



ევროპის უნივერსიტეტი
EUROPEAN UNIVERSITY

Heart 2

Surgery 2

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Thoracic Aneurysms and Aortic Dissection

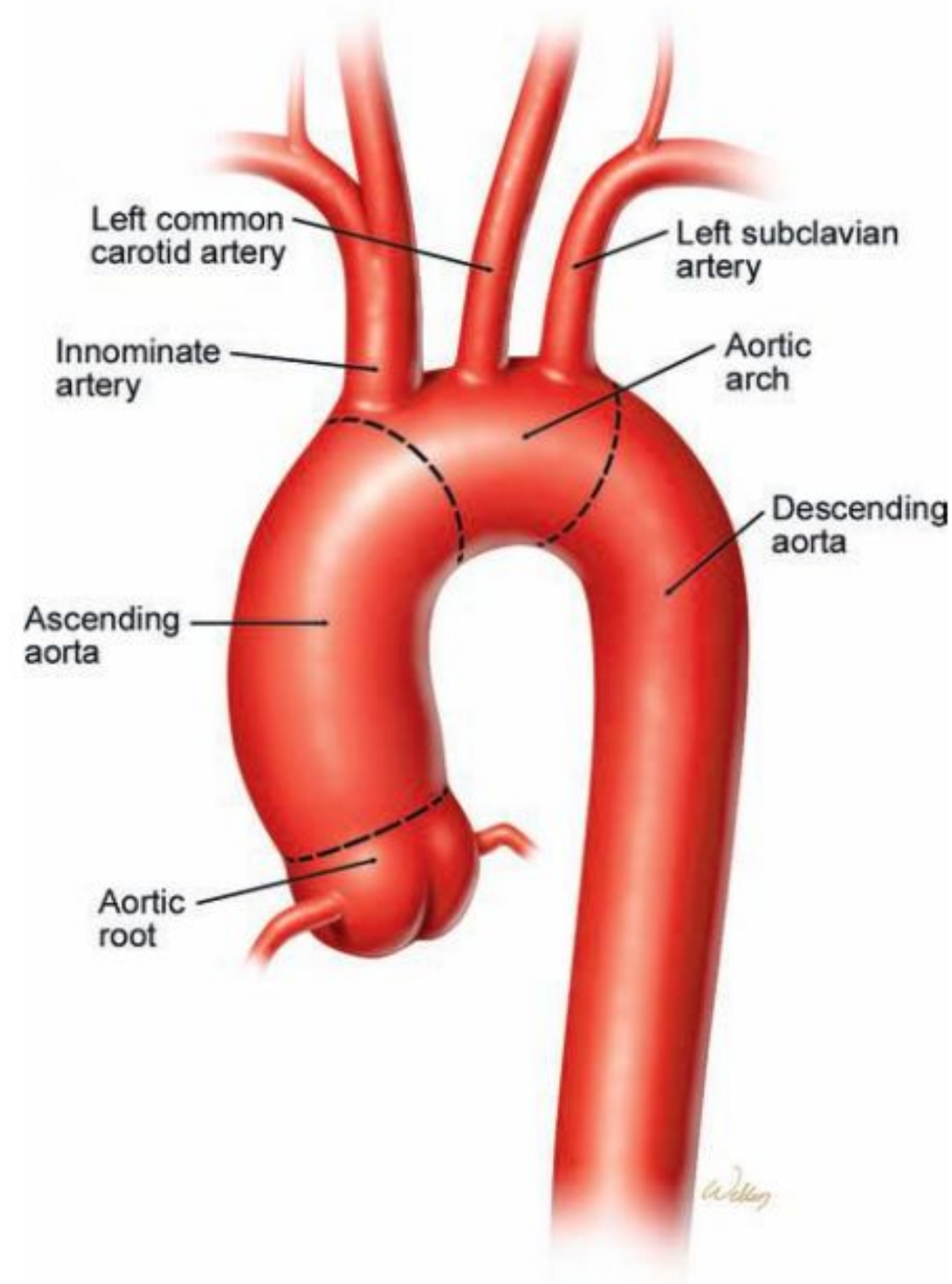
Anatomy of the Aorta

1. The proximal aortic segment:

- a. Ascending aorta
 - Aortic valve
 - Aortic root
 - Three sinuses of Valsalva - coronary arteries originate from two of these sinuses.
 - Ends at the origin of the innominate artery.
- b. **Transverse aortic arch** - is the area from which the brachiocephalic branches arise.

2. The distal aortic segment:

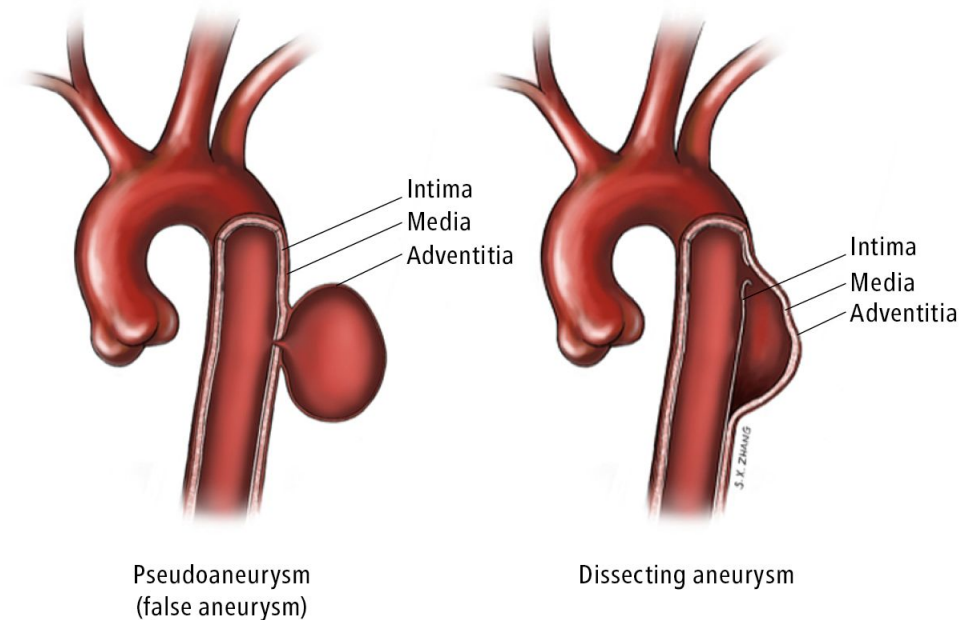
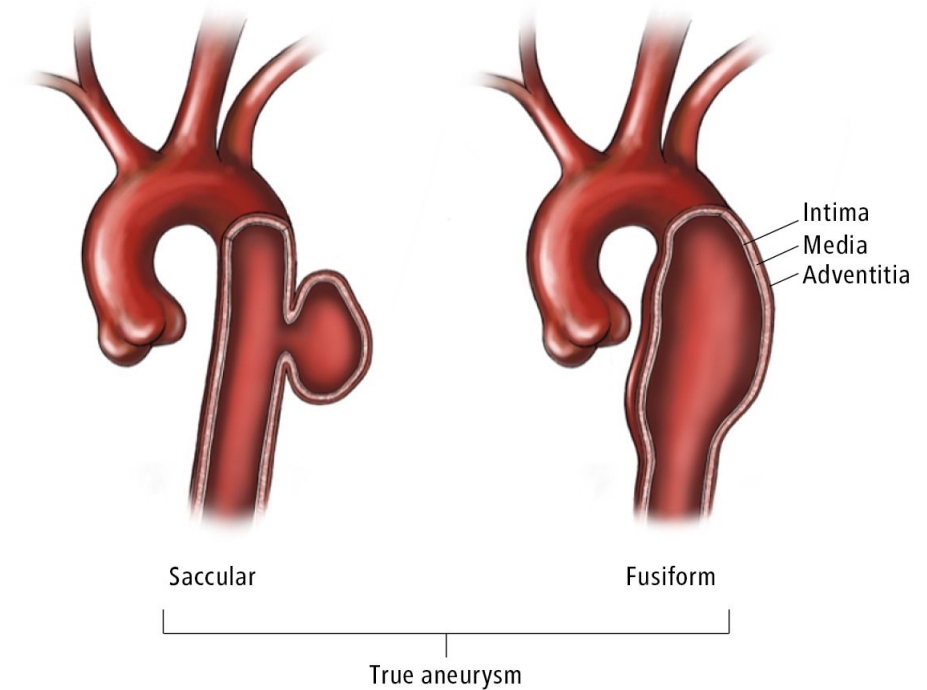
- a. Descending thoracic aorta → Diaphragmatic hiatus
- b. Abdominal aorta.
 - Suprarenal
 - Infrarenal



Thoracic Aortic Aneurysms

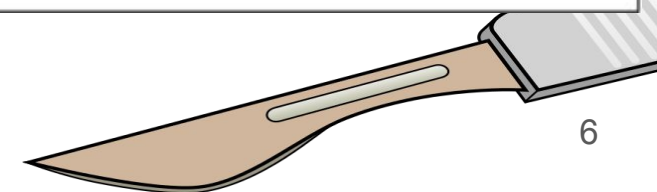
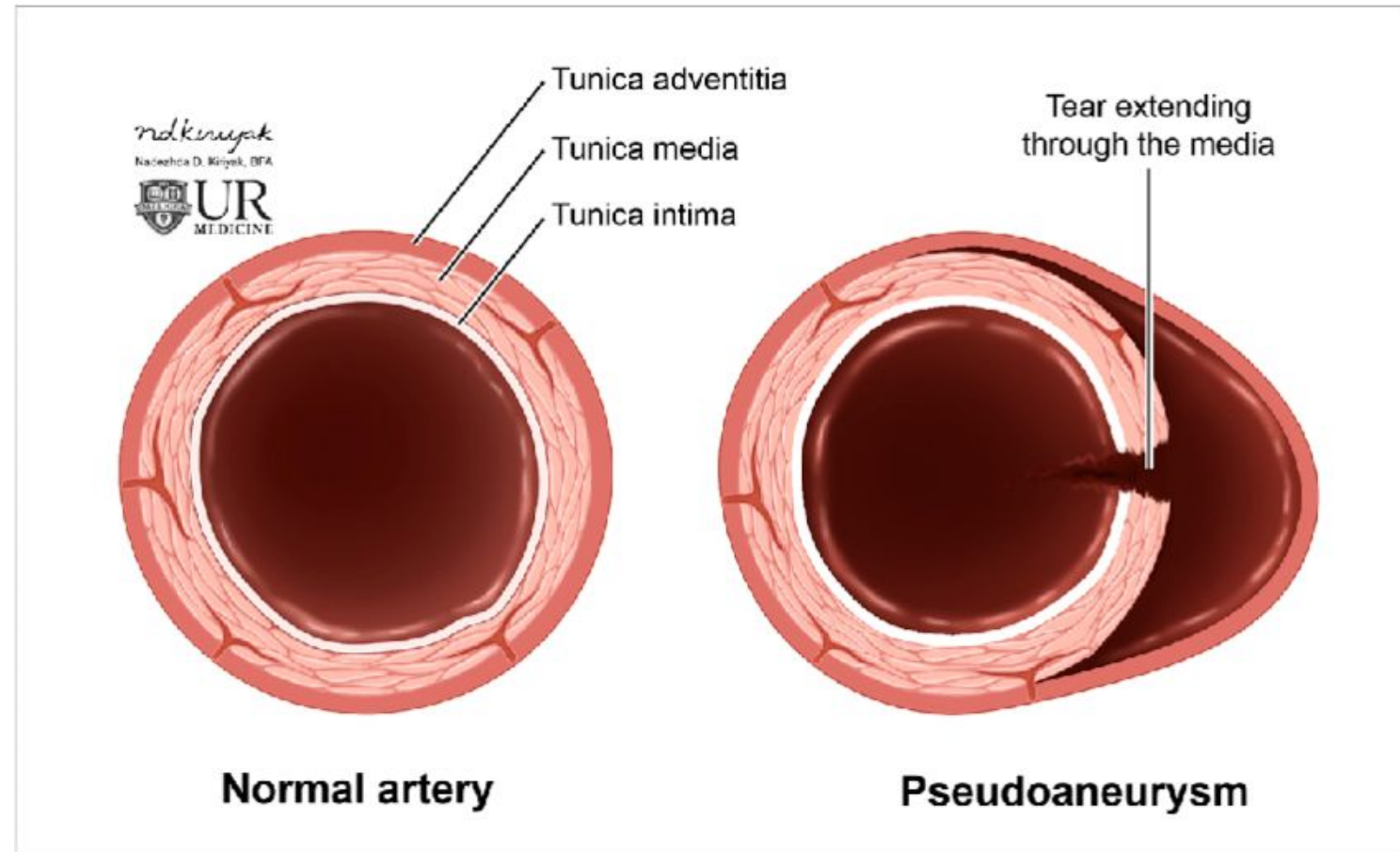
THORACIC AORTIC

- Aortic aneurysm is a permanent, localized dilatation of the aorta to a diameter that is at least 50% greater than is normal.
- Causes of thoracic aortic aneurysms:
 - Degenerative disease of the aortic wall,
 - Aortic dissection
 - Aortitis
 - Infection
 - Trauma.
- Single aortic segment
- Multiple segments (e.g. Thoracoabdominal)
- Entire aorta is aneurysmal = mega-aorta.



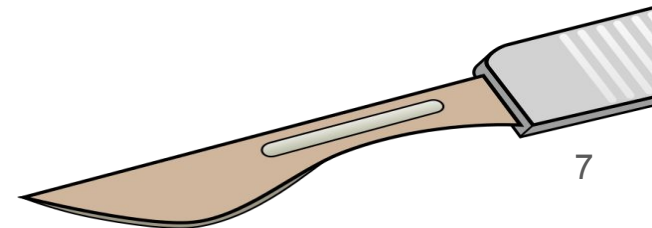
THORACIC AORTIC ANEURYSMS

- True aneurysms= symmetrical dilatation
 - Fusiform
 - Saccular. Fusiform aneurysms are more
- False aneurysms = pseudoaneurysms, are leaks in the aortic wall that are contained by the outer layer of the aorta and/or the periaortic tissue
- Complications:
 - Rupture, which is usually a fatal event. Therefore, aggressive treatment is indicated in all but the poorest surgical candidates.



THORACIC AORTIC ANEURYSMS

- Small, asymptomatic thoracic aortic aneurysms
 - **can be followed**, especially in high-surgical-risk patients, and can be treated surgically later if symptoms or complications develop, or if progressive enlargement occurs.
 - **Meticulous control of hypertension!**
- Large asymptomatic ⇒ diameter of at least twice normal in the involved segment (5–6 cm in most thoracic segments) ⇒ **Elective resection with graft replacement**
- **An emergency operation** is performed for any patient in whom a **ruptured aneurysm** is suspected.
- An alternative for a descending thoracic aortic aneurysm is endovascular stent grafting.



THORACIC AORTIC ANEURYSMS

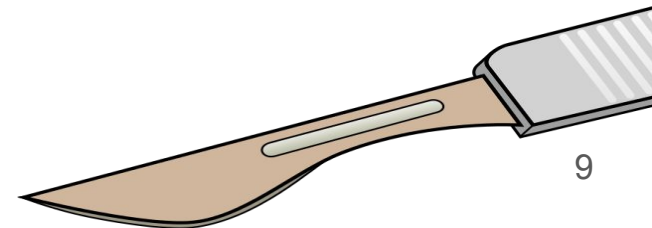
Causes and Pathogenesis

- Medial layer ⇒ Elasticity and tensile strength
- 45 to 55 lamellae of elastin, collagen, smooth muscle cells, and ground substance.
- Maintenance of the aortic matrix involves complex interactions among smooth muscle cells, macrophages, proteases, and protease inhibitors.
- Any alteration in this delicate balance can lead to aortic disease.
- **Pressure** ⇒ aortic dilatation ⇒ increasing wall tension
- Laplace's law (tension = pressure × radius)
- **Turbulent blood** flow is also recognized as a factor.
- **Atherosclerosis** - In most thoracic aortic aneurysms, atherosclerosis appears to be a coexisting process, rather than the underlying cause.

- **Nonspecific medial degeneration is the most common cause of thoracic aortic disease.**
Fragmentation of elastic fibers and loss of smooth muscle cells, are expected in the aging aorta ⇒ progressive weakening of the aortic wall, aneurysm formation, and eventual dissection, rupture, or both.
- **Aortic Dissection:** Tear in the inner aortic wall ⇒ progressive separation of the medial layers ⇒ creates two channels within the aorta.
- **Genetic Disorders.**
 - Marfan Syndrome
 - Loeys-Dietz Syndrome
 - Ehlers-Danlos syndrome
 - Aneurysms-Osteoarthritis Syndrome
 - Congenital Bicuspid Aortic Valve
 - Families without the heritable connective tissue

Causes and Pathogenesis

- Infection
 - Bacterial endocarditis
 - Endothelial trauma
 - Staphylococcus aureus, Staphylococcus epidermidis, Salmonella, and Streptococcus.
 - Syphilitic aortitis was once the most common cause of ascending aortic aneurysms
- Aortitis - idiopathic -localized transmural inflammation and subsequent fibrosis can develop.
- Systemic autoimmune disorders also cause thoracic aortitis.
 - Aortic Takayasu arteritis
 - Rheumatoid aortitis
 - Ankylosing spondylitis
- Pseudoaneurysms
 - Primary defects in the aortic wall (e.g., after trauma or contained aneurysm rupture, leaking anastomosis, cannulation site) ⇒ chronic leaks ⇒ Hematoma ⇒ Aneurysmal wall develops from organized thrombus and associated fibrosis.
 - High incidence of morbidity and rupture.



- Critical risk factors of rupture
 - Ascending aorta - 6.0 cm
 - Descending thoracic aorta 7.0 cm
 - Marfan or Loeys-Dietz syndrome
 - Saccular aneurysms

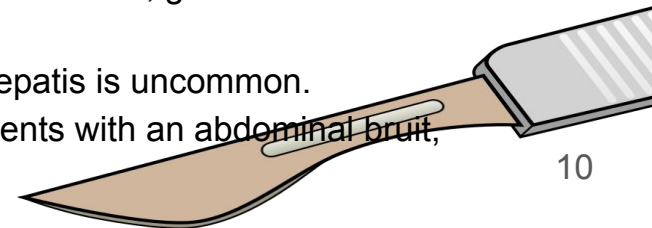
Clinical Manifestations

Most are symptomatic at the time of diagnosis.

1. Compression or erosion of adjacent structures
2. Aortic valve regurgitation
3. Distal embolism, and rupture.

1. Local Compression and Erosion.

- Mild, chronic pain.
- Aneurysms of the ascending aorta and transverse aortic arch
 - Compression of the superior vena cava, the pulmonary artery, the airway, or the sternum.
 - Rarely, erosion into the superior vena cava or right atrium, causing acute high-output failure.
 - Stretch the recurrent laryngeal nerve, which results in left vocal cord paralysis and hoarseness.
- Descending thoracic and thoracoabdominal aneurysms
 - Back pain localized between the scapulae.
 - Thoracic or lumbar vertebral body erosion ⇨ back pain;
 - Airway obstruction ⇨ cough, wheezing, stridor, or pneumonitis.
 - Pulmonary or airway erosion presents as hemoptysis.
 - Esophagus ⇨ dysphagia, hematemesis.
 - Duodenal obstruction or, if they erode through the bowel wall, gastrointestinal bleeding.
 - Jaundice due to compression of the liver or porta hepatis is uncommon.
 - Erosion into the inferior vena cava or iliac vein presents with an abdominal bruit, widened pulse pressure, edema, and heart failure.



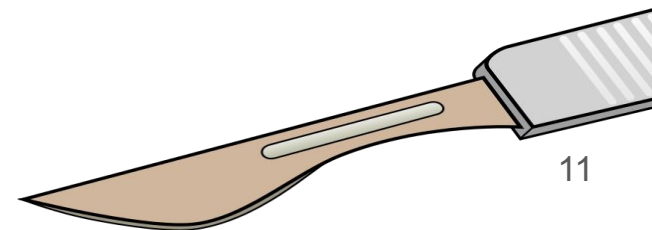


2. Aortic Valve Regurgitation.

- Ascending aortic aneurysms ⇨ displacement of the aortic valve commissures and annular dilatation
⇨ progressively worsening aortic valve regurgitation ⇨ progressive heart failure, a widened pulse pressure, and a diastolic murmur.

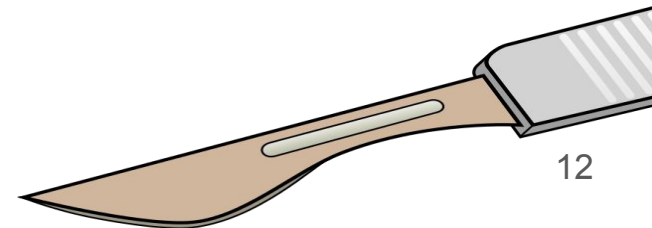
3. Distal Embolization.

- Atheromatous plaque and mural thrombus ⇨ embolize distally, causing occlusion and thrombosis of the visceral, renal, or lower extremity branches.



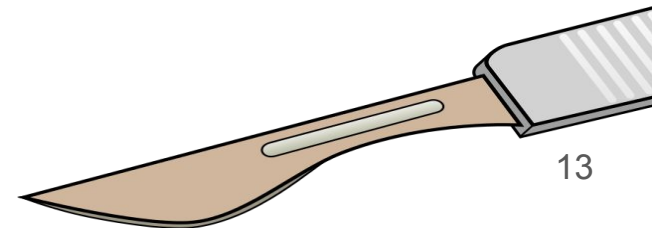
Rupture

- Patients with ruptured thoracic aortic aneurysms often experience **sudden, severe pain** in the anterior chest (ascending aorta), upper back or left chest (descending thoracic aorta), or left flank or abdomen (thoracoabdominal aorta).
- Ascending aortic aneurysms rupture ⇒ **bleed into the pericardial space** ⇒ acute cardiac tamponade and death.
- Descending thoracic aortic aneurysms ⇒ **rupture into the pleural cavity** ⇒ severe hemorrhagic shock and respiratory compromise.
- **External rupture** is extremely rare; saccular syphilitic aneurysms have been observed to rupture externally after eroding through the sternum.



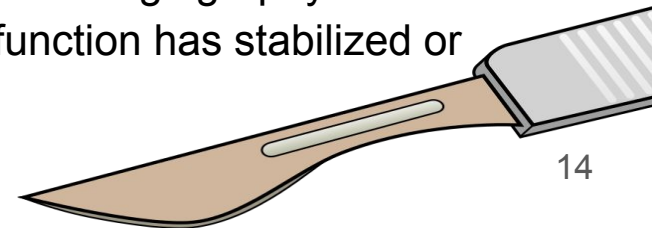
Aorta: Diagnostic Evaluation

- Plain Radiography of the chest, abdomen, or spine.
 - Ascending aortic aneurysms produce a **convex shadow** to the right of the cardiac silhouette.
 - Chest radiographs **may appear normal**. Aortic root aneurysms, often are hidden within the cardiac silhouette.
 - **Widening** of the descending thoracic aortic shadow.
 - **Aortic calcification**.
- Both transthoracic and transesophageal echocardiography.
- Computed tomographic (CT) ⇨ multiplanar and 3-dimensional aortic reconstructions.
 - Information about the aortic lumen and can detect mural thrombus, aortic dissection, inflammatory periaortic fibrosis, and mediastinal or retroperitoneal hematoma due to contained aortic rupture.
 - Possibility of contrast-induced acute renal failure
- Magnetic Resonance Angiography.
 - This modality produces aortic images comparable to those produced by contrast-enhanced CT but does not necessitate exposure to ionizing radiation.
 - Excellent visualization of branch vessel details, and it is useful in detecting branch vessel stenosis.
 - High expense and a susceptibility to artifacts created by ferromagnetic materials, and gadolinium—the contrast agent for MRA—may be linked to nephrogenic systemic fibrosis and acute renal failure in patients with advanced renal insufficiency.
 - **MRA environment is not appropriate for many critically ill patients**, and unlike CT imaging, MRA imaging is suboptimal in patients with extensive aortic calcification.



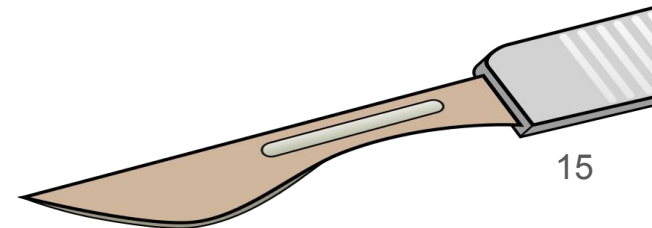
Aorta: Diagnostic Evaluation

- Invasive Aortography .
 - Cross-sectional imaging (i.e., CT and MRA) has largely replaced this modality.
 - CT and MRA are now the primary modes Limited to those undergoing endovascular therapies or when other types of studies are contraindicated or have not provided satisfactory results.
- Cardiac Catheterization
 - Unlike standard aortography, cardiac catheterization is important.
 - Is that it images only the lumen and may therefore underrepresent the size of large aneurysms that contain laminated thrombus.
 - Manipulation of intraluminal catheters can result in embolization of laminated thrombus or atheromatous debris. 0.6% to 1.2% risk of stroke.
 - Allergic reaction to contrast agent,
 - Iatrogenic aortic dissection
 - Bleeding at the arterial access site.
 - Contrast agent → significant renal toxicity. **To minimize the risk:**
 - IV hydration
 - Mannitol
 - Acetylcysteine.
 - Surgery is performed ≥ 1 day after angiography whenever possible to ensure that renal function has stabilized or returned to baseline.



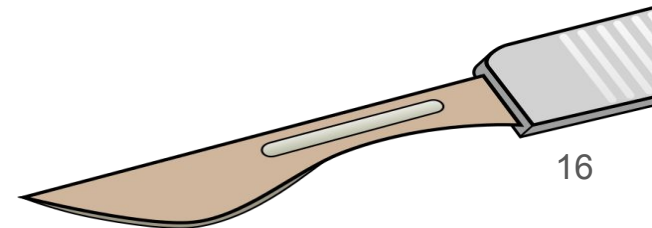
Treatment

- Patient education, particularly if the patient is asymptomatic
- Surveillance imaging and aggressive blood pressure control
- Symptomatic or aneurysms grow ⇨ surgical candidates.
- **Endovascular therapy**
 - **Endoluminal stenting is approved for isolated descending thoracic aortic aneurysms**
 - **For proximal aortic disease and thoracoabdominal aortic aneurysms remains experimental.**
 - **Emergent aneurysm repair**, such as for patients with aortic rupture.
 - For the treatment of blunt aortic injury and penetrating **aortic ulcer**.
 - Hybrid repairs, which combine open **“debranching”** techniques (to reroute
- Proximal aneurysms → sternotomy approach.
- Descending thoracic
 - Endovascular repair
 - Left thoracotomy.



Treatment

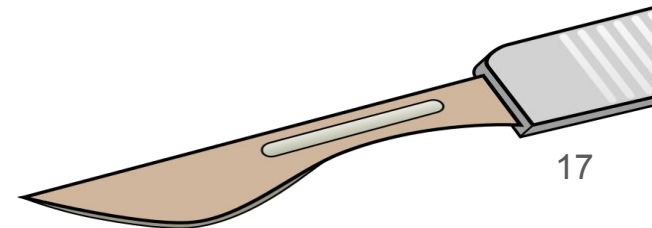
- Indications for Operation ⇨ prevention of fatal rupture.
 - **Asymptomatic patients** - there is time for thorough preoperative evaluation and preparation
 - Thoracic aortic disease:
 - Ascending >5.5 cm,
 - Descending thoracic >6.0 cm
 - The rate of dilatation is >0.5 cm/y.
 - Connective tissue disorders (Marfan and Loeys-Dietz syndromes):
 - Ascending 4.0–5.0 cm
 - Descending thoracic 5.5 to 6.0 cm
 - For women with connective tissue disorders who are considering pregnancy, **prophylactic aortic root replacement is considered** -



Treatment

Open Repair vs. Endovascular Repair

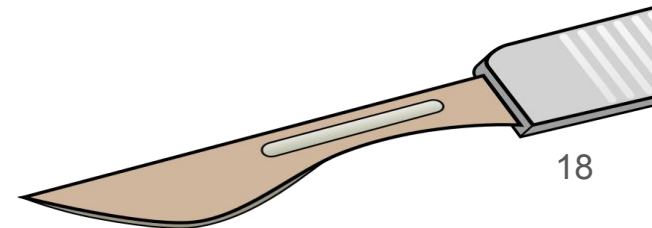
- Endovascular repair: Limitations
 - Patients with isolated degenerative descending thoracic aortic aneurysms - **5.5 cm** (which is slightly below the 6.0-cm threshold for open repair).
 - **The proximal and distal neck diameters** should fall within a range that will allow proper sealing.
 - The **proximal and distal landing zones** should ideally be at least 20 mm long so that an appropriate seal can be made. Limiting structures proximally and distally are the brachiocephalic vessels and celiac axis, respectively.
 - The femoral and iliac arteries have to be wide enough to accommodate the large sheaths necessary to deploy the stent grafts,



Open Repair

Proximal Thoracic Aortic Aneurysms

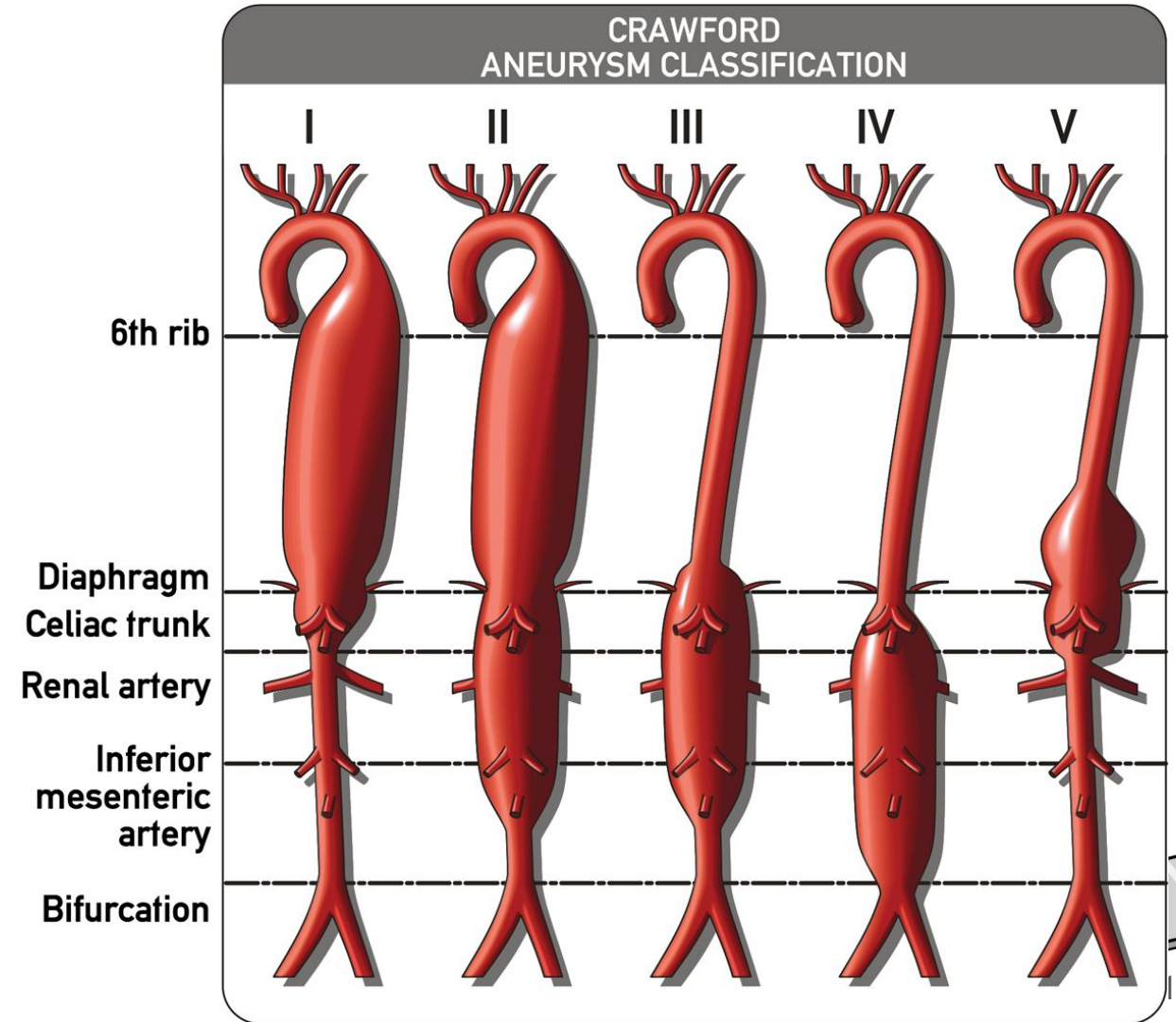
- Midsternal incision and cardiopulmonary bypass.
- Aortic Valve Disease
 - mild to moderate valve regurgitation ⇒ **plicating** the annulus with mattress sutures
 - Severe valvular regurgitation or with valvular stenosis, **the valve is replaced with a stented biologic or mechanical prosthesis.**
- Root aneurysm - aortic root replacement:
 - Composite valve grafts, which consist of a bileaflet **mechanical** valve attached to a polyester tube graft;
 - Aortic root homografts, which are harvested from **cadavers** and cryopreserved
 - Stentless **porcine** aortic root grafts.
 - Ross procedure, in which the patient's pulmonary artery root is excised and placed in the aortic position
- Aortic root replacement requires reattaching the coronary arteries to openings in the graft.



Open Repair

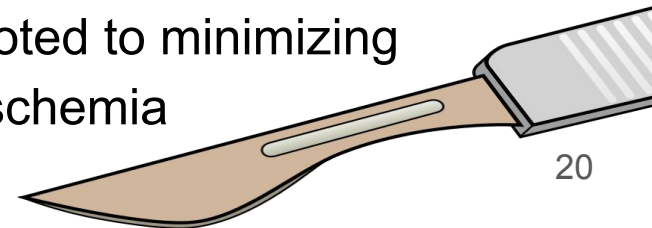
Distal Thoracic Aortic Aneurysms

- Surgical repair of thoracoabdominal aortic aneurysms is categorized by the extent of aortic replacement according to the **Crawford classification scheme**
 - Extent I - From left subclavian artery, to above renal arteries
 - Extent II - From left subclavian artery to aortic bifurcation.
 - Extent III - Below the sixth rib to aortic bifurcation.
 - Extent IV - From 6th intercostal space to aortic bifurcation.
 - Extent V - From 6th intercostal space to above renal arteries.



Open Repair

- Descending thoracic aortic aneurysms are repaired through a left thoracotomy.
- In patients with thoracoabdominal aortic aneurysms, the thoracotomy is extended across the costal margin and into the abdomen.
- Use of a double-lumen endobronchial tube allows selective ventilation of the right lung and deflation of the left lung.
- Transperitoneal exposure of the thoracoabdominal aorta is achieved by performing medial visceral rotation and circumferential division of the diaphragm.
- During a period of aortic clamping, the diseased segment is replaced with a polyester tube graft. Important branch arteries—including intercostal arteries and the celiac, superior mesenteric, and renal arteries—are reattached to openings made in the side of the graft.
- Clamping the descending thoracic aorta causes
 - ischemia of the spinal cord ⇒ paraplegia or paraparesis
 - abdominal viscera ⇒ acute renal failure.
- Therefore, several aspects of the operation are devoted to minimizing spinal and renal ischemia



- Prevention of ischemic complications

- Quick repair
- Moderate systemic heparinization (1.0 mg/kg) to prevent small vessel thrombosis
- Mild permissive hypothermia (32°C–34°C nasopharyngeal temperature)
- Reattachment of segmental intercostal and lumbar arteries.
- Cerebrospinal fluid drainage is used ⇨ improves spinal perfusion
- Motor evoked potentials are used by some groups to monitor the spinal cord throughout the operation
- Balloon perfusion cannulas connected to the left heart bypass circuit can be used to deliver blood directly to the celiac axis and superior mesenteric artery during their reattachment.
- Whenever possible, renal protection is achieved by perfusing the kidneys with cold (4°C [39.2°F]) crystalloid.

Current strategy for spinal cord and visceral protection during repair of distal thoracic aortic aneurysms

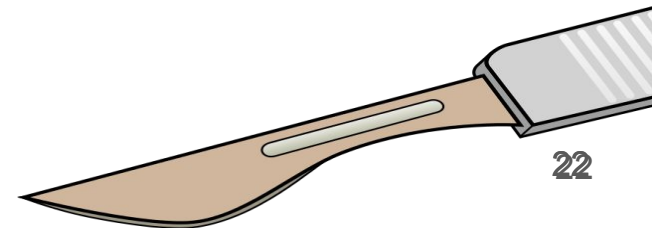
All extents

- Permissive mild hypothermia (32°C–34°C, nasopharyngeal)
- Moderate heparinization (1 mg/kg)
- Aggressive reattachment of segmental arteries, especially between T8 and L1
- Sequential aortic clamping when possible
- Perfusion of renal arteries with 4°C crystalloid solution when possible

Crawford extent I and II thoracoabdominal repairs

- Cerebrospinal fluid drainage
- Left heart bypass during proximal anastomosis
- Selective perfusion of celiac axis and superior mesenteric artery during intercostal and visceral anastomoses

- Complete repair of extensive aneurysms involving the ascending aorta, transverse arch, and descending thoracic aorta generally requires staged operations.
- **When distal segment is treated during the initial operation:**
 - A reversed elephant trunk repair, in which a portion of the proximal end of the aortic graft is inverted down into the lumen, can be performed during the first operation;
 - Spinal cord ischemia
 - Renal failure
 - Pulmonary dysfunction
 - Vocal cord paralysis ⇨ direct cord medialization (type 1 thyroplasty).
 - Injury to the esophagus
 - Aortoesophageal fistula
 - Severe myocardial ischemia and cardiac arrest.



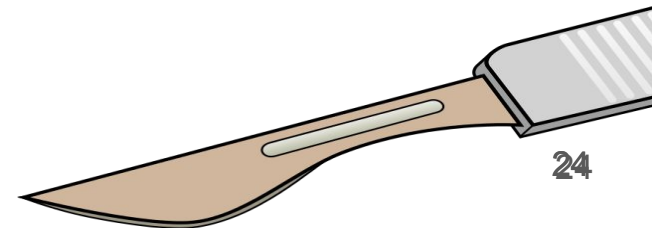
- Endovascular Repair

- Descending Thoracic Aortic Aneurysms
 - Stent graft repair of descending thoracic aortic aneurysms has become an accepted treatment option for selected patients.
 - To protect patients against spinal cord ischemia ⇨ Cerebrospinal fluid drainage.
 - After 5000 to 10,000 units of heparin are administered, a guidewire and the delivery sheath are typically inserted into the access artery under fluoroscopic guidance; recently, sheathless stent-grafts have been introduced, which are less bulky. The device is then deployed, and the proximal and distal ends are expanded by using a balloon catheter (“ballooned”),

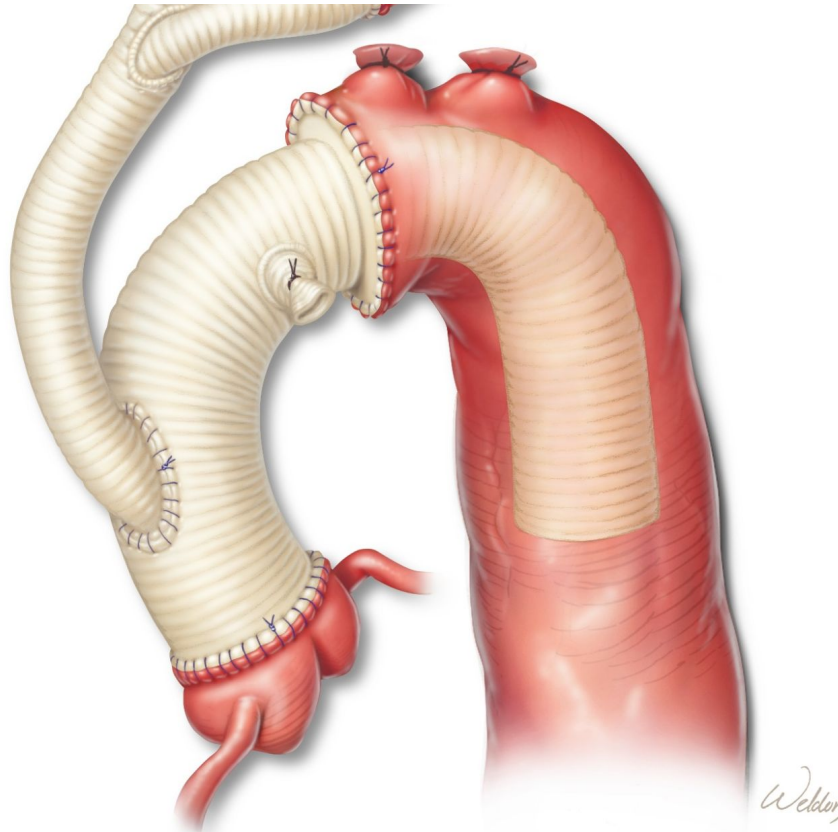
- Thoracoabdominal Aortic Aneurysms
 - At least one of the visceral arteries is incorporated into the repair → fenestrated grafts, reinforced fenestrated grafts, branched or cuffed grafts, modular combinations of grafts, and multilayer stents.
 - Some centers now propose distal coverage of the celiac axis ⇨ risks of paraplegia, renal failure, stroke, and death, despite the apparent benefits of its being a less invasive procedure.
 - Hybrid thoracoabdominal aortic aneurysm repair use open surgical techniques to reroute blood supply to the visceral arteries so that their aortic origins can be covered by stent grafts without causing visceral ischemia. Endovascular methods are then used (either as part of the

● Complications

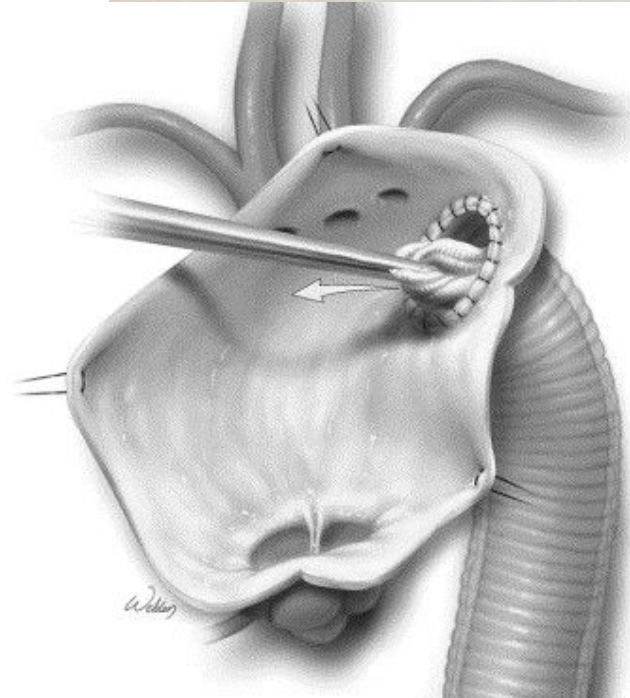
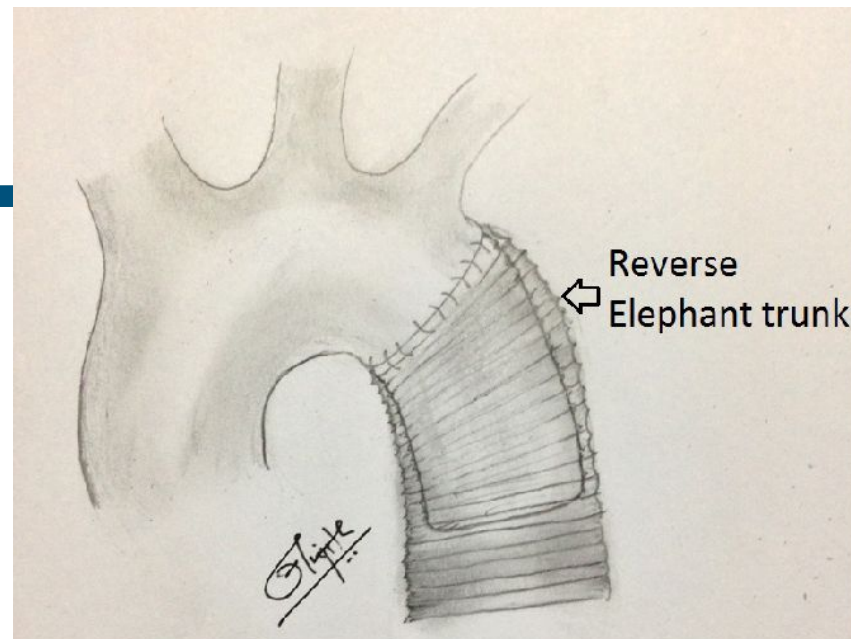
- Aortic anastomoses are often extremely fragile during the early postoperative period. Even brief episodes of postoperative hypertension can disrupt suture lines and precipitate severe bleeding or pseudoaneurysm formation. (between 80 and 90 mmHg)
- Aortic rupture is rare
- Acute iatrogenic retrograde dissection into the aortic arch and ascending aorta ⇒ emergency repair of the ascending aorta and aortic arch via sternotomy and cardiopulmonary bypass.
- An endoleak occurs when there is a persistent flow of blood (visible on radiologic imaging) into the aneurysm sac, ⇒ expansion or even rupture.
- Stent graft misdeployment, device migration, endograft kinking, and stent-graft infection, including fistula.



stage 1 of the **elephant trunk procedure** with ascending aorta and arch repair and the distal end of the graft suspended within the descending thoracic aorta



When ascending aorta is repaired first



When descending aorta is repaired first

Aortic Dissection

The most common catastrophic event involving the aorta

- A tear forms in the intima and inner media
- Progressive separation of the aortic wall layers.
- Separation of the layers of the media propagates
 - Progresses distally
 - Proximal extension or retrograde dissection.
- At least two channels form:
 - The true lumen
 - The false lumen - the newly formed channel within the layers of the media, which is called
 - The dissecting membrane separates the true and false lumens.
 - Additional tears = communication between the two channels = reentry sites.



Normal aorta



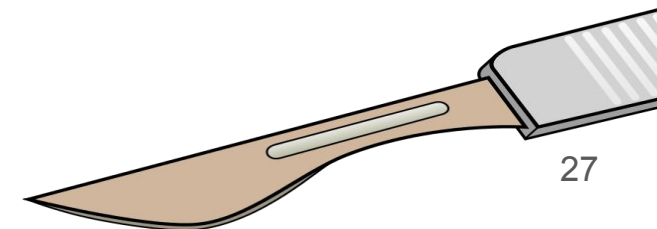
Aortic dissection



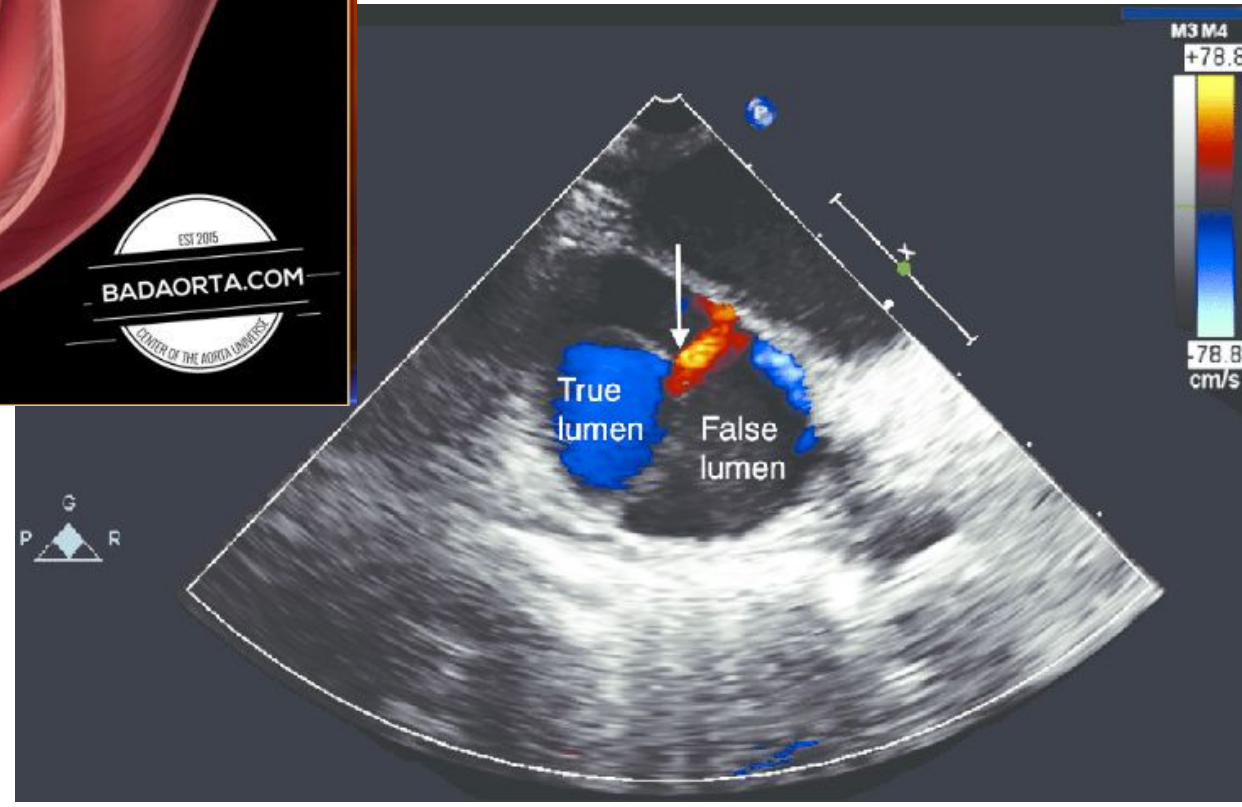
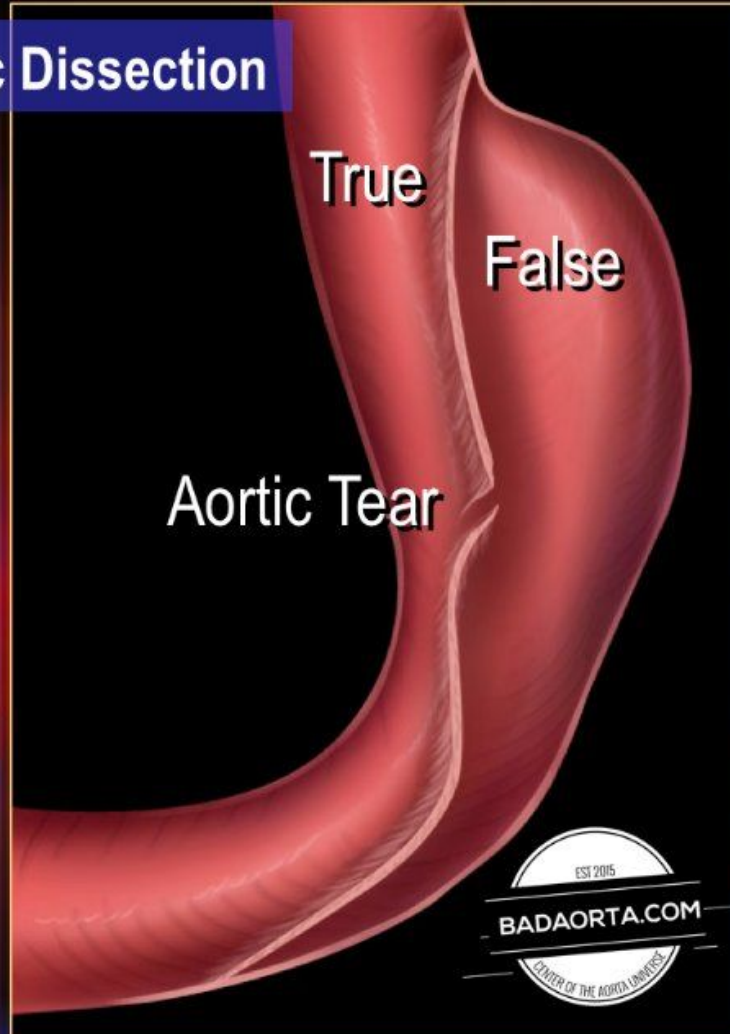
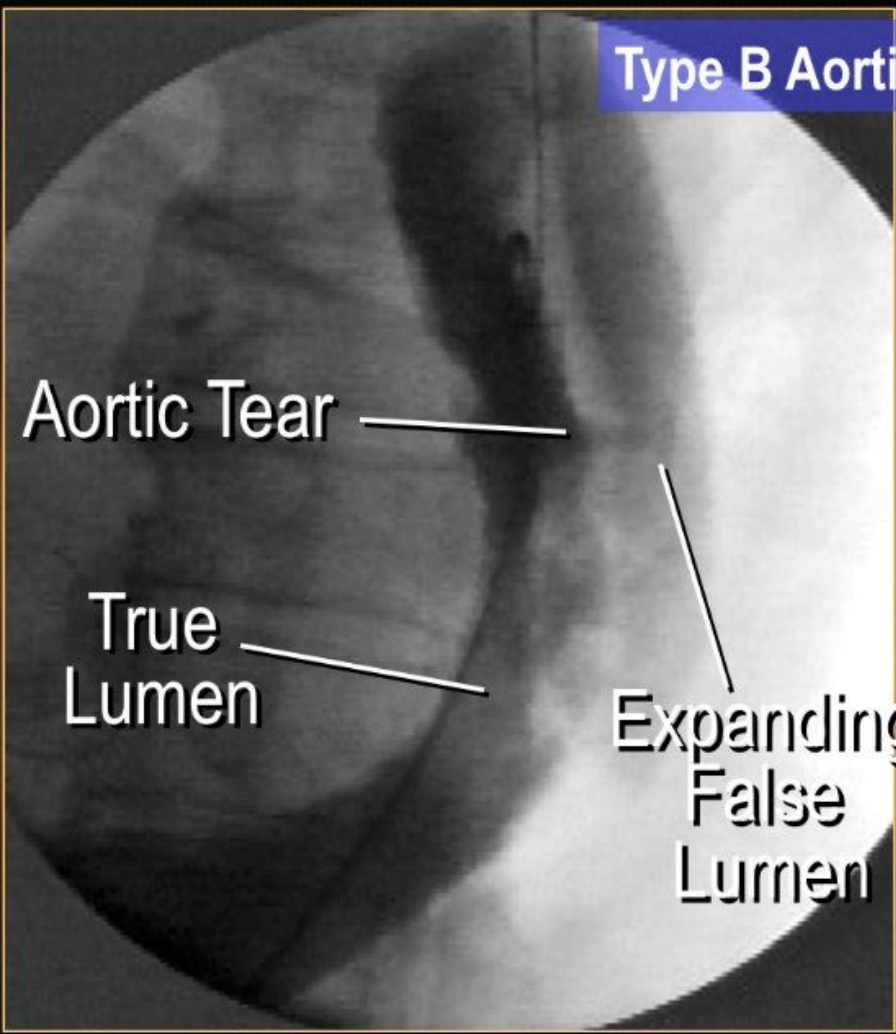
Intramural hematoma



Penetrating aortic ulcer

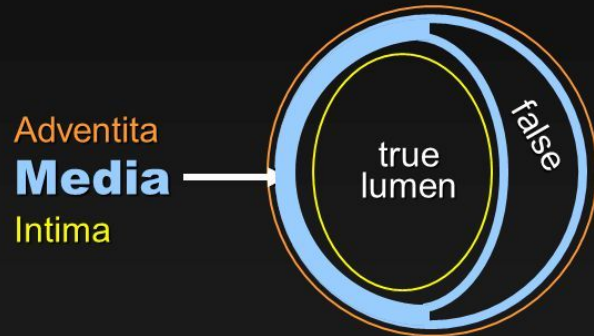


Type B Aortic Dissection

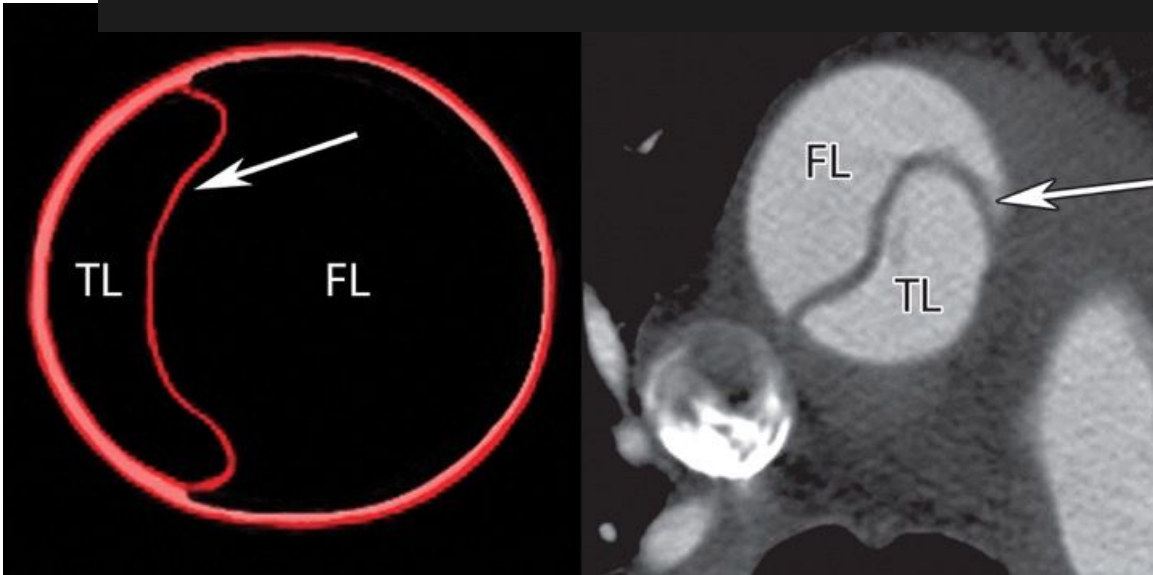


Classic Aortic Dissection

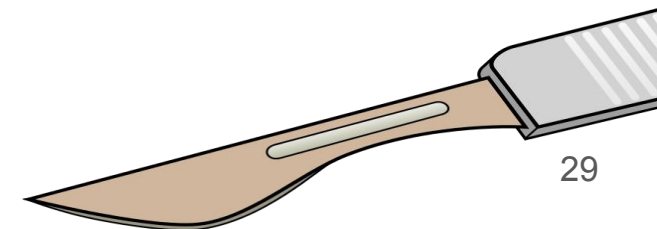
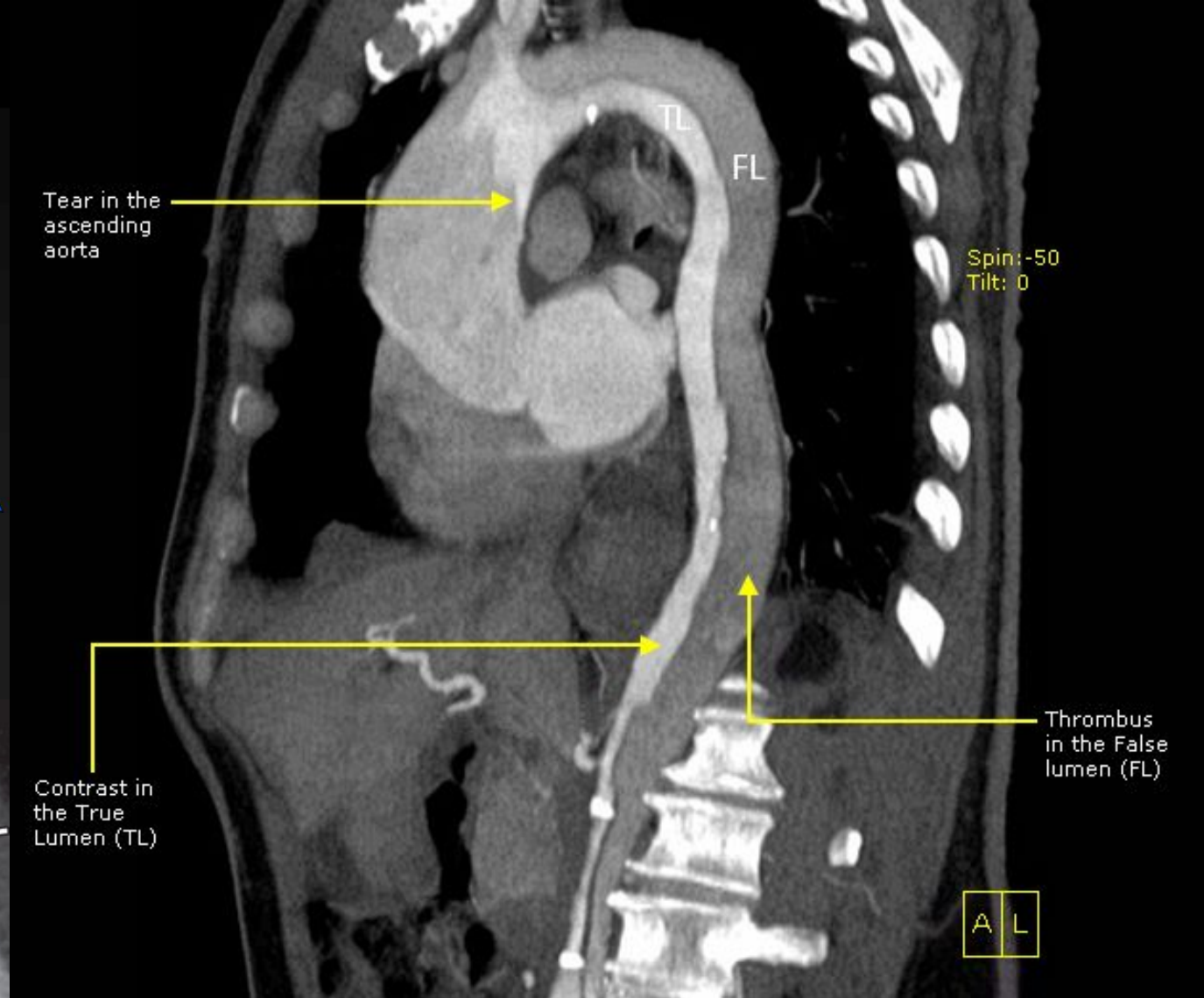
- false lumen within the media
- 'intimal flap'=inner 2/3 of med + intima
→ intimo-media flap



- entry tear (primary intimal tear [PAI])
- exit tear(s) ['reentry tear', fenestrations]

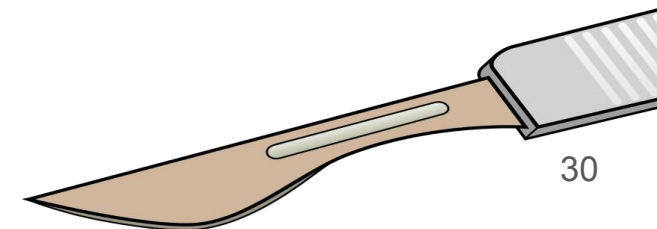


Aortic dissection, with an intimomedial flap (arrow) separating the true lumen (TL) from the false lumen (FL).
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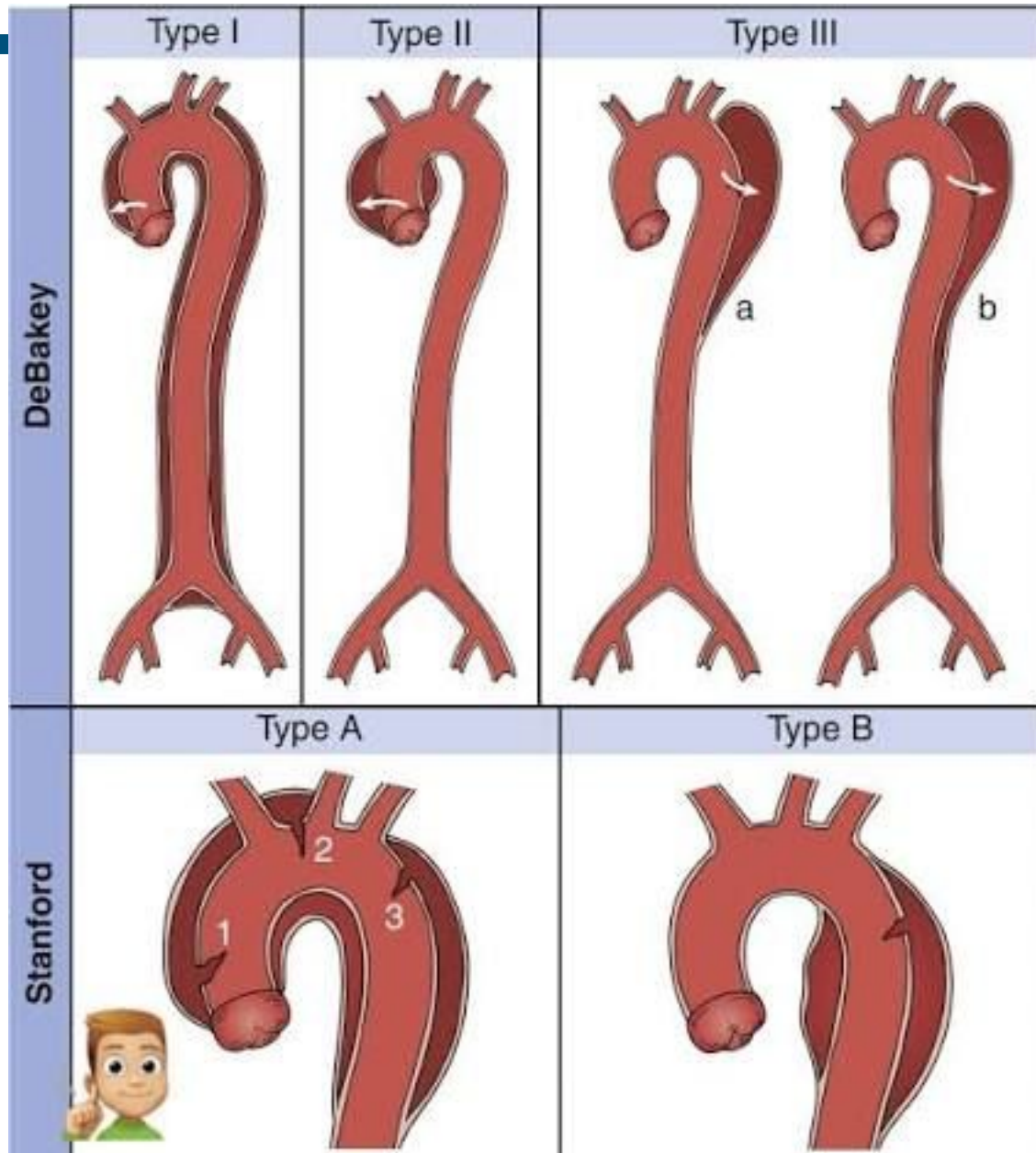


- Outer wall of the false lumen is extremely thin, inflamed, and fragile ⇒ expansion or rupture
- Expanding false lumen can compress the true lumen and cause malperfusion syndrome by interfering with blood flow in the aorta or any of its branch vessels, including the coronary, carotid, intercostal, visceral, renal, and iliac arteries.
- Aortic valve commissures can become unhinged, which results in acute valvular regurgitation.

- Dissection vs. Aneurysm.
- **Dissection and aneurysm are separate entities**
- **In most cases, dissection occurs in patients without aneurysms.**
- **They often coexist** and are mutual risk factors.
 - Dissection ⇒ progressive dilatation of the weakened outer aortic wall ⇒ aneurysm.
 - Degenerative aneurysms ⇒ deterioration of the aortic wall ⇒ superimposed dissection.

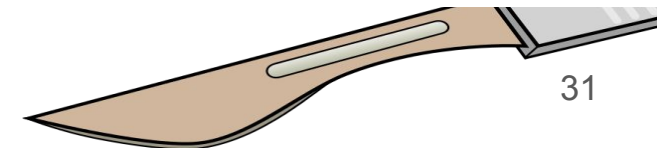


DeBakey and the Stanford classification



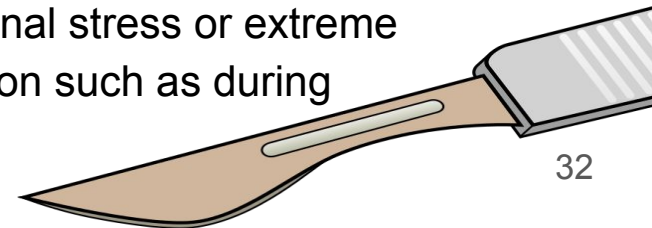
Aortic dissection also is categorized according to the time elapsed since the initial tear.

- **Acute** within the first 14 days after the initial tear;
- The **subacute** period encompasses days 15 through 60 after the initial tear.
- After, the dissection is considered **chronic**.



DeBakey and the Stanford classification systems

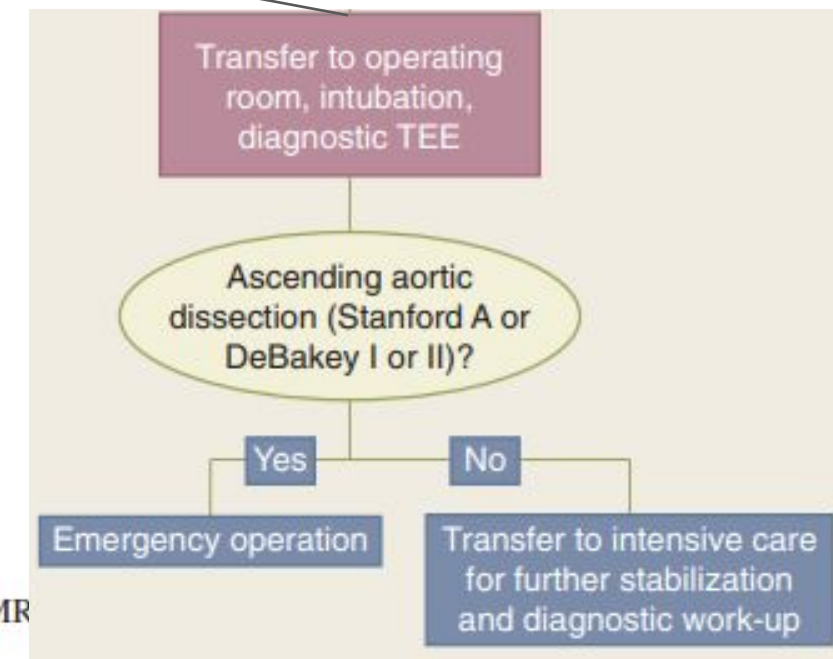
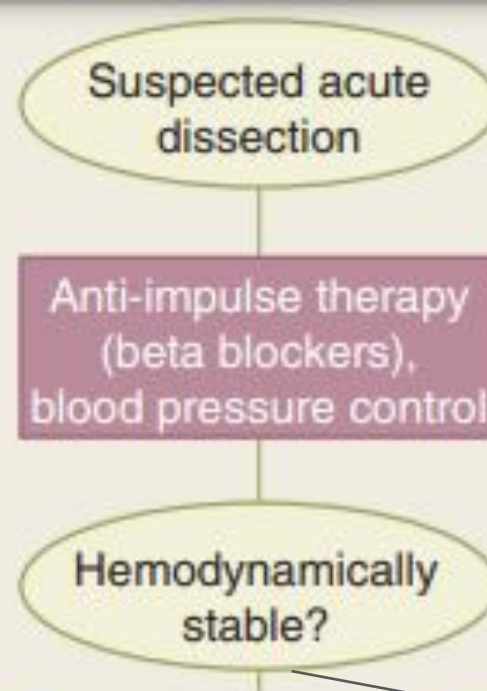
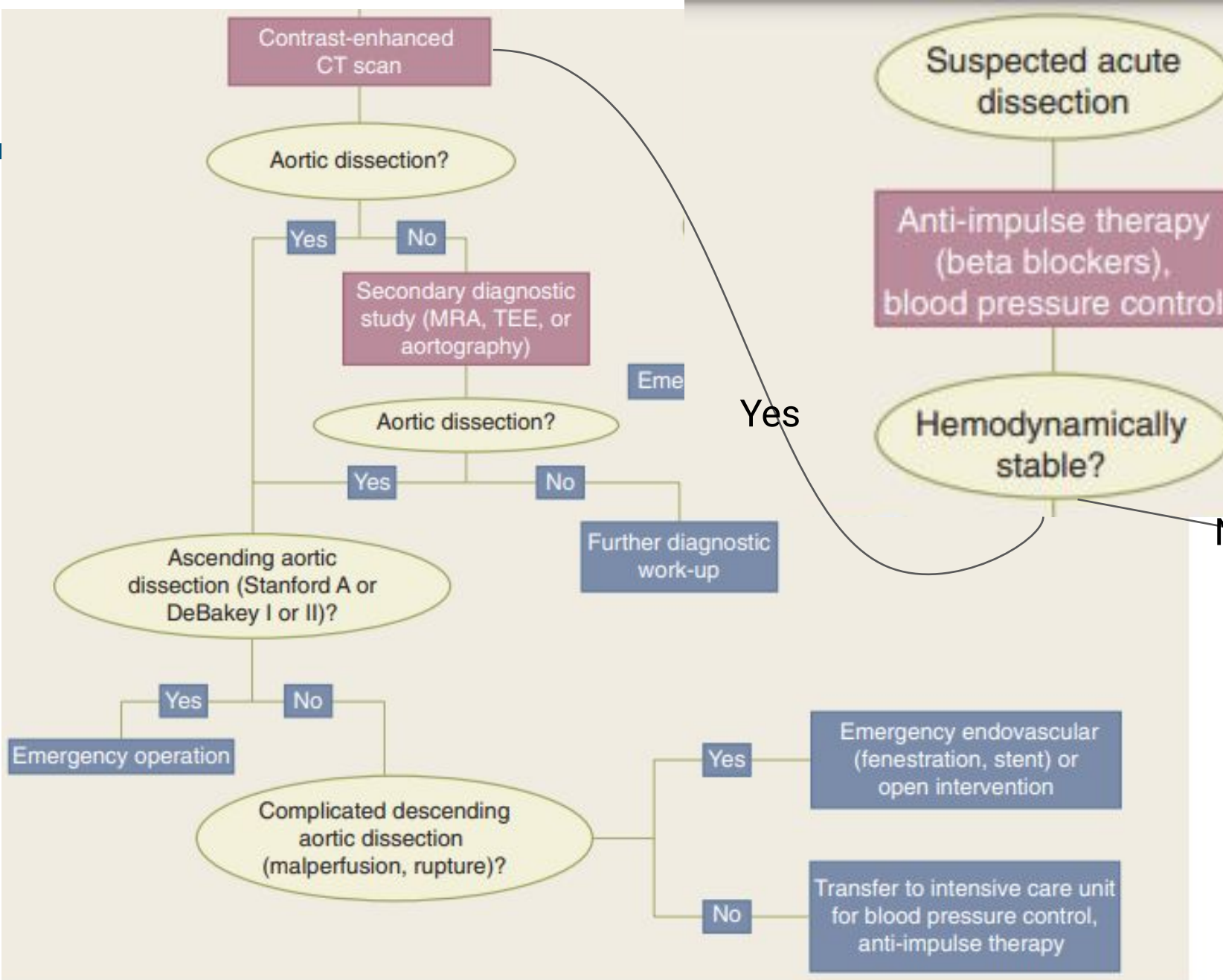
- Variants of aortic dissection
 - **Intramural hematoma (IMH)** - collection of blood within the aortic wall, without an intimal tear, that is believed to be due to rupture of the vasa vasorum within the media. The accumulation of blood can result in a secondary intimal tear that ultimately leads to a full dissection. Because IMH and aortic dissection represent a continuum, it is possible that IMH is seen less frequently than aortic dissection because IMH rapidly progresses to true dissection.
 - **Penetrating aortic ulcer (PAU)** == disrupted atherosclerotic plaque that projects into the aortic wall and is associated with surrounding hematoma. Eventually, the ulcer can penetrate the aortic wall, which leads to dissection or rupture.
- Risk factors of aortic dissection:
 - Common general cardiovascular risk factors, such as smoking, hypertension, atherosclerosis, and hypercholesterolemia, are associated with aortic dissection.
 - Patients with connective tissue disorders, aortitis, bicuspid aortic valve, or preexisting medial degenerative disease are at risk for dissection, especially if they already have a thoracic aortic aneurysm.
 - Aortic injury during cardiac catheterization, surgery, or endovascular aortic repair is a common cause of iatrogenic dissection.
 - Other conditions that are associated with aortic dissection include cocaine and amphetamine abuse
 - Severe emotional stress or extreme physical exertion such as during weightlifting.



Clinical Manifestations

- Severe chest or back pain, classically described as “tearing,” that migrates distally as the dissection progresses along the length of the aorta.
 - Pain in the anterior chest suggests involvement of the ascending aorta,
 - Pain in the back and abdomen generally indicates involvement of the descending and thoracoabdominal aorta.
 - Dissection’s potential anatomic manifestations == Dissection of the aorta (and involved secondary arteries):
 - Cardiac ischemia (coronary artery) or tamponade
 - Stroke (brachiocephalic arteries), paraplegia or paraparesis (intercostal arteries)
 - Mesenteric ischemia (superior mesenteric artery),
 - Kidney failure (renal arteries)
- Diagnostic Evaluation
 - Diagnostic delays are common
 - Severe pain in the chest, back, or abdomen, occurs suddenly, has a sharp or tearing quality, and often migrates distally as the dissection progresses along the aorta.
 - A discrepancy between the extremities in pulse, blood pressure, or both is the classic physical finding in patients with aortic dissection.
 - Secondary manifestations
 - Signs of stroke
 - Threatened ischemic limb
 - Several reports indicate that D-dimer is an extremely sensitive indicator of acute aortic dissection;
 - CXRs may show a widened mediastinum or abnormal aortic contour
 - **Once the diagnosis of dissection is**

Algorithm For The Management Of Acute Aortic Dissection



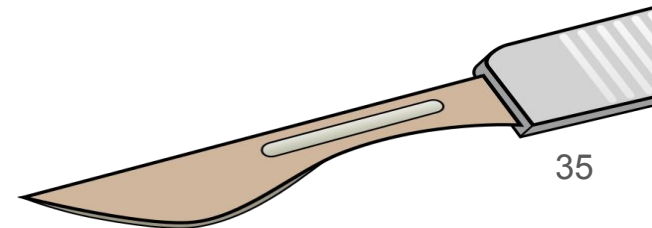
Yes

No

0. Algorithm used to facilitate decisions regarding treatment of acute aortic dissection. CT = computed tomography; MR = magnetic resonance angiography; TEE = transesophageal echocardiography.

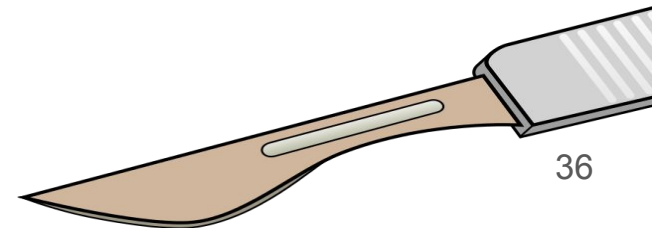
Initial Assessment and Management

- Regardless of the location of the dissection, the initial treatment is the same for all patients with suspected or confirmed acute aortic dissection (see Fig. 22-20). Furthermore, because of the potential for rupture before the diagnosis is confirmed, **aggressive pharmacologic management** is started once there is clinical suspicion of dissection, and this treatment is continued during the diagnostic evaluation. **The goals of pharmacologic treatment are to stabilize the dissection and prevent rupture.**
 - Patients are monitored closely in an intensive care unit.
 - Indwelling radial arterial catheters are used to **monitor blood pressure and optimize**



Treatment of Ascending Aortic Dissection

- Acute ascending aortic dissection ⇒ risk of aortic rupture ⇒ absolute indication for emergency surgical repair - **Emergent graft replacement of the ascending aorta.**
- Delayed repair should be considered:
 - Severe acute stroke
 - Mesenteric ischemia
 - Are elderly and have substantial comorbidity
 - Are in stable condition and may benefit from transfer to specialized center
 - Have undergone a cardiac operation in the remote past.



- Median sternotomy with cardiopulmonary bypass and hypothermic circulatory arrest
- In the majority of patients who undergo surgical repair of acute ascending dissection, the dissection persists distal to the site of the operative repair. Extensive dilatation of the arch or distal aorta develops in 25% to 40% of survivors^{156,157} and often necessitates further aortic repair.
- One-piece hybrid prostheses are now available that incorporate a polyester graft for the proximal repair and a stent-graft component for the descending aorta. == “frozen elephant trunk” repair.

Chronic Dissection

- Occasionally, patients with ascending aortic dissection present for repair in the chronic phase. In most respects, the operation is similar to that for acute dissection repair. One notable difference is that the tissue is stronger in chronic dissection than in acute dissection, which makes suturing safer. In addition, the false lumen is not obliterated at the distal anastomosis; instead, the dissecting membrane is fenestrated into the arch to ensure perfusion of both lumens and to prevent postoperative malperfusion complications.
- Unlike operations for acute dissection, operations for chronic dissection are often aggressive repairs that extend into the arch and