs 64.3% at 1 year and 79.1% vs 61.2% at 5 years. Kaplan-Meier estimates of freedom from secondary intervention were 91.5% for TEVAR and 88.4% for the open repair at 5 years. TEVAR with the TX2 is a safe and effective alternative to open surgical repair for the treatment of anatomically suitable descending thoracic aortic aneurysms and ulcers.

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At the 2-year follow-up, what did the RELAY Endovascular Registry for Thoracic Disease II (RESTORE II) study demonstrate?	It showed the safety and effectiveness of RELAY and RELAY NBS stent grafts for elective endovascular thoracic aortic repair, as well as their lower rate of perioperative complication compared with the RELAY first-generation device. Rate of all-cause 30-day mortality was 4.2% vs the RESTORE registry 7.2%. Perioperative neurologic complications were lower in RESTORE II vs RESTORE study paraplegia/paraparesis (2.9% vs 2.0%) and stroke (0.6% vs 1.6%), respectively. Device-associated complications were detected in 4.6% of the patients in RESTORE II vs 5.3% in RESTORE study. Endoleak rate was 6.4% (type I 5.8% and type II 1.7%).

Common Questions

What are the types of endoleaks?	Type 1: Inadequate seal of proximal/distal attachment site Type 2: Retrograde perfusion of the aneurysm via branch vessels Type 3: Inadequate seal between endograft components Type 4: Endograft porosity (rare) Type 5: Endotension (aneurysm sac expansion without an identifiable endoleak on angiography or CTA)

What is the most common type of endoleak?	Type 2
Which type(s) of endoleak should be treated immediately?	Type 1 and type 3 because of the increased risk of aneurysm rupture secondary to the direct communication with high-pressure arterial blood. Type 1 endoleaks may be corrected by securing the attachment sites with balloon angioplasty to produce an adequate seal between the stent and vessel wall. If the vessel leak persists, then balloon-mounted bare metal stents or stent-graft extensions can be used to secure the attachment sites. Type 3 endoleaks may be corrected by covering the inadequate seal between endograft components with a stent-graft extension. If type 1 and type 3 endoleaks continue following an endovascular approach, then conversion to open repair should be considered.
What is the type of imaging surveillance recommended for clinical follow-up?	CTA may be performed at 1–3, 6, and 12 months. The CTA should include an unenhanced, enhanced arterial phase, and a delayed series to evaluate for endoleak, graft migration, or aneurysm sac enlargement. MRA can be used as an alternative to CTA in patients with renal disease (compatibility of stent graft must be verified prior to imaging the patient). Unenhanced images help visualize calcifications, which may be confused for an active arterial bleed or intramural hematomas, which are hyperdense on non-contrast studies and may be less obvious after contrast administration.

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What is the technical success rate for thoracic stent-graft placement?	98–99.5%
At 1 year, what is the percentage of descending TAAs that remain stable or decrease (>5 mm) in size?	91–92.9%
At 5 years, what is the aneurysm-related mortality of TAAs with TEVAR versus open surgery?	2.8–5.9% with TEVAR compared with 11.7–12% for open surgery

Further Reading

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