In Part 1 of this 2-part series, the causes of thoracic aneurysms and the noninvasive treatment by stent placement are described. In Part 2, the complications of this therapy and monitoring requirements will be outlined.
Professional Gaps

Thoracic endovascular aneurysm repair represents a technique with special considerations that may not be known by many practicing anesthesiologists. This lesson aims to explain these changes and developments.

Learning Objectives

At the end of this activity, the participant should be able to:

1. Outline the causes of aortic dissection and natural history of descending thoracic aneurysm.
2. Describe the criteria and technique used for performing thoracic endovascular aneurysm repair (TEVAR).
3. Prescribe the preanesthetic assessment of the patient undergoing TEVAR.
4. Evaluate the anesthetic implications for the patient undergoing endovascular graft deployment.
5. Tabulate the criteria for TEVAR.
7. Recognize the off-label status of endovascular stents when used in the treatment of aortic dissection.
8. List the indications for stent graft placement.
9. Identify perioperative goals.
10. Describe the intraoperative use of adenosine.

Case History

A 67-year-old woman presented to the emergency room with severe back pain and diaphoresis. She had a history of hypertension and coronary artery disease (CAD). Computed tomography (CT) angiogram revealed an aortic dissection involving the descending thoracic aorta distal to the left subclavian artery origin extending to the aortic bifurcation. There was a 6-cm dilatation of the proximal region of the descending thoracic aorta with evidence of extravasation. There was no disruption of blood flow to the celiac axis, superior mesenteric, and renal vessels on angiogram. Cardiac catheterization revealed nonobstructive CAD and an ejection fraction of 40%. Transthoracic echo revealed left ventricular hypertrophy with normal aortic root and ascending aorta.

On physical examination, the patient had no neurologic deficits; blood pressure (BP) was 170/110 mm Hg; heart rate was 110 beats per minute; and all peripheral pulses were palpable. She was scheduled to undergo thoracic endovascular stent placement to create a seal at the area of extravasation.

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Causes of Aortic Dissection

Aortic dissection occurs when an intimal tear develops, permitting entry of blood to a diseased media characterized by elastic degeneration and loss of smooth muscle cells. Causes include connective tissue disorders, chronic arterial hypertension in combination with atherosclerosis, decelerating injuries,
blunt trauma, pregnancy, and use of tobacco and cocaine. Descending thoracic aorta dissections that are distal to the origin of the left subclavian artery are classified as DeBakey type III or Stanford type B, and may extend to the aortic bifurcation.

The mean growth rate for thoracic aneurysms is 0.1 cm per year, with the site of the aortic aneurysm directly correlating with rupture, dissection, and death. Aneurysms that have reached 5 cm in diameter have a faster rate of enlargement with increased risk for rupture. Independent risk factors for rupture of a thoracoabdominal aortic aneurysm (TAAA) include nondimensional characteristics, such as a history of tobacco use, presence of chronic obstructive pulmonary disease (COPD), advanced age, and the presence of hypertension.¹

Diagnostic techniques for aortic dissections include CT, transesophageal echocardiography (TEE), magnetic resonance imaging (MRI), and aortography.

Criteria Used To Determine TEVAR

Thoracic endovascular aneurysm repair (TEVAR) was initially developed for the treatment of degenerative aneurysms of the descending thoracic aorta. It has been applied to the entire spectrum of descending thoracic aortic pathology in both the elective and emergent settings. Emergent TEVAR increasingly is being considered a potentially safer and less-invasive technique for acute surgical emergencies involving the descending thoracic aorta. It entails a lower short-term morbidity and mortality and compares favorably with historic results for emergent open surgical procedures on the descending thoracic aorta.²

Although endovascular stent grafts commonly are used for treatment of aortic dissection in the acute or chronic phases, such use is off-label as the FDA has not yet approved any endovascular stent grafts for treatment of aortic dissections. More evidence is needed to support the use of TEVAR in type B aortic dissection. A nationwide inpatient survey showed that the safe use of the endovascular approach is increasing for older patients with more comorbidities.³

Currently, the indications for stent-graft placement include the obstruction of aortic branch arteries, descending thoracic dissection with intractable pain, extravasation of blood from the aorta (periaortic hematoma) as a sign of impending rupture, or a rapidly expanding false lumen. If attempts at endovascular repair are unsuccessful, open surgical repair may be necessary.¹

Not every patient with a TAAA is considered suitable for TEVAR. Suitability depends on anatomical/pathologic characteristics of the aneurysm (Table 1). The landing zones or neck of the aneurysm is the area of normal aorta situated proximal and distal to the aneurysm. This zone provides a seal zone for the stent graft to fasten in place. When considering the endovascular management of thoracic aortic aneurysms, a proximal and distal landing zone of 2 to 2.5 cm is recommended. The seal zone should be devoid of excessive thrombus or calcification as it may weaken endograft apposition to the aortic wall. Endograft coverage may span regions of thoracic aorta between the left common carotid artery and celiac axis. The celiac axis occasionally may be covered if necessary to achieve an adequate distal seal zone.
Hybrid techniques, including open aortic arch and thoracoabdominal debranching procedures, have been used to allow creation of proximal and/or distal landing zones for the stent-graft seal.4

**Surgical Technique for TEVAR**

An adequately sized femoral or iliac access vessel is necessary for endograft introduction (Figure 1). The endografts generally are introduced via the femoral vessels, although introduction via the iliac arteries may be necessary in some cases if the femoral vessels are unsuitable because of inadequate size or heavy calcification.

A stent graft is a self-expandable stent that is positioned to exclude the aneurysmal sac. The stent is a mesh-like metal structure providing support to the graft. The graft is a special fabric (ie, Dacron or polytetrafluoroethylene) that is impervious to blood and covers the stent (Figure 2). The blood remaining in the aneurysm sac will clot off, sealing the sac. The stent graft used to treat aneurysms is compressed in small-diameter
tubes. When released, the graft expands to its original diameter. The area where the stent graft makes contact with the normal artery is known as the landing or seal zone. The outward radial force of the stent creates a seal in this area, preventing the flow of blood outside the stent graft and into the aneurysmal sac.

After the femoral/iliac vessels are exposed, various catheters are advanced proximally to the descending thoracic aorta under fluoroscopic guidance. The contralateral groin is accessed for intraarterial catheter placement. The patient’s respiration is suspended during digital subtraction angiography as the slightest movement may distort images. Molding of the stent graft is performed with a balloon at all the sealing zones to fix the stents in place. Digital subtraction angiogram confirms stent-graft position, verifies visceral and renal arterial flow, and authenticates that there is no filling of the aneurysm sac (Figure 3).
**Preanesthetic Considerations for TEVAR**

The goal of preoperative evaluation is to optimize the patient’s medical status, and plan an anesthetic technique that minimizes complications. Prior to surgery it is important to discuss with the surgeon the operative procedure, and whether evoked potential (EP) monitoring is planned. Symptomatic patients with leaking aneurysms require urgent intervention, and there generally is little time to perform more than the most basic preoperative assessment.

Systemic hypertension contributes to expansion and rupture of TAAA. All antihypertensive medications should be continued until the time of surgery. β-blockers are used initially to reduce the shear force exerted on the dissection.

Patients undergoing TEVAR are subjected to less hemodynamic stress as the aorta is not cross-clamped, and the anesthesiologist does not have to contend with major fluid shifts and blood loss.

Pulmonary injury is an unlikely event after TEVAR, as increased fluid resuscitation, blood product transfusion, and one-lung ventilation do not complicate the procedure. Dyspnea or stridor may be signs of tracheal/bronchial compression.

A history of transient ischemic attacks, and stroke should be specifically sought preoperatively because of the potential for neurologic complications after surgery. Carotid angiography or duplex studies may be appropriate in patients with a history of strokes or severe atherosclerosis.

Baseline renal insufficiency is related to hypertension, diabetes, and atherosclerotic disease and is an independent predictor of postoperative renal failure. Angiographic contrast dye used preoperatively during CT imaging and during the intraoperative evaluation of the aneurysm often causes transient abnormalities of renal function.

Preoperatively, it is routine to discontinue antiplatelet medications and warfarin. Coagulopathy following TEVAR is uncommon but is likely to occur in the setting of hypothermia, and with use of heparin.

**Anesthetic Considerations During Endovascular Graft Deployment**

Although endovascular repair is a less-invasive procedure, patients should be anesthetized with the possibility that open surgical repair may be necessary. The risk has decreased with improvements in endovascular devices and with greater surgical experience.

Endovascular aortic repair should be classified, similar to aortic and peripheral vascular surgery, as a higher risk procedure.

Perioperative goals during TEVAR are to provide hemodynamic stability while preserving cardiac, spinal, and splanchnic flow; and maintaining intravascular volume, adequate oxygenation, and body temperature. Both general and regional techniques have been used successfully. However, with the increasing use of neurologic monitoring and TEE for TEVAR, general anesthesia is an appropriate choice. Although epidural anesthesia can be used, it may be difficult to distinguish the effects of central neuroaxial blockade by local anesthetics from spinal cord ischemia (SCI). The use of epidural
anesthesia is disadvantageous if lower extremity weakness ensues following operations involving the thoracic aorta. Neurologic examination is performed immediately upon emergence from general anesthesia. Any neurologic deficit detected should be considered to be SCI until disproved.

Various imaging modalities such as angiography, fluoroscopy, and TEE may be used to confirm the position of the stent. The proximal and distal ends of the endograft are then sealed to the aortic wall by endoluminal balloon inflation. The transient balloon inflation may cause a short-lived hemodynamic change that usually will not require any intervention.

Blood loss can be difficult to quantify as it often is lost around the sheaths and catheters and can be retroperitoneal in the case of injury to femoral or iliac vessels. The retroperitoneal approach is an alternative technique used in cases with failed femoral access. However, this approach results in higher risks for retroperitoneal bleeding and a longer procedure time. Because of the difficulty associated with accurate prediction of substantial blood loss and the possible need for allogenic blood transfusion it would be appropriate to set up a cell-salvage device in a back-up mode. Following graft deployment, vasopressors and inotropes are needed to manage hemodynamic emergencies and maintain higher mean arterial pressures.6

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REFERENCES


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Post-test

1. Anesthetic considerations for endovascular graft deployment include all of the following EXCEPT:
   a. The procedure may become open at any time
   b. The procedure is performed on vascular patients with significant comorbidities
   c. Regional techniques are preferred as they facilitate neurologic examination
   d. Vasopressors and inotropes should be immediately available for management of hemodynamic emergencies

2. Aortic dissection is least likely to include:
   a. an intimal tear
   b. loss of smooth muscle cells
   c. blood in the arterial wall
   d. increased elasticity of the arterial wall, which allows ballooning

3. Precipitating causes of aortic dissection include:
   a. chronic hypertension
   b. decelerating injuries
   c. some hereditary disorders such as Marfan’s syndrome
   d. all of the above

4. The natural history of thoracoabdominal aortic aneurysms is______.
   a. static over about 10-20 years
   b. about 90% are in the descending aorta
   c. 1 cm per year
   d. no relationship between site and risk for rupture

5. TEVAR _______.
   a. is not used in the emergent situation
   b. applies to the entire spectrum of descending thoracic aortic pathology
   c. has yielded only slightly poorer results than open repair
   d. was developed for acute situation only
6. **Suitability for TEVAR depends on:**
   a. presence of a seal zone of 1-2 cm
   b. absence of excessive thrombus
   c. predominately S-shaped aneurysm
   d. small iliac access vessels

7. **The stent graft is:**
   a. a mesh-like metal structure
   b. impervious to blood
   c. self-expandable
   d. all of the above

8. **Differences between open aortic aneurysm repair and TEVAR technique include which of the following:**
   a. less blood loss with TEVA, as the aorta is not cross-clamped
   b. greater hemodynamic instability with TEVAR as all antihypertensive agents must be stopped
   c. none of the above

9. **Preoperative testing for patients undergoing TEVAR is least likely to include:**
   a. CT or MR angiography
   b. echocardiography
   c. pulmonary function tests
   d. liver function tests as a baseline

10. **Adenosine:**
    a. has no cardiac effects
    b. has been replaced by self-deploying stents
    c. increases patient movement
    d. is essential to allow correct stent graft deployment