



TEVAR: Endovascular Approach to Aortic Disease



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Disclosures

- None



Aortic Pathology

- King George II of Great Britain
 - Born 1683, Coronated 1727
 - Longest serving British monarch at the time
 - Oct 25, 1760 after his morning coffee, his valet heard a loud crash and discovered him on the floor of his room





Aortic Pathology

- His personal physician, Frank Nicholls, observed that he “appeared to have come from his necessary-stool”
- Post-mortem revealed that “in the trunk of the aorta, we found a transverse fissure on its inner side, about an inch and a half long, through which some blood had recently passed, under its external coat, and formed an elevated ecchymosis. This appearance showed the true state of an incipient aneurysm of the aorta.”





Aortic Pathology

- Progression in Understanding and Treatment
 - Elucidation of pathophysiology
 - Advances in imaging
 - Establishment of clinical databases
 - IRAD (International Registry of Acute Aortic Dissection)

Classification of Pathologies

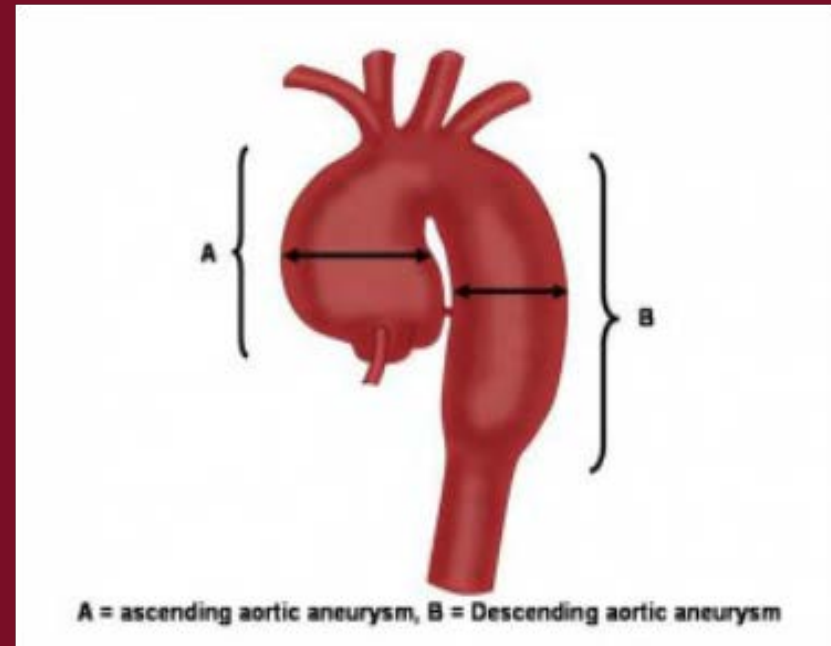


- Thoracic Aortic Aneurysm (TAAs)
- Acute Aortic Syndromes
 - Aortic dissection (TAAD)
 - Intramural hematoma (IMH)
 - Penetrating aortic ulcer (PAU)



Thoracic Aortic Aneurysms (TAAs)

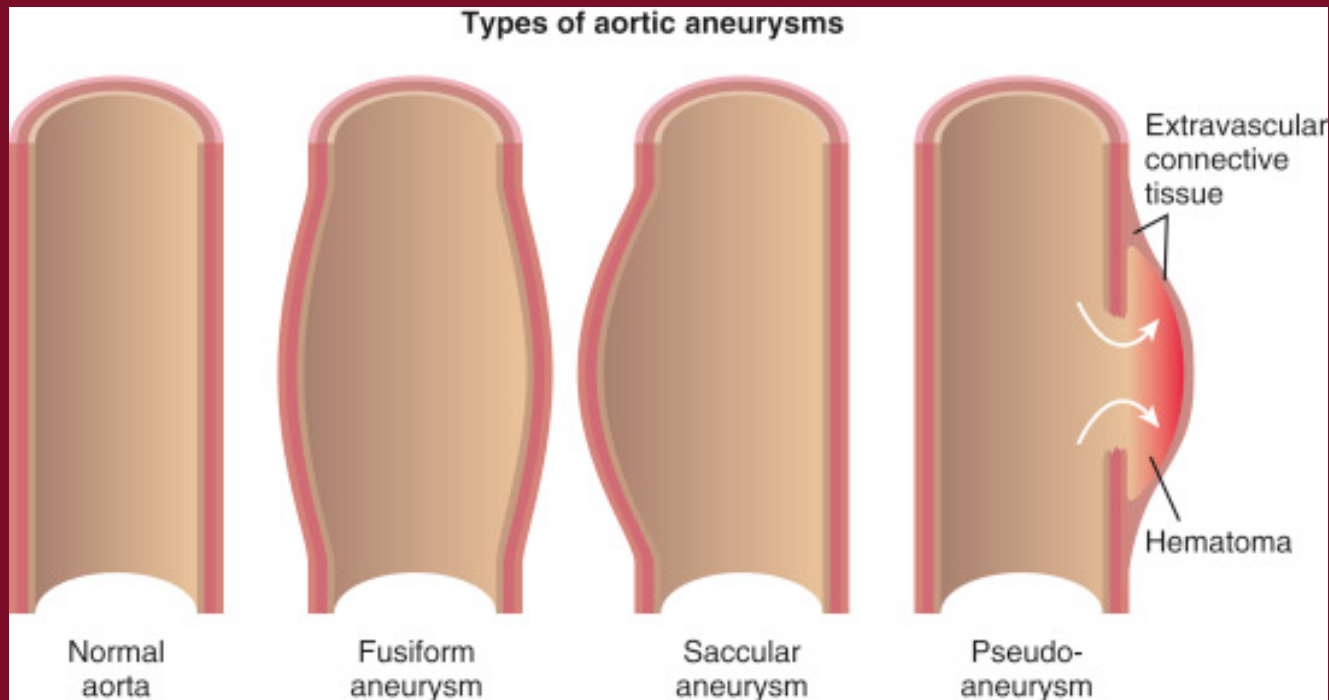
- Described according to location
 - 60% ascending, 40% descending
- 3% prevalence at autopsy
- 2:1 male predominance





Thoracic Aortic Aneurysms (TAAs)

- Fusiform vs Saccular





Thoracic Aortic Aneurysms (TAAs)

Fusiform



Saccular





Thoracic Aortic Aneurysms (TAAs)

- Predisposing Factors
 - Modifiable – HTN, atherosclerosis, COPD
 - Genetic – Marfan syndrome, Loeys-Dietz syndrome, Ehlers-Danlos
- Most diagnoses are incidental
 - Only 5% symptomatic on presentation



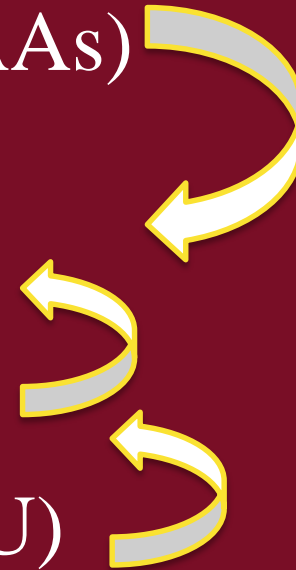
Thoracic Aortic Aneurysms (TAAs)

- Indications for Intervention
 - Maximal diameter
 - Rate of growth
 - Presence of symptoms



Classification of Pathologies

- Thoracic Aortic Aneurysm (TAAs)
- Acute Aortic Syndromes
 - Aortic dissection (TAAD)
 - Intramural hematoma (IMH)
 - Penetrating aortic ulcer (PAU)



- **DYNAMIC PROCESS**



Acute Aortic Syndromes

- Classification
 - Acute <14 days
 - Highest rate of morbidity & mortality
 - Subacute 14-90 days
 - Chronic >90 days



Acute Aortic Syndromes

- DeBakey Classification System

Type I - originating ascending with propagation to arch

Type II - originating and confined to ascending

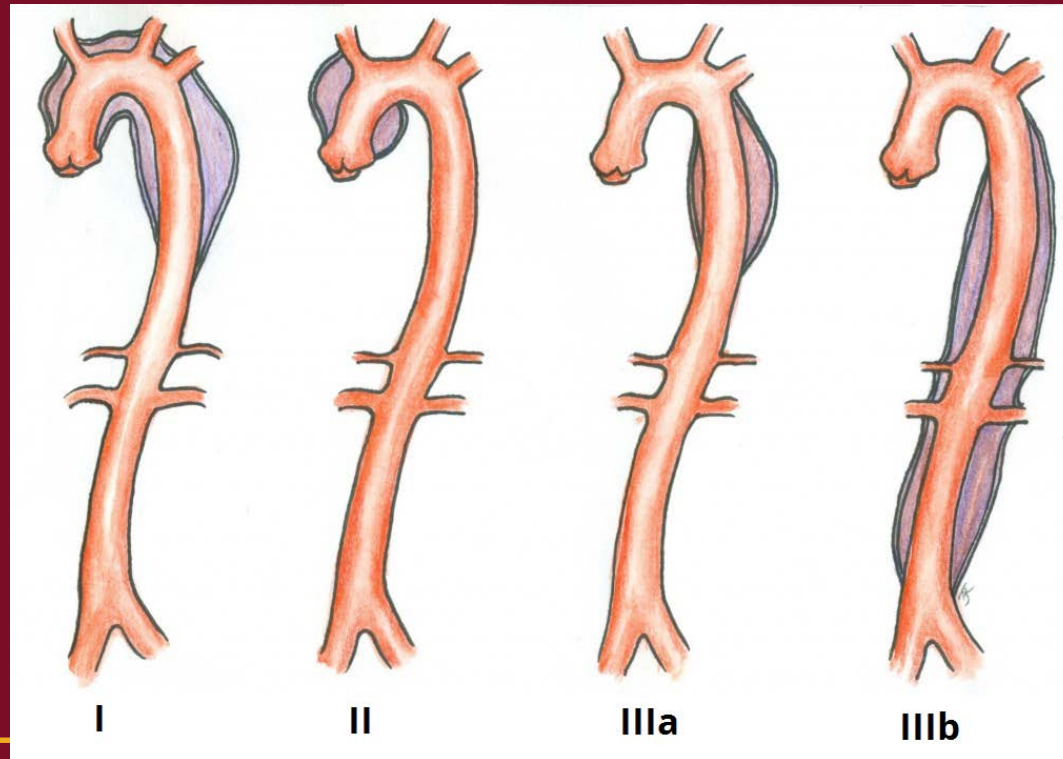
Type IIIa - originating and confined to descending

Type IIIb - originating descending with propagation distally



Acute Aortic Syndromes

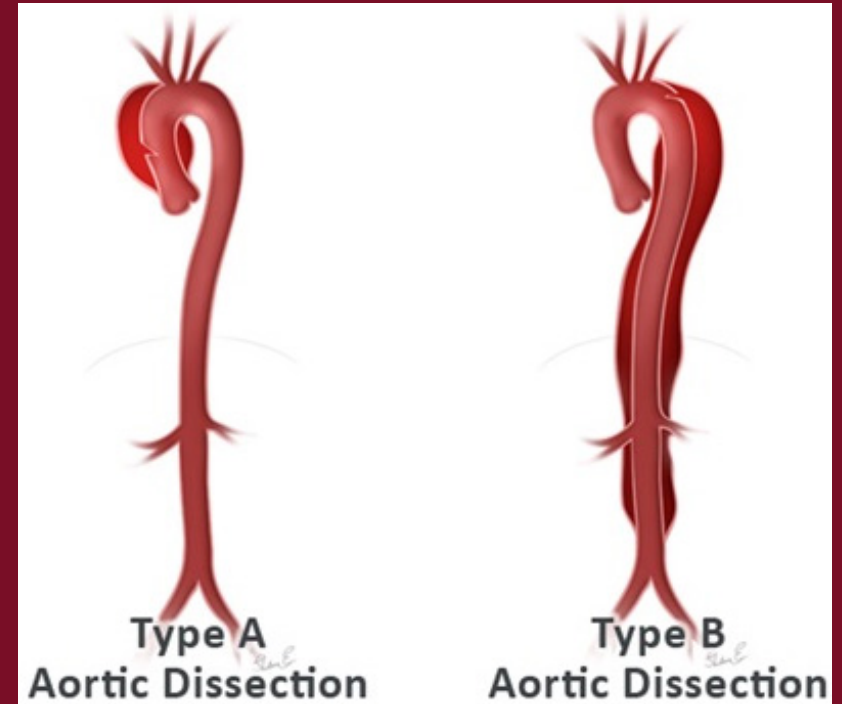
- DeBakey Classification System





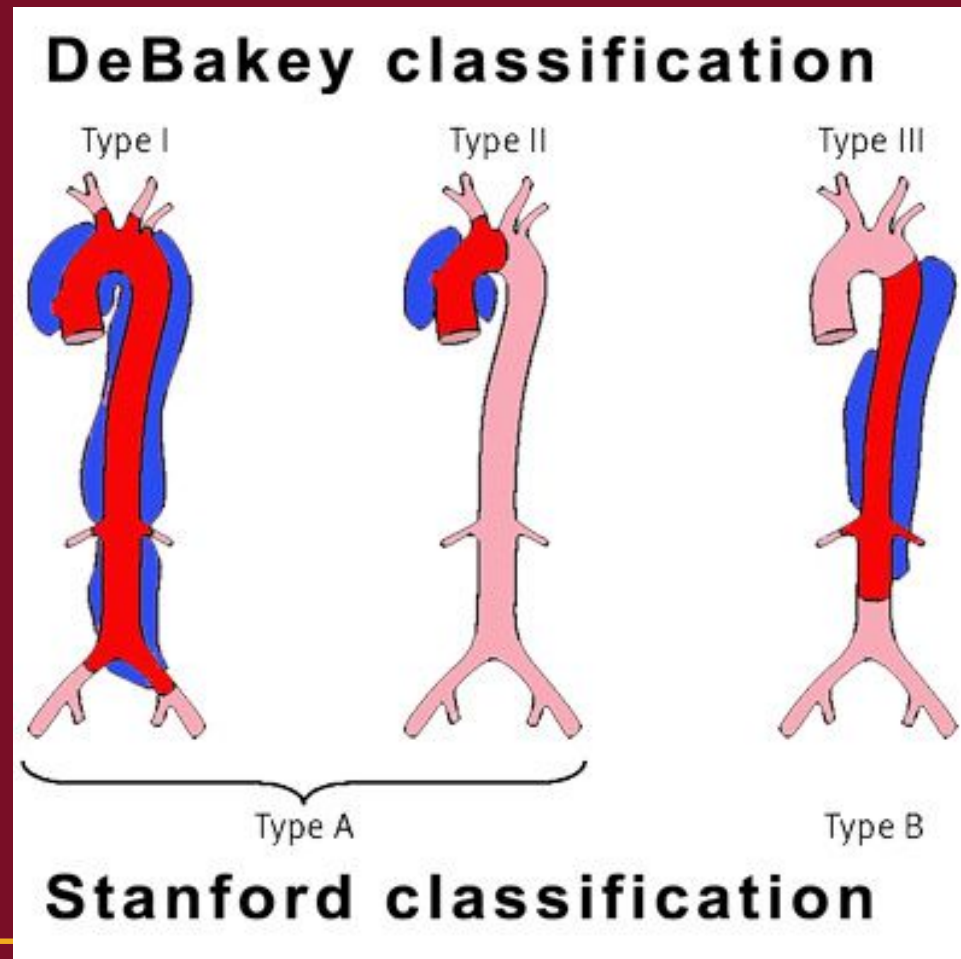
Acute Aortic Syndromes

- Stanford Classification System
 - Type A
 - Involves ascending aorta
 - Type B
 - No involvement of ascending aorta





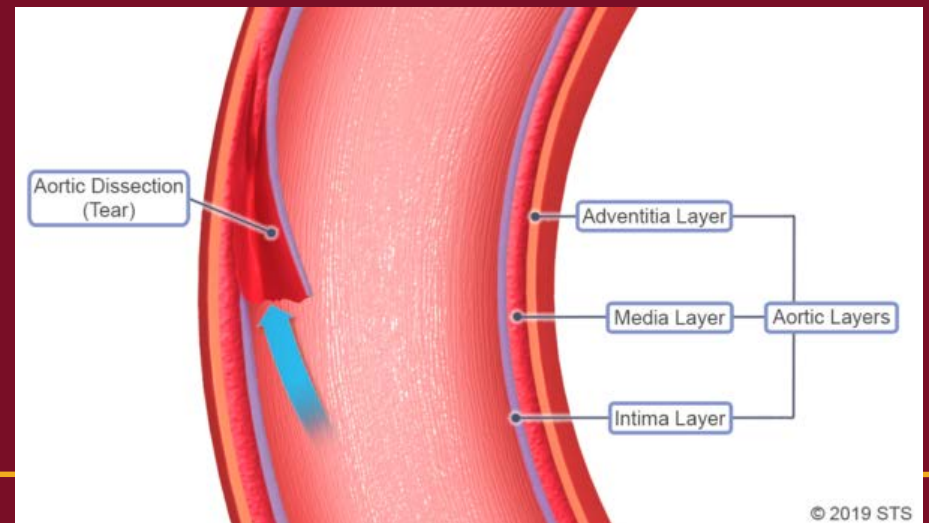
Acute Aortic Syndromes





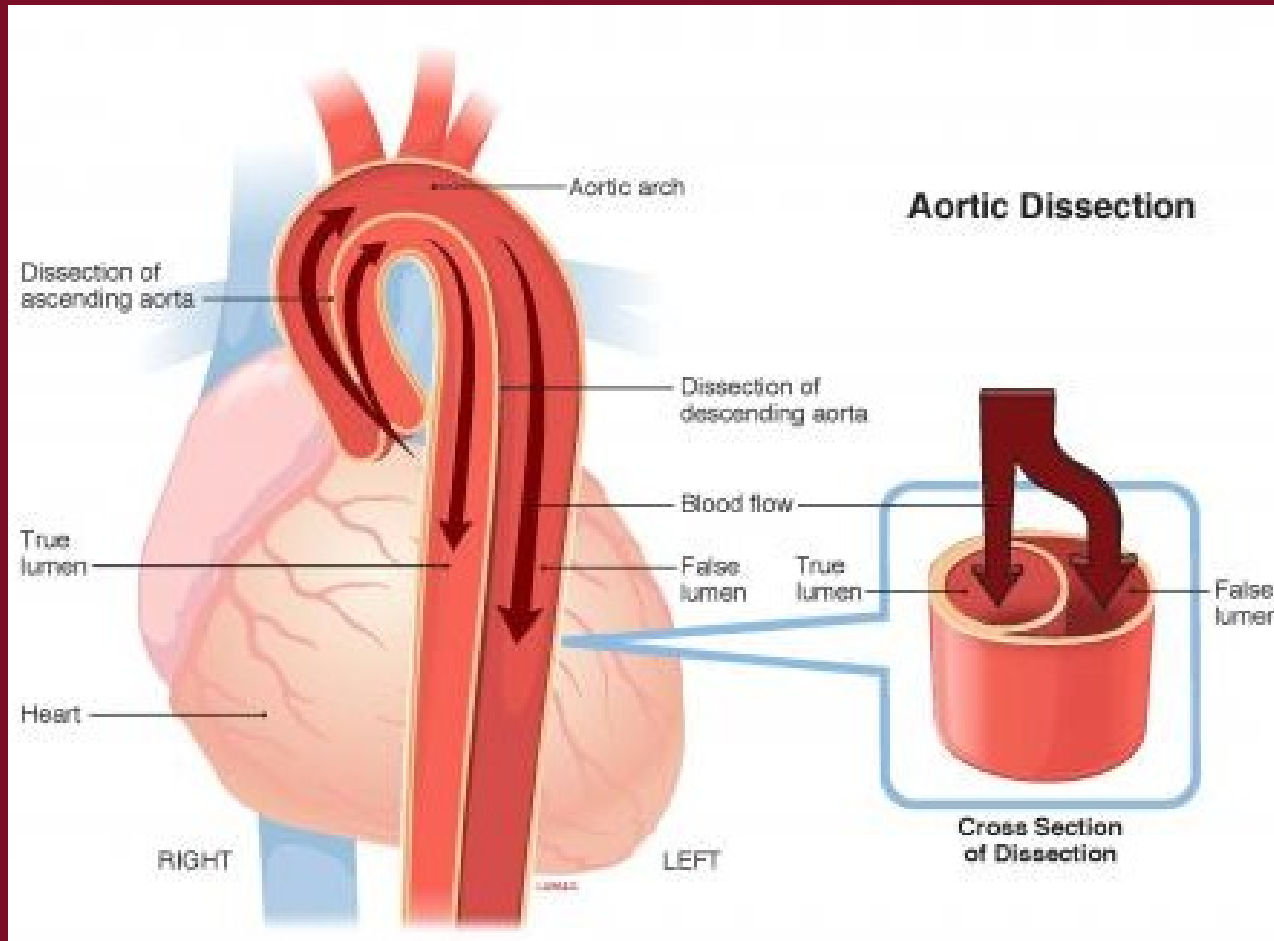
Acute Aortic Syndromes

- Acute Aortic Dissection
 - Intimal tear with propagation into media
 - Creation of true/false lumen separated by intimomedial flap
 - 85-95% of pts with AAS
 - Median age 61yo (range 4th to 7th decade)
 - Presenting symptoms
 - Chest/back pain 85%
 - Pulse deficit 30%
 - Hypotension 25%
 - Syncope 13%





Acute Aortic Dissection

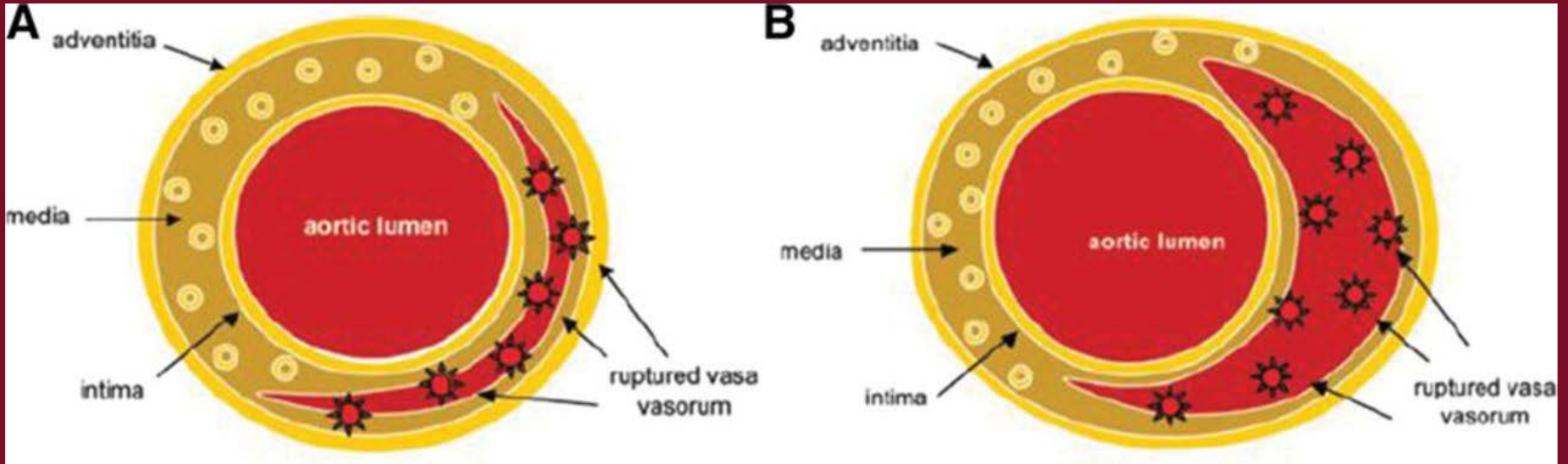




Acute Aortic Syndromes

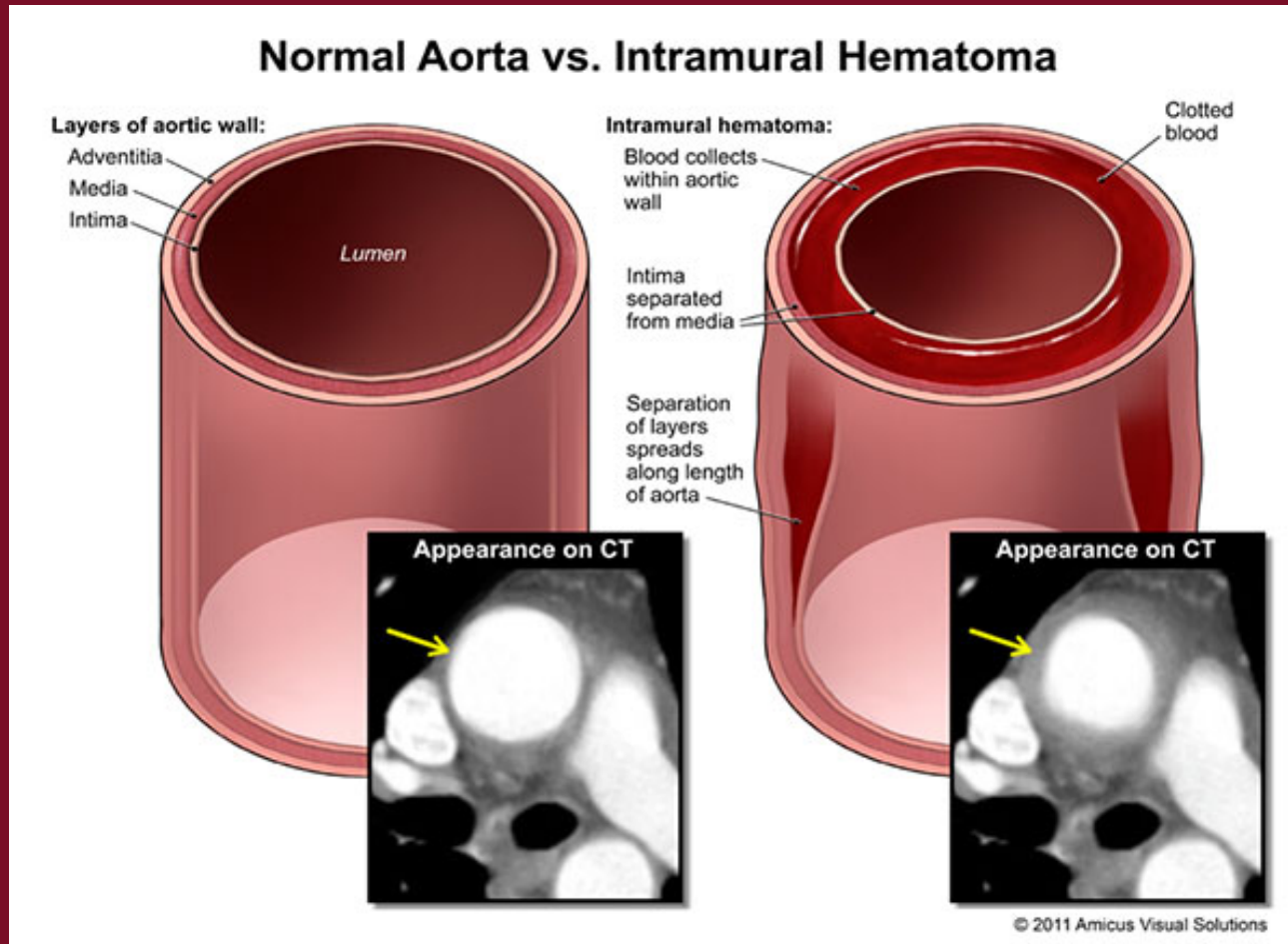
- Intramural Hematoma (IMH)
 - Rupture of vasa vasorum into media
 - No identifiable intimal tear
 - 5-10% of AAS
 - <10% spontaneous regression
 - 47% may progress to dissection
 - Predominantly descending aorta
 - Older age than aortic dissection (mean 68 yrs)
 - Similar mortality to aortic dissection

Intramural Hematoma (IMH)

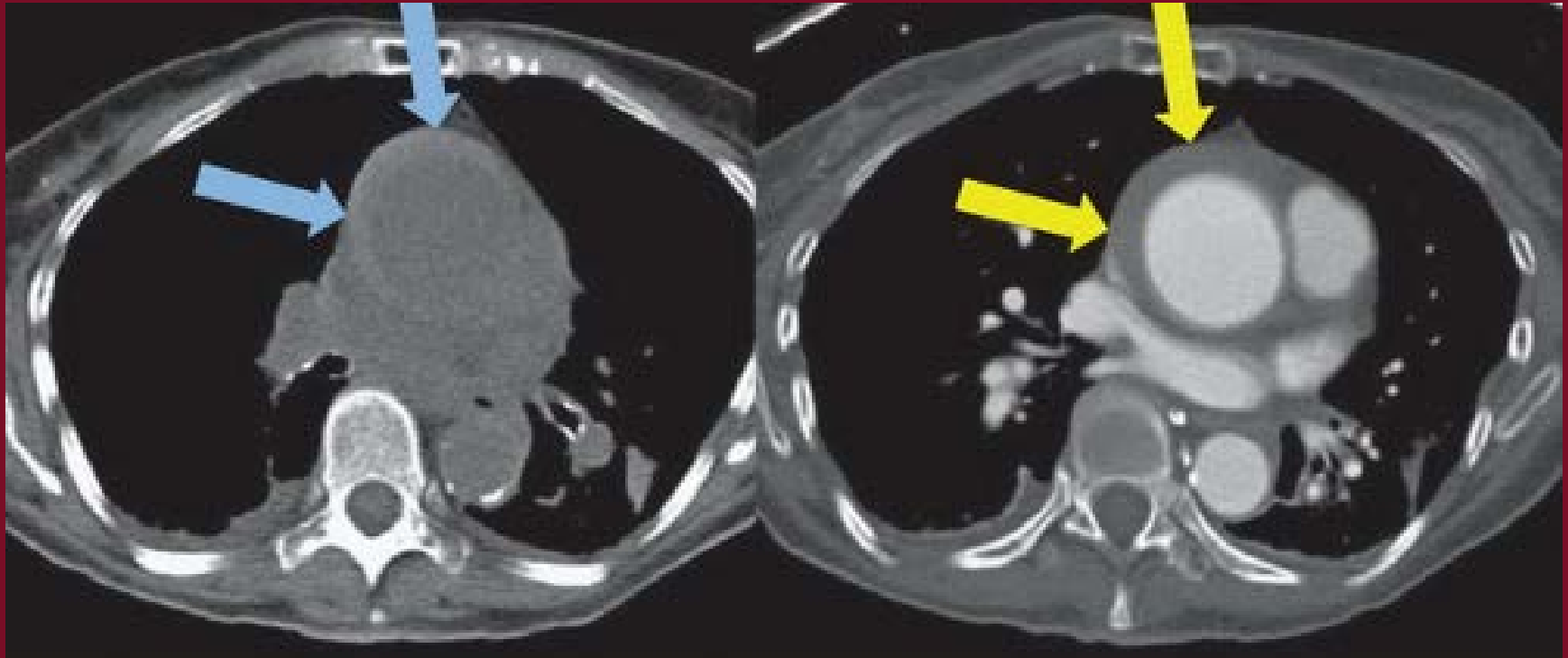




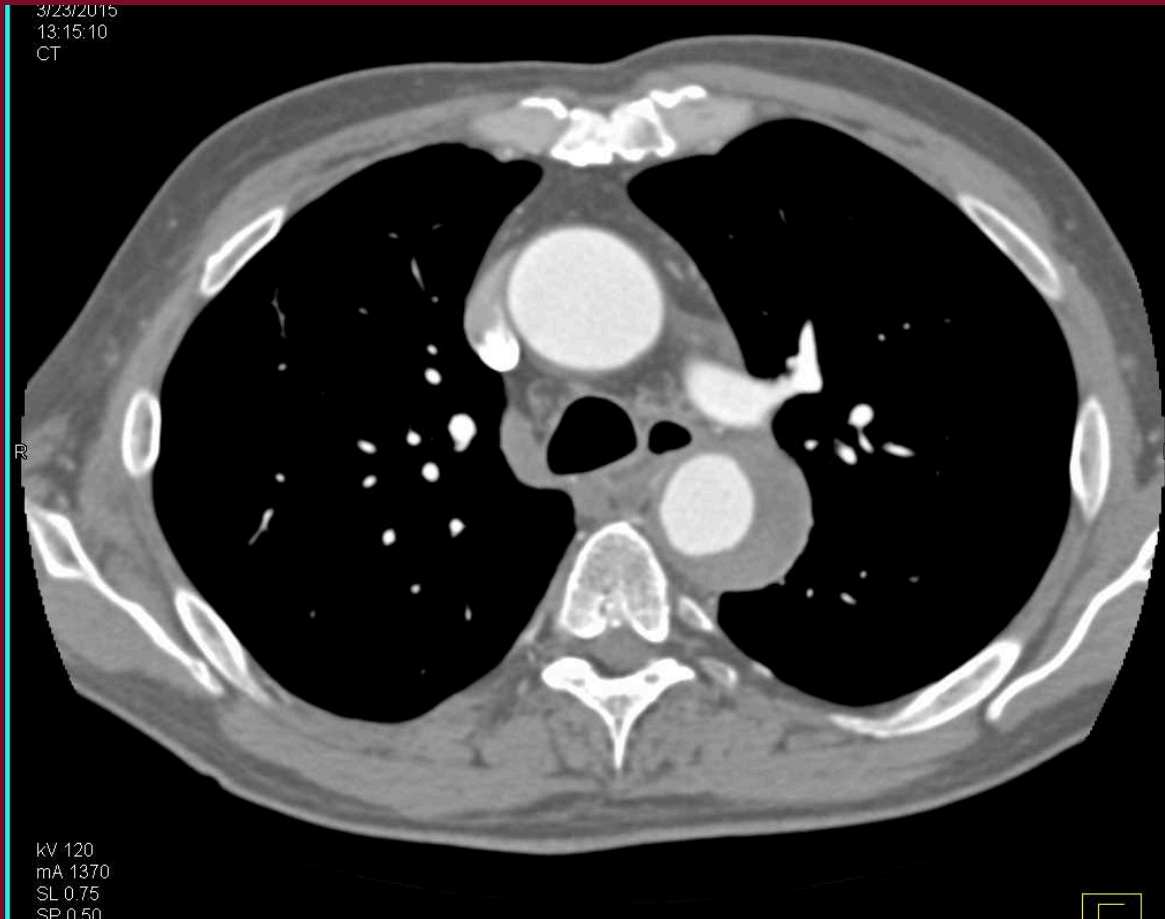
Intramural Hematoma (IMH)



Intramural Hematoma (IMH)



Intramural Hematoma (IMH)



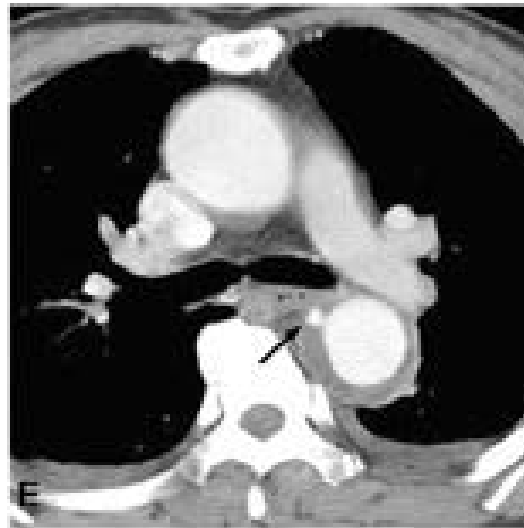
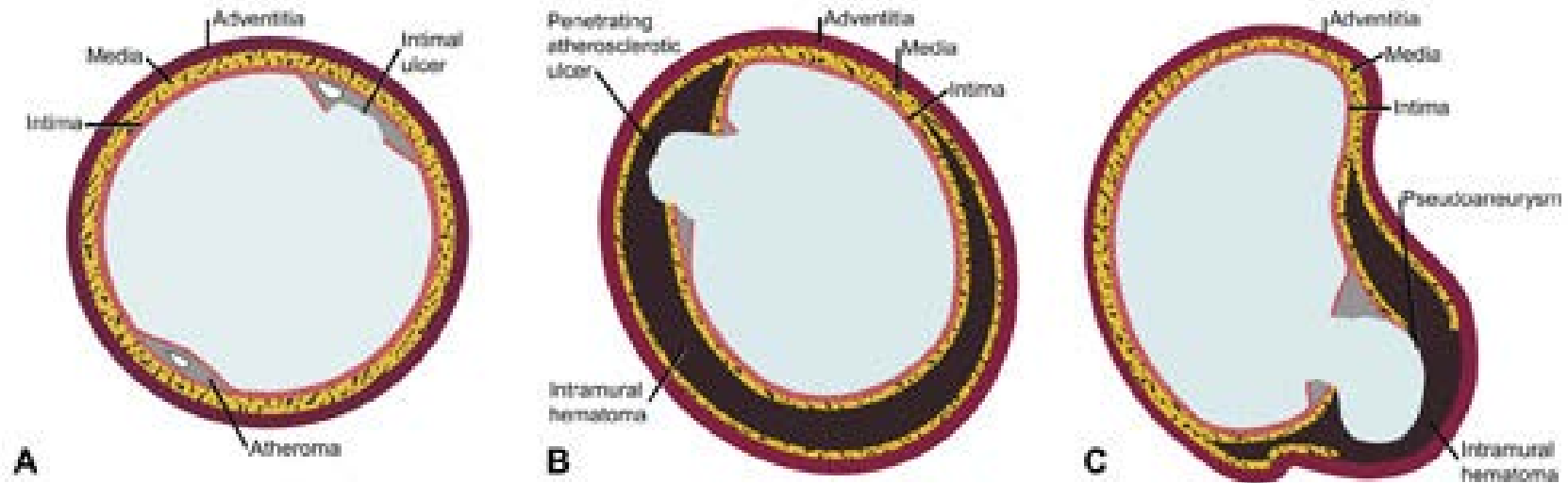


Acute Aortic Syndromes

- Penetrating Aortic Ulcer (PAU)
 - Outpouching of blood through internal elastic lamina
 - Typically arising from atherosclerotic plaque
 - 2-7% of AAS
 - Often have associated IMH
 - May progress to dissection, pseudoaneurysm formation, or rupture
 - Typically older patients (mean 74 yrs)
 - Majority occur in descending aorta

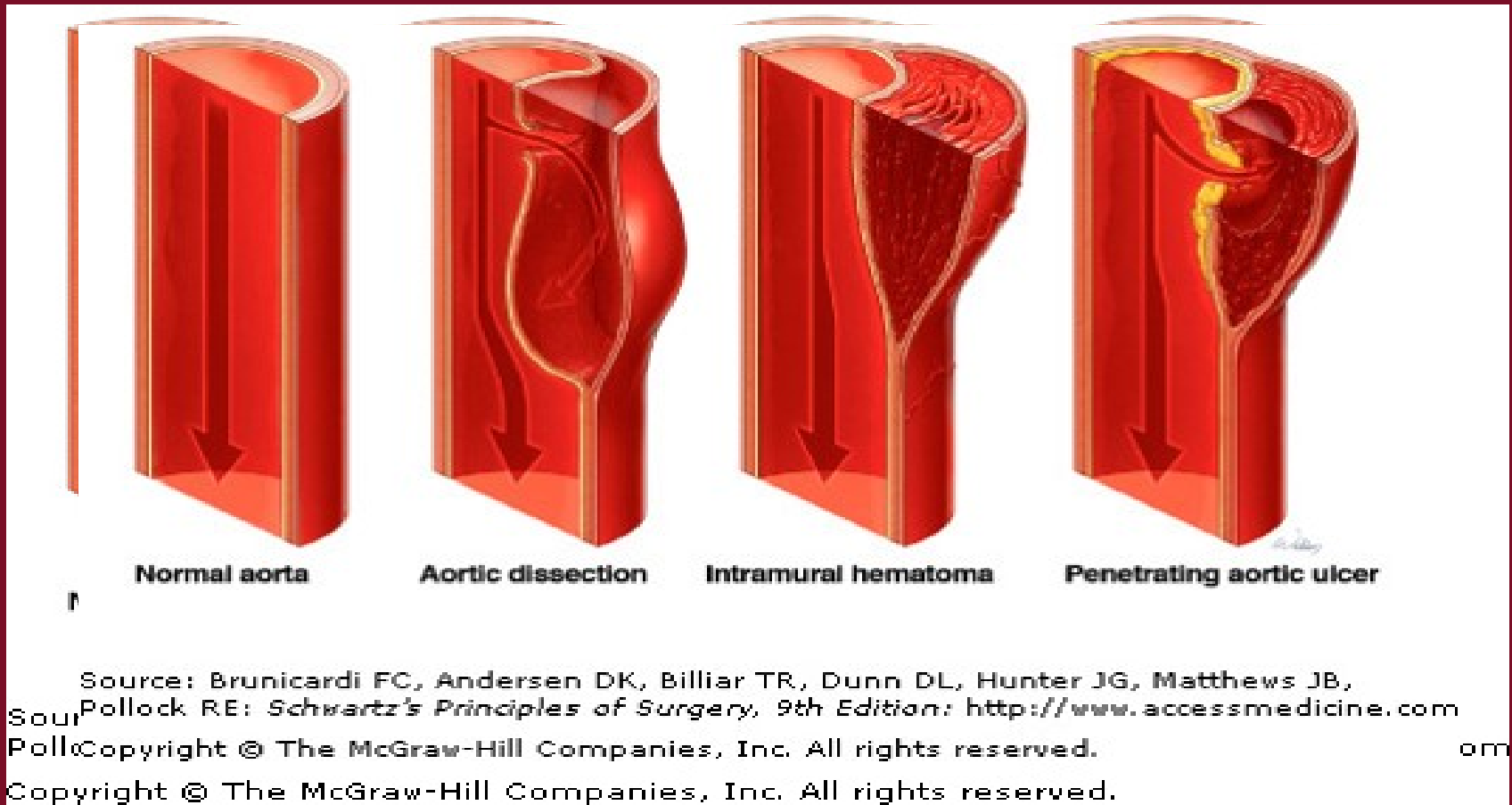


Penetrating Aortic Ulcer (PAU)





Acute Aortic Syndrome Continuum





AAS Continuum





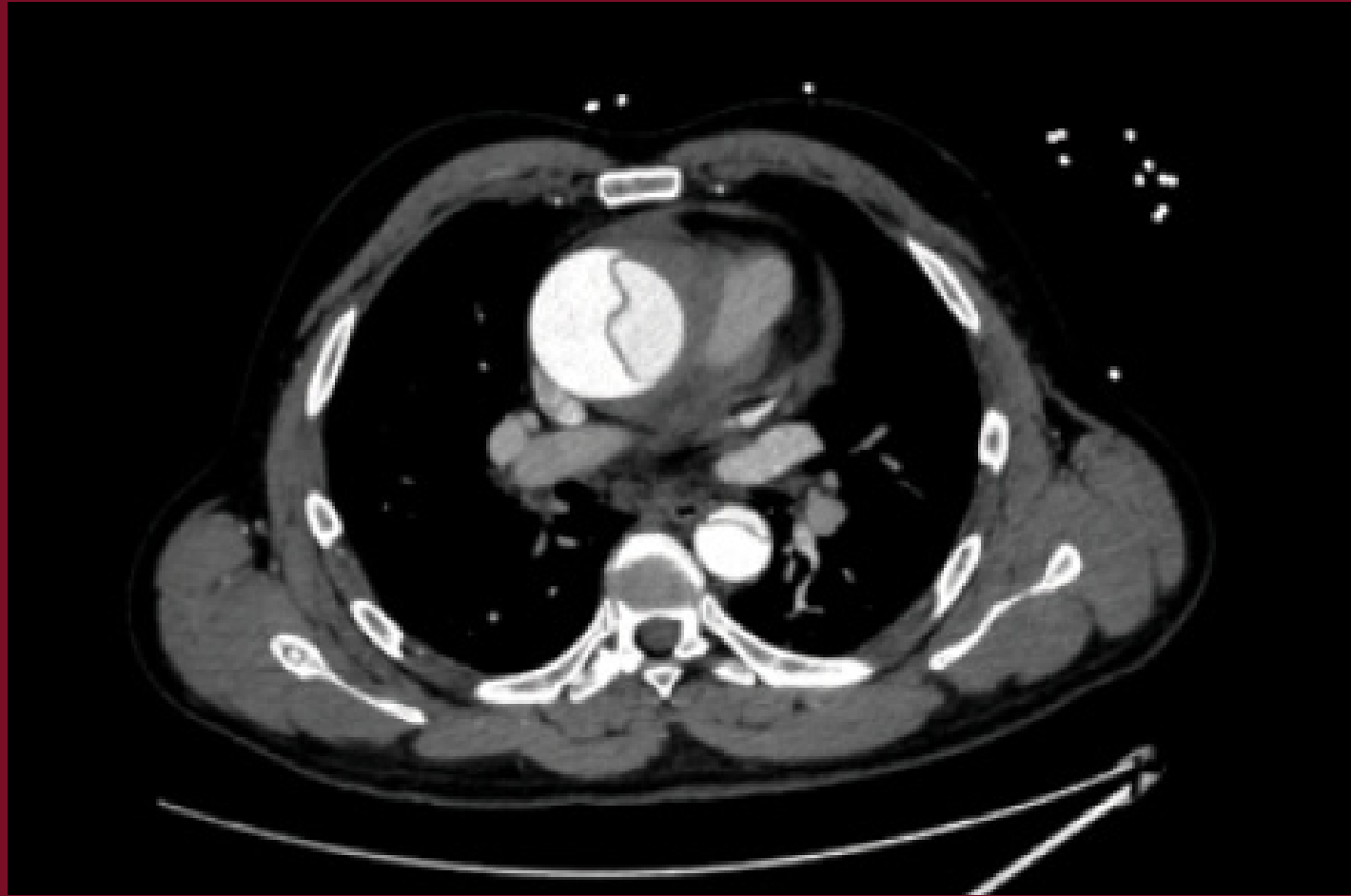
AAS Continuum



Figure 6. Descending PAU associated with IMH.

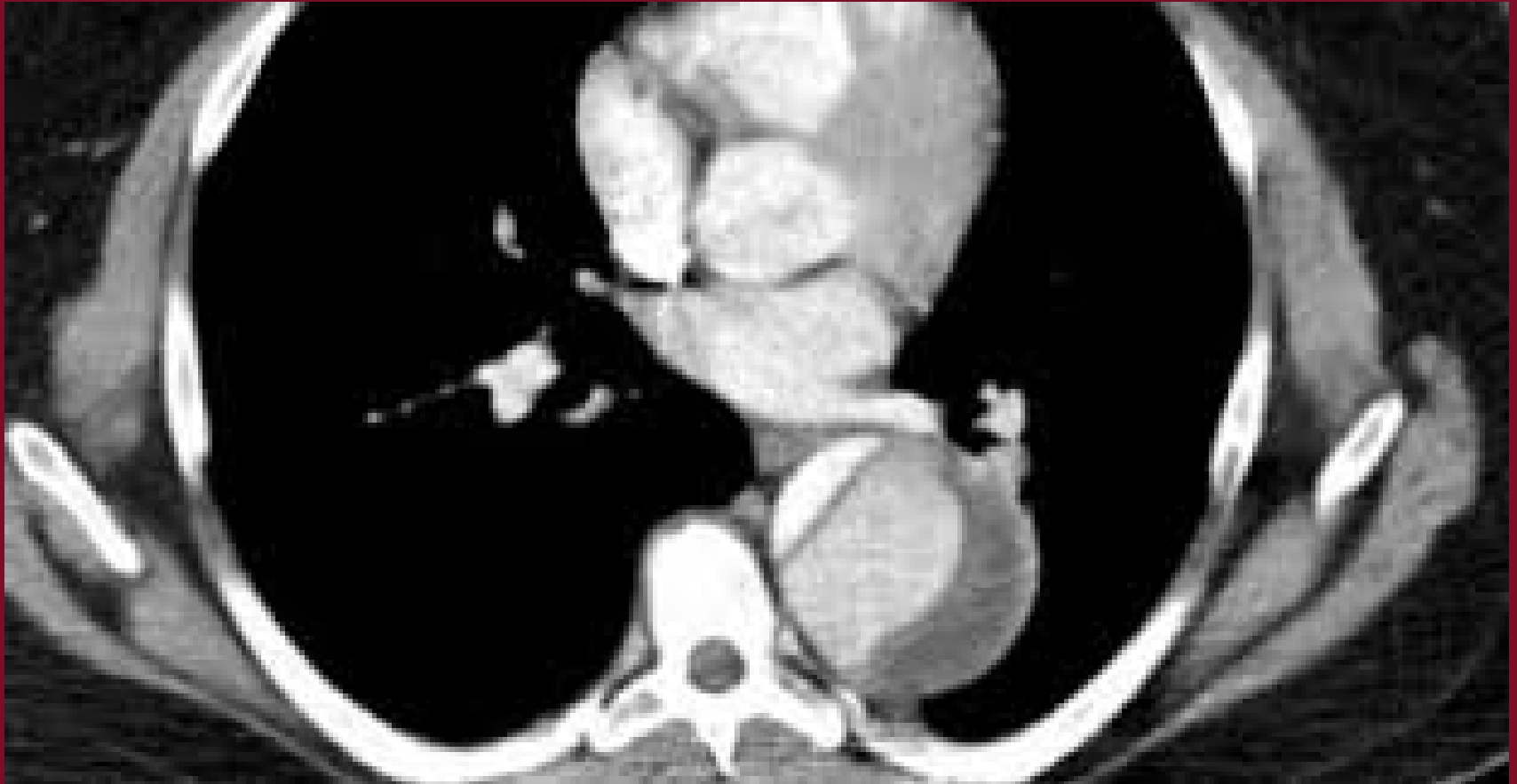


AAS Continuum





AAS Continuum





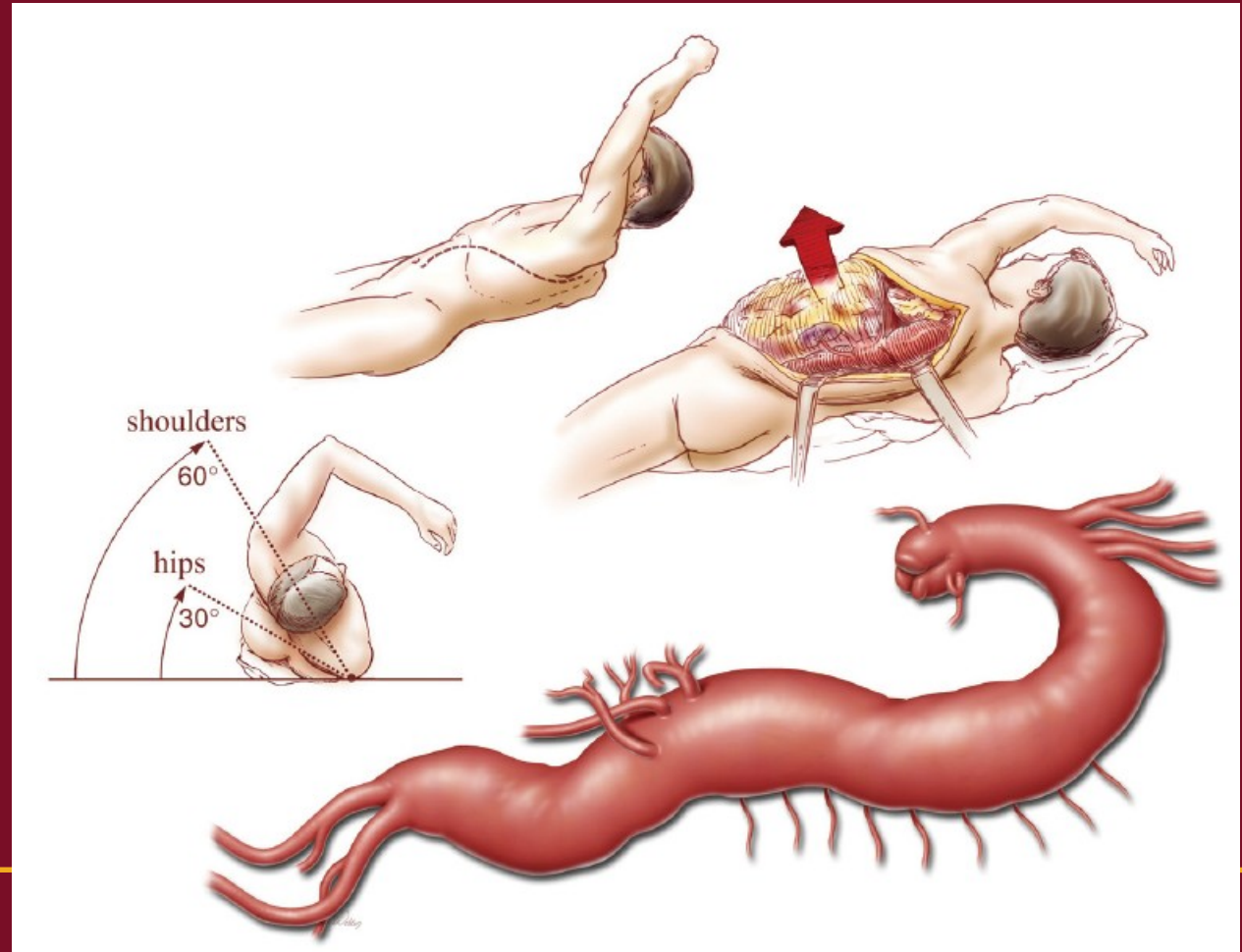
Thoracic Endovascular Aneurysm Repair (TEVAR)

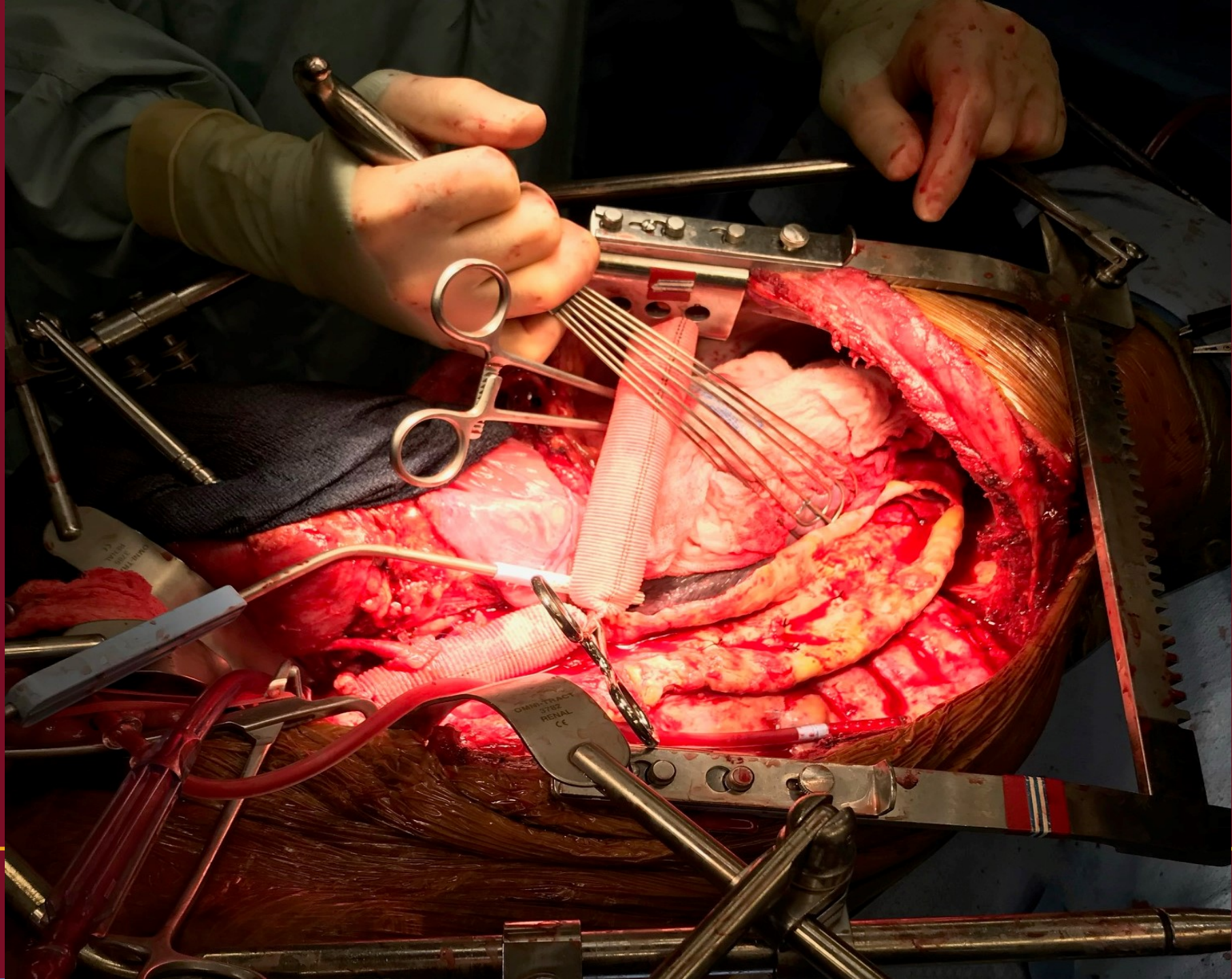
- First performed by Dake et al. in 1992
- Initially reserved for non-surgical candidates
- FDA approval in 2005
- Gold standard for treating majority of TAAs and TBADs
 - Other applications – blunt thoracic injury, type A dissection, aorto-esophageal fistula

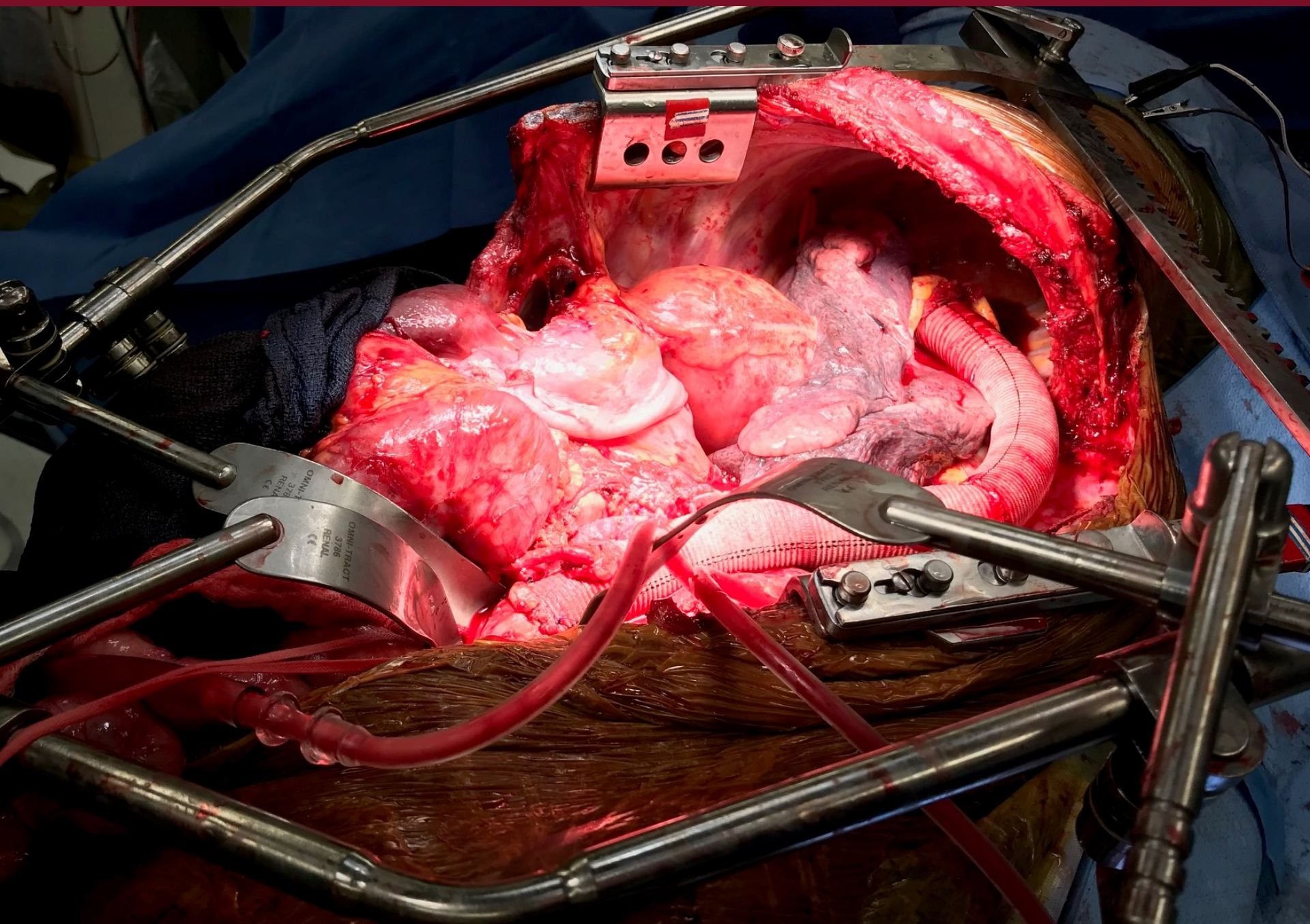


TEVAR

- Why?







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3786
REVAL
CC

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REVAL
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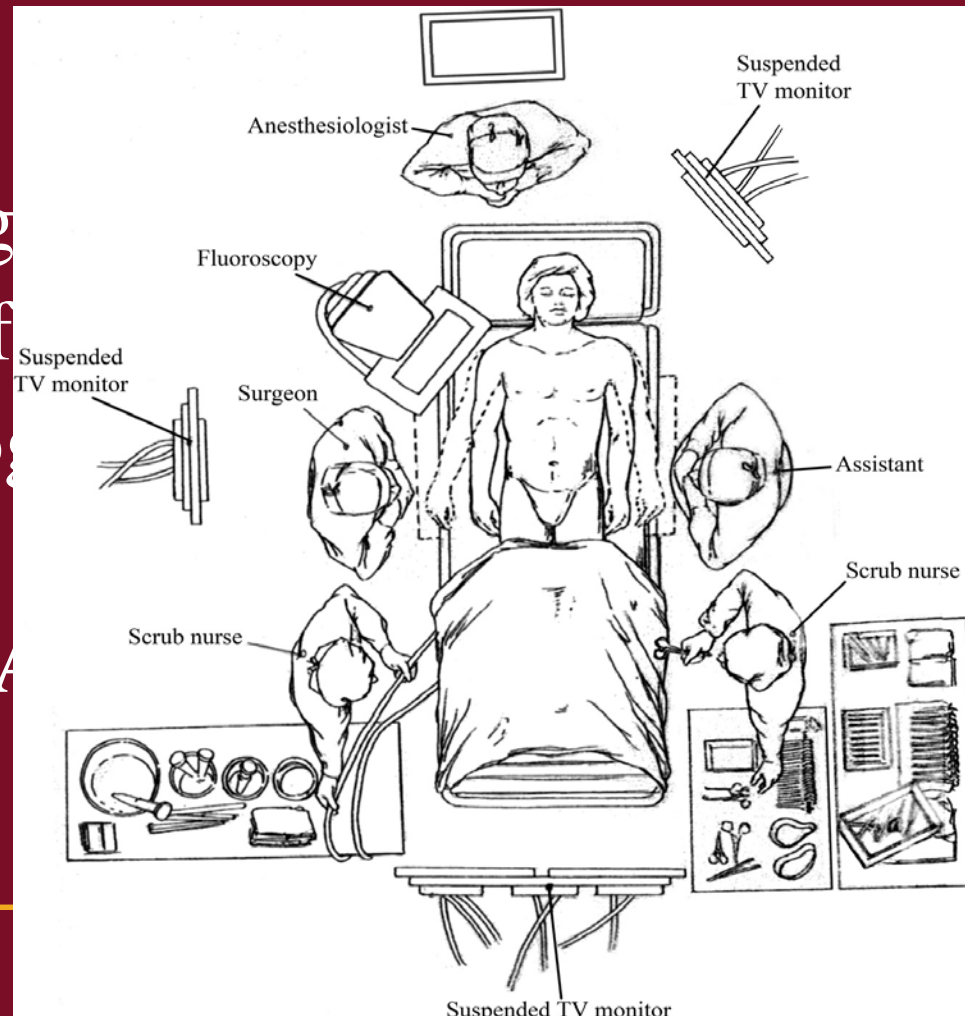
TEVAR

- Endovascular vs Open (meta-analysis, JVS 2008)
 - Avoidance of sternotomy/thoracotomy
 - Avoidance of aortic cross-clamping
 - Less blood loss
 - Lower incidence of end-organ ischemia
 - Less ventilator dependence
 - Shorter hospitalization



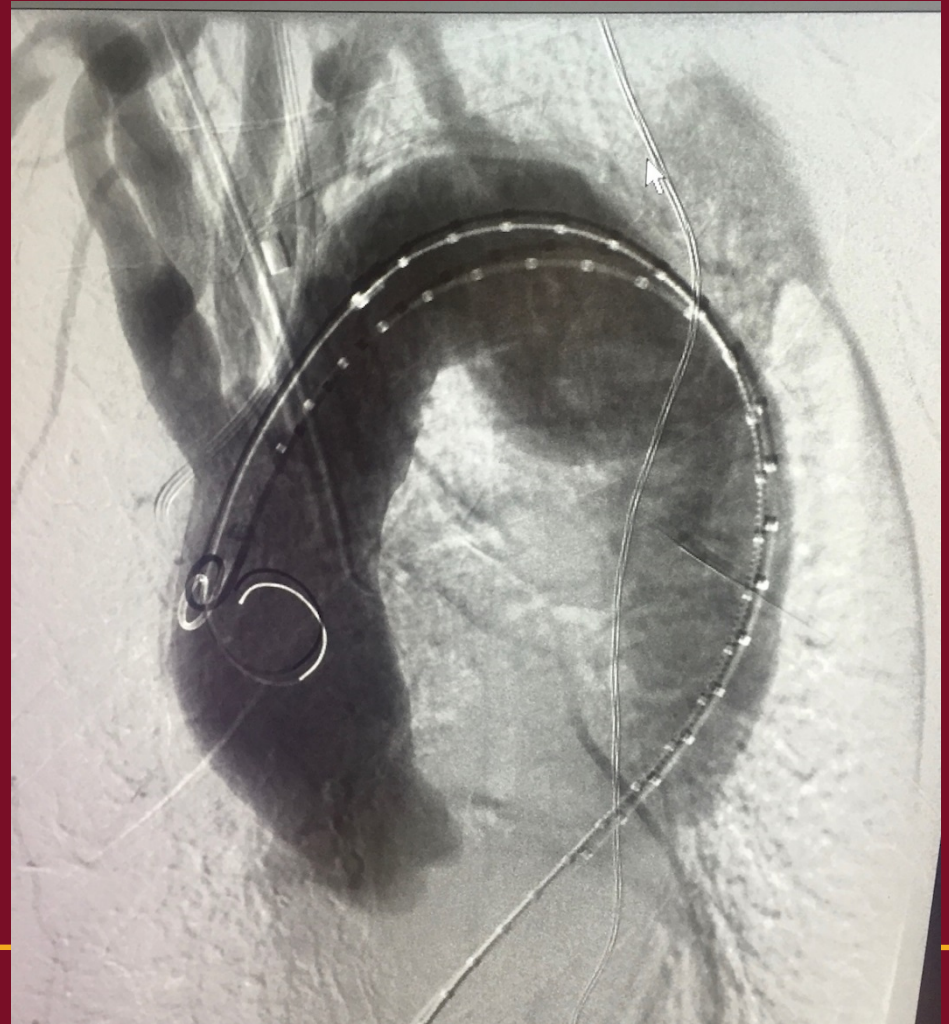
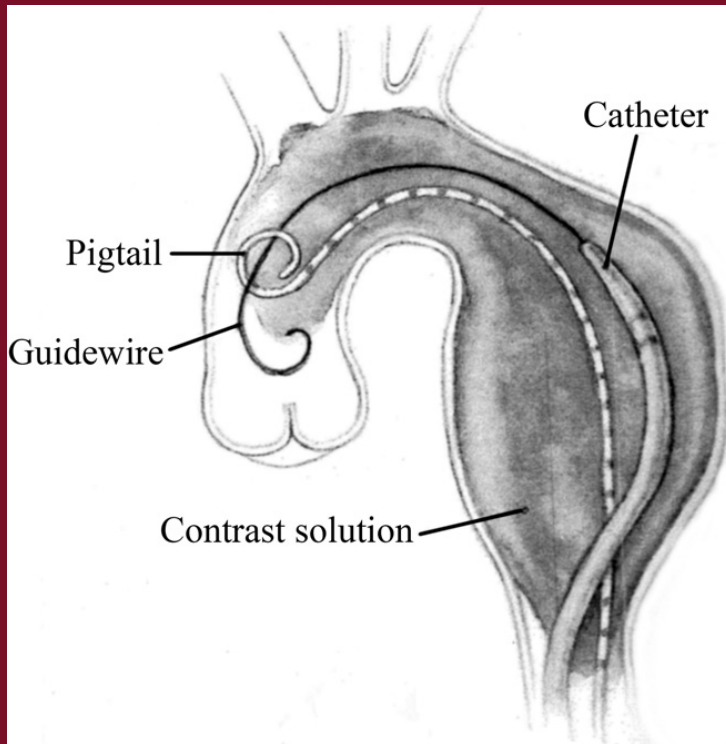
TEVAR

- How?
 - Ultrasound-guided
 - Placement of stent
 - Initial Angiogram
 - Deployment
 - Completion Angiogram
 - Closure



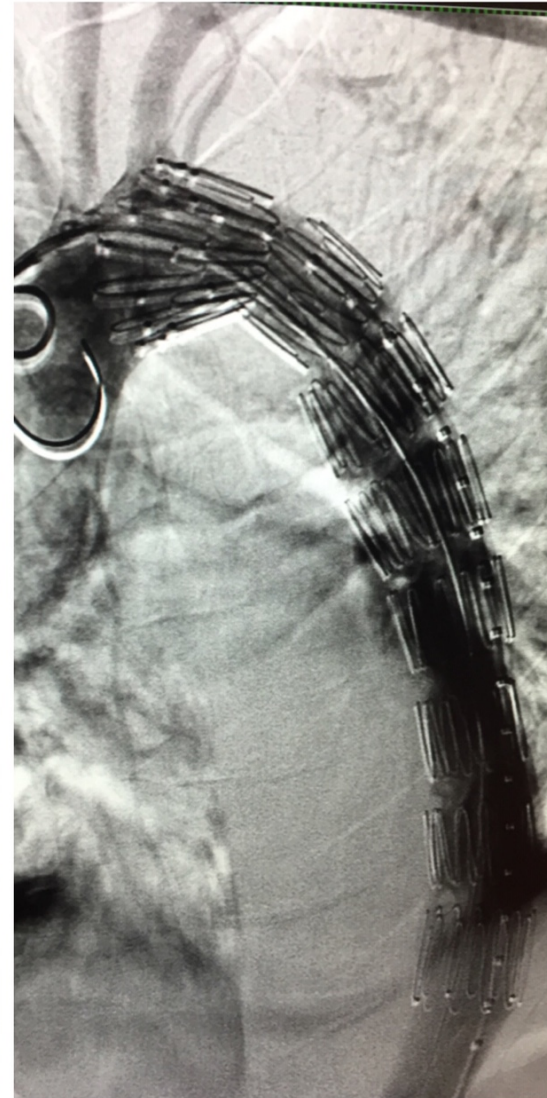
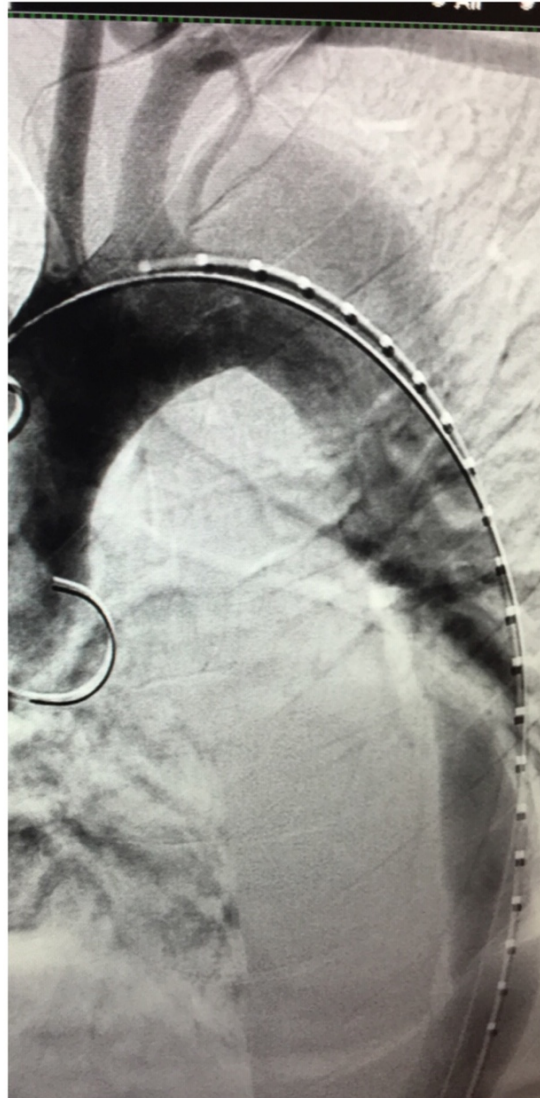


Angiography










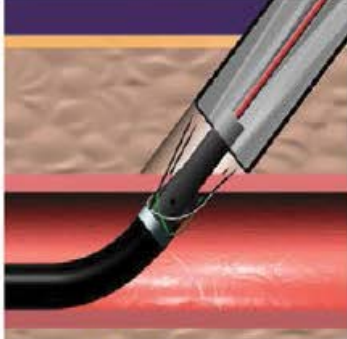
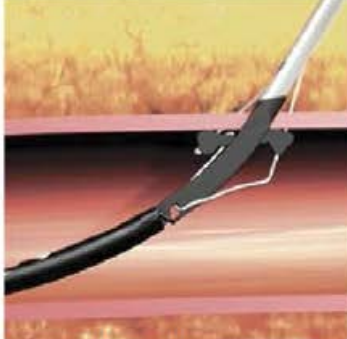
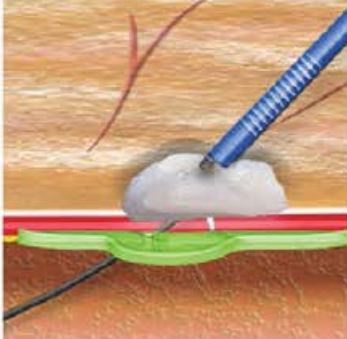
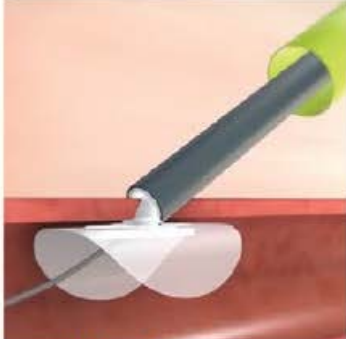

Deployment





Vascular Closure

Figure 2: Commercially Available Vascular Closure Devices

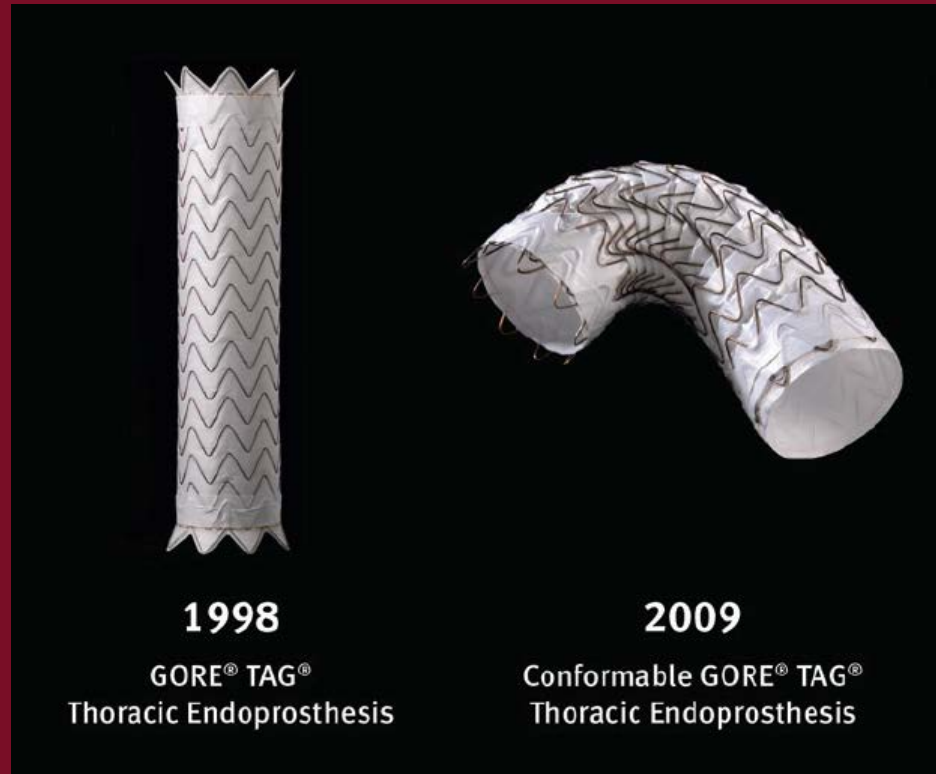
Prostar® XL	ProGlide®	MANTA™	PerQseal®	InSeal
				
				
Suture-based	Suture-based	Collagen-based	Patch-based	Membrane-based
8.5–10 Fr (off-label use > 10 Fr)	5–8 Fr (off-label use > 8 Fr)	10–14 Fr (14 Fr system) 14–22 Fr (18 Fr system)	< 24 Fr	14–21 Fr
CE mark	CE mark	CE mark	CE mark	CE mark

Source: Abbott Vascular, Essential Medical, InSeal Medical and Vivasure Medical.



TEVAR - Devices

- Gore





TEVAR - Devices

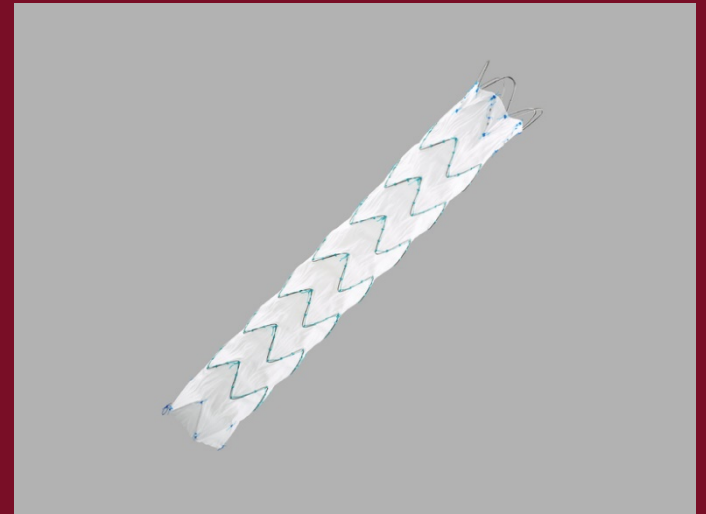
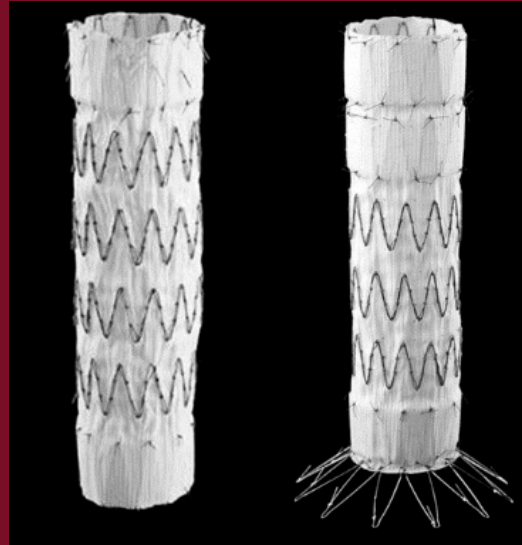
- Medtronic
– Valiant





TEVAR - Devices

- Cook
 - TX2
 - Alpha





TEVAR - Devices

- Bolton
 - Relay





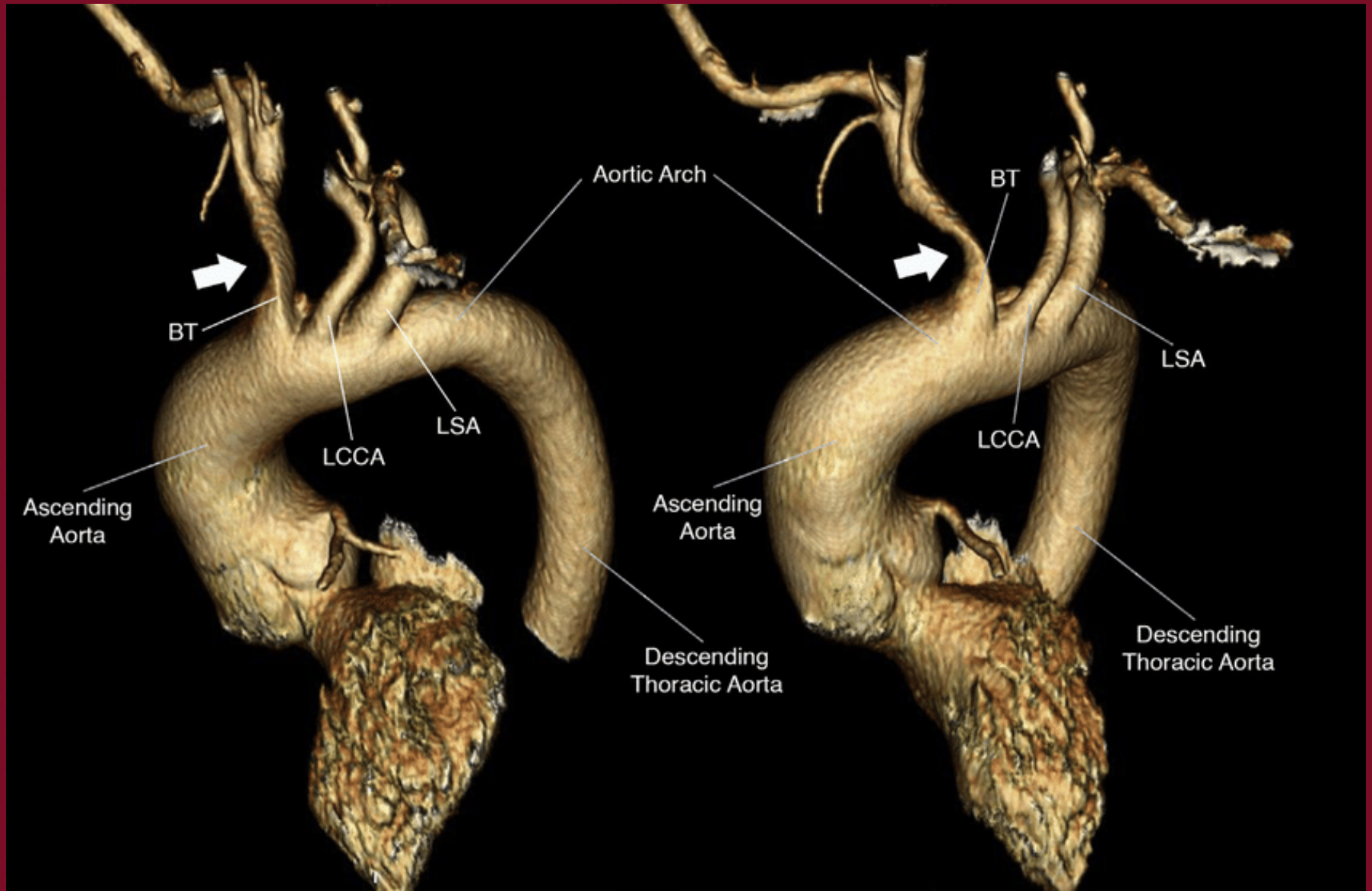
TEVAR - Devices

- Technical Considerations
 - Sheath Size
 - Structural Support (Nitinol)
 - More comformability = better seal
 - More kinking / thrombosis
 - Graft material
 - Dacron vs PTFE



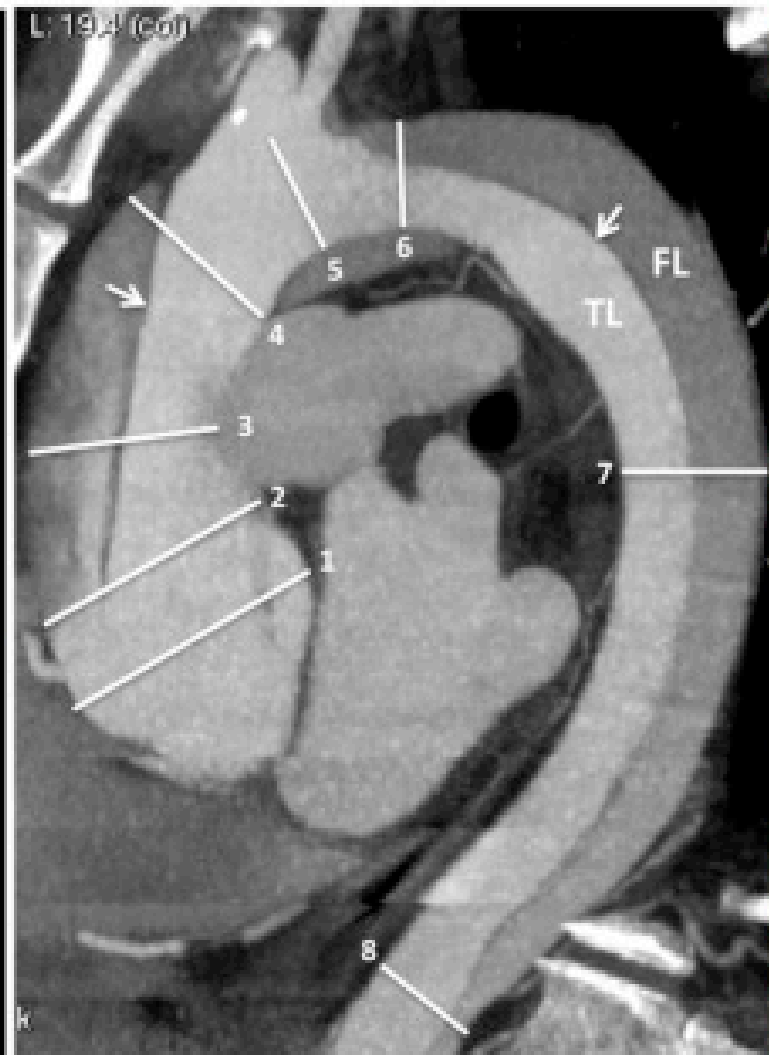
TEVAR

- Procedural Planning
 - CT Angiography – gold standard
 - Chest, abdomen, pelvis, femorals
 - 3-D reconstruction preferable

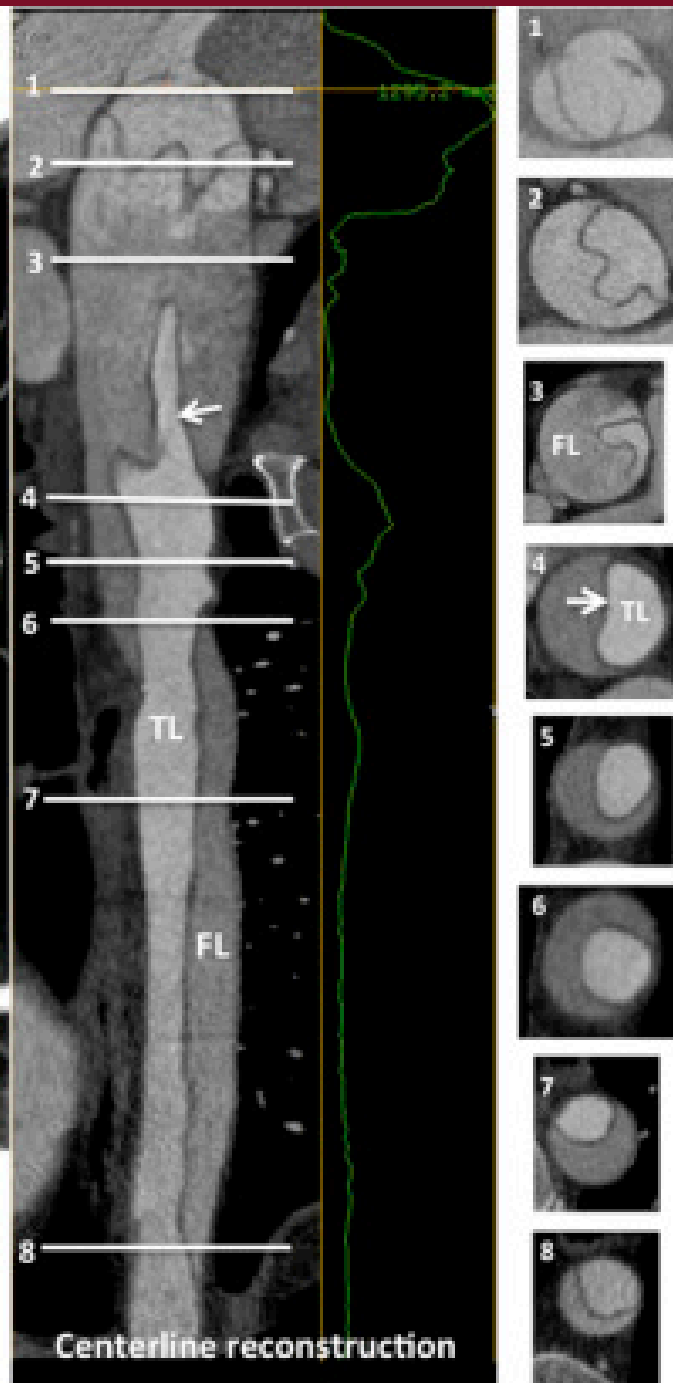


A

**Aortic CTA 3-D
volume rendering**

B

**CTA: Oblique coronal view of
the thoracic aorta**

C

Centerline reconstruction



TEVAR

- Procedural Planning
 - MRA acceptable alternative to CTA
 - Doesn't demonstrate vessel wall calcification
 - Intravascular Ultrasound (IVUS)
 - Confirmation of preoperative measurements
 - Identification of true/false lumens
 - Identification of branch vessels



TEVAR for Thoracic Aortic Aneurysm (TAA)

- Initial device trials
 - Valiant
 - 2% 30-day mortality, 41% morbidity (vs 84% in open repair)
 - TAG
 - 2% 30-day mortality
 - TX2
 - 15.6% morbidity (vs 44.3% in open repair)
- Open repair associated with 2x risk of spinal ischemia
- Prior to 2003 <10% of TAA underwent TEVAR
- Since 2007 >27% of TAA underwent TEVAR



TEVAR for Thoracic Aortic Aneurysm (TAA)

- 2017 European Society for Vascular Surgery Guidelines
 - Repair considered for $>60\text{mm}$ (class II, level B evidence)
 - $>66\%$ chance of rupture over 5 yrs
 - 14.1%/yr risk of rupture, dissection, or death
 - 6.5%/yr between 50-60mm



TEVAR for Thoracic Aortic Aneurysm (TAA)

- 2017 European Society for Vascular Surgery Guidelines
 - Saccular aneurysms $>20\text{mm}$ with total aortic diameter $>50\text{mm}$
 - Lower threshold of 50-55mm for women
 - Connective tissue disorder $>50\text{mm}$
 - Rapid growth $>10\text{mm/yr}$



TEVAR for Type B Aortic Dissection (TBAD)

- TEVAR has better long-term outcomes than medical management alone when treating TBAD
 - Five-year survival rates for TEVAR vs. medical management are 76% vs. 60% (*Ianuzzi et al. JVS 2018*)
 - Medical therapy fails in 58.4% of cases (29.2% aorta-related interventions, 38.3% deaths), TEVAR pts had higher survival rate at 6 years than those receiving medical management alone, 76.4% vs. 59.3% (*Durham, et al. JVS 2015*)



Type B Aortic Dissection (TBAD)

- Acuity
 - Acute <2 wks
 - Subacute 2 wks - 6 wks
 - Chronic > 6 wks
- Uncomplicated vs Complicated
 - End-organ malperfusion
 - Refractory pain
 - Rapidly expanding false lumen
 - Impending/frank rupture
 - Progressive aneurysmal dilation (chronic)



Indications for TEVAR in TBAD

- End-organ malperfusion
 - Branch occlusion
 - May present early or late (dynamic process)
 - Visceral – abdominal pain, renal dysfunction
 - Spinal cord – paraplegia, paraparesis
 - Extremity – pulse deficit, hemiplegia



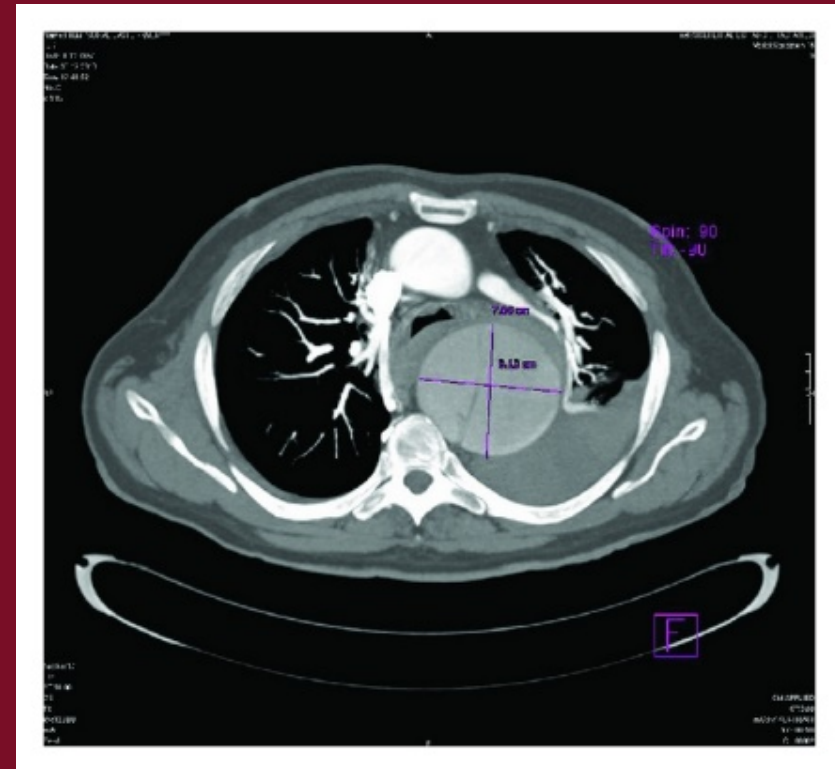
Indications for TEVAR in TBAD

- Refractory Pain despite adequate medical management
 - Significant predictor of in-hospital mortality, odd ratio 3.3 (IRAD database)
 - In-hospital mortality 4% vs 17.4% for TEVAR vs medical mgmt.
- Rapidly expanding false lumen
 - >5mm in 6 mos, >10cm in 1 yr



Indications for TEVAR in TBAD

- Impending/Frank rupture
 - Increasing periaortic or pericardial hematoma, hemothorax



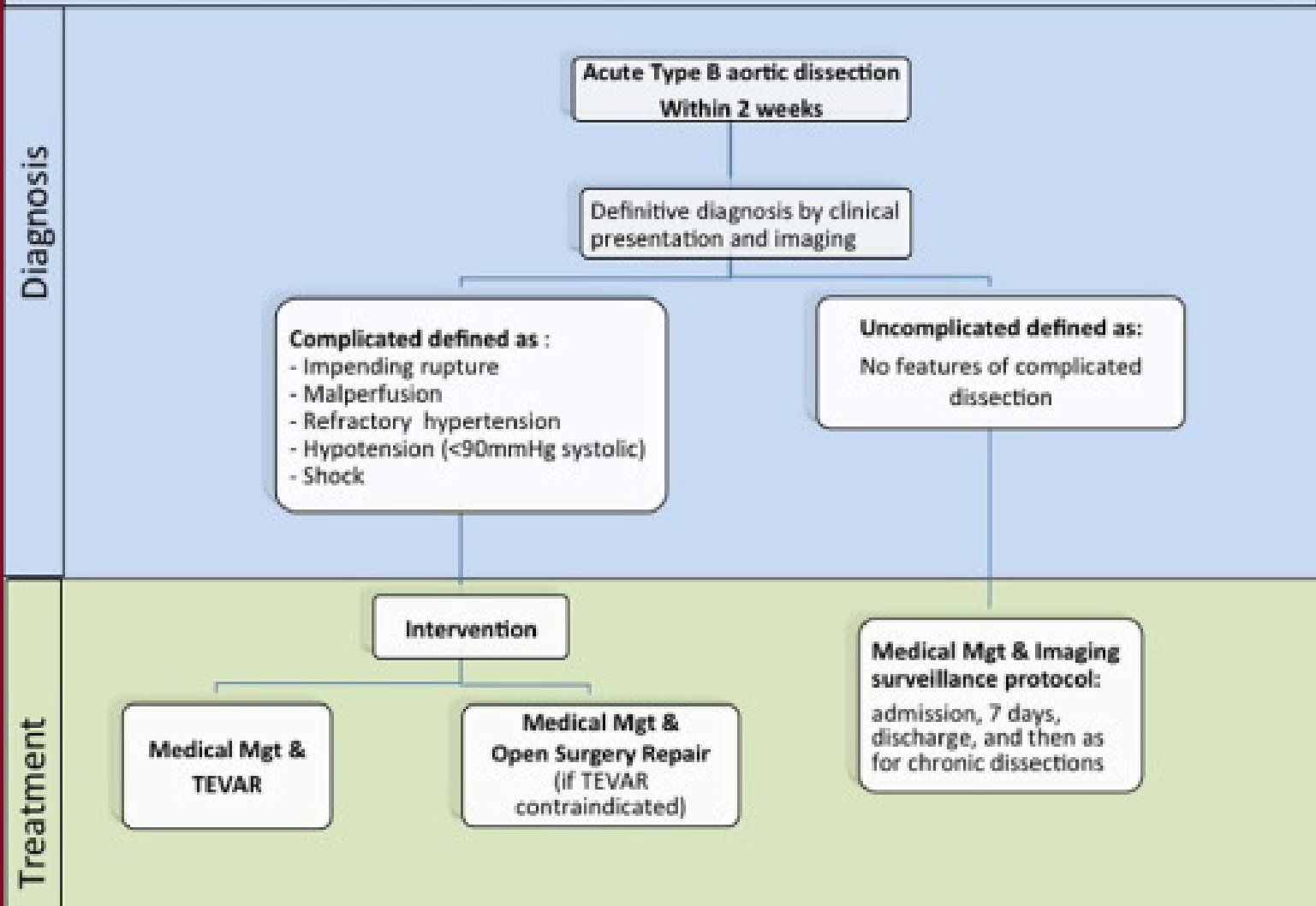


Contraindications for TEVAR in TBAD

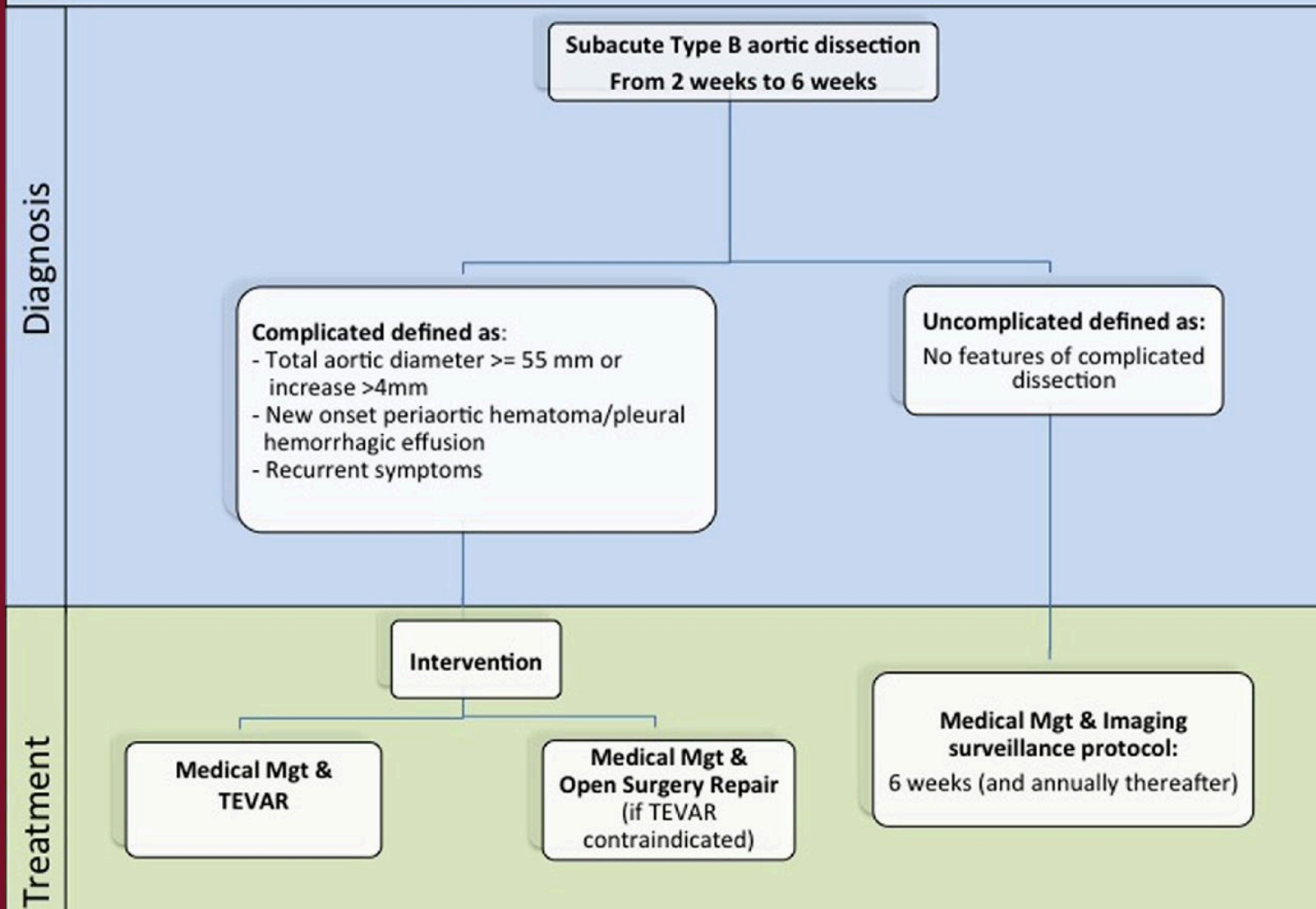
- Unfavorable anatomy
 - Inadequate proximal or distal seal zones (>20mm)
 - Tortuosity
 - Lack of vascular access
 - Extremes of aortic diameter (<21 or >46mm)
- Connective tissue disorder
- Inability to complete follow-up surveillance



Acute Type B Aortic dissections Algorithm



Subacute Type B Aortic dissections Algorithm





Chronic Type B Aortic dissections Algorithm

Diagnosis

Treatment

Chronic Type B aortic dissection
After 6 weeks

Complicated defined as :

- Total aortic diameter ≥ 55 mm
- Total aortic diameter yearly increase >4 mm
- Recurrent symptoms

Uncomplicated defined as:
No features of complicated dissection

Intervention

Medical Mgt &
TEVAR

Medical Mgt &
Open Surgery Repair
(if TEVAR
contraindicated)

Medical Mgt & Imaging
surveillance protocol:
6 weeks and annually
thereafter

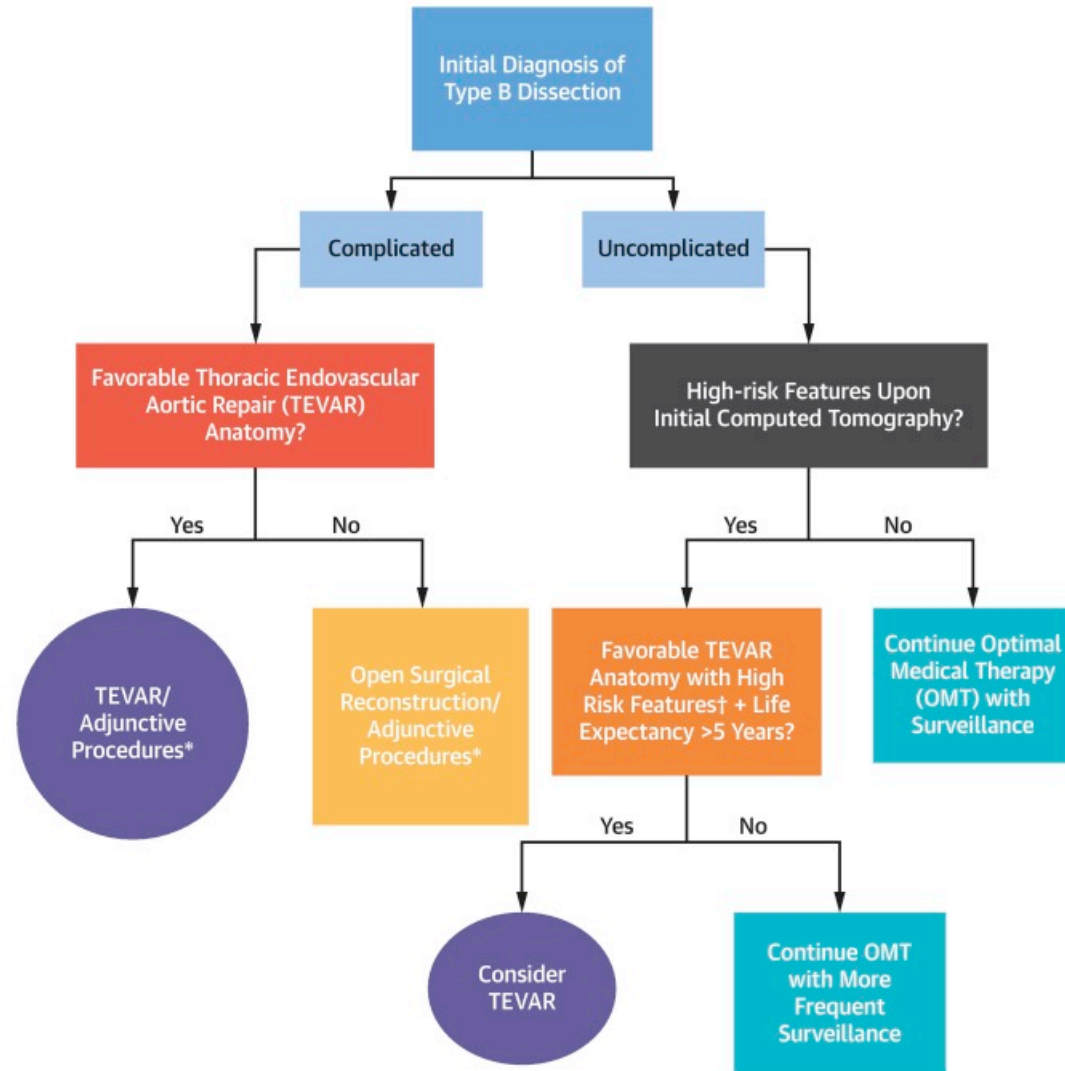


Expanding Indications for TEVAR in TBAD

- INSTEAD trial – TEVAR vs medical mgmt.
 - No difference in all-cause mortality at 1yr
 - Intervention unnecessary for uncomplicated
- INSTEAD XL trial – 5yr follow-up
 - Decrease in aorta-specific mortality and disease progression with TEVAR
 - Trend towards improved overall mortality



CENTRAL ILLUSTRATION: Algorithmic Framework for the Treatment of Type B Aortic Dissection



Tadros, R.O. et al. J Am Coll Cardiol. 2019;74(11):1494-504.



Expanding Indications for TEVAR in TBAD

- Acute, Uncomplicated TBAD
 - High-Risk features
 - Primary entry tear
 - single
 - on concavity of distal arch
 - Size <1cm
 - Proximal descending aorta >40mm
 - False lumen
 - Located at inner curve
 - Size >22mm
 - Elliptical or saccular
 - Partially thrombosed or patent
 - Inadequate BP control despite maximal medical management or medication non-compliance

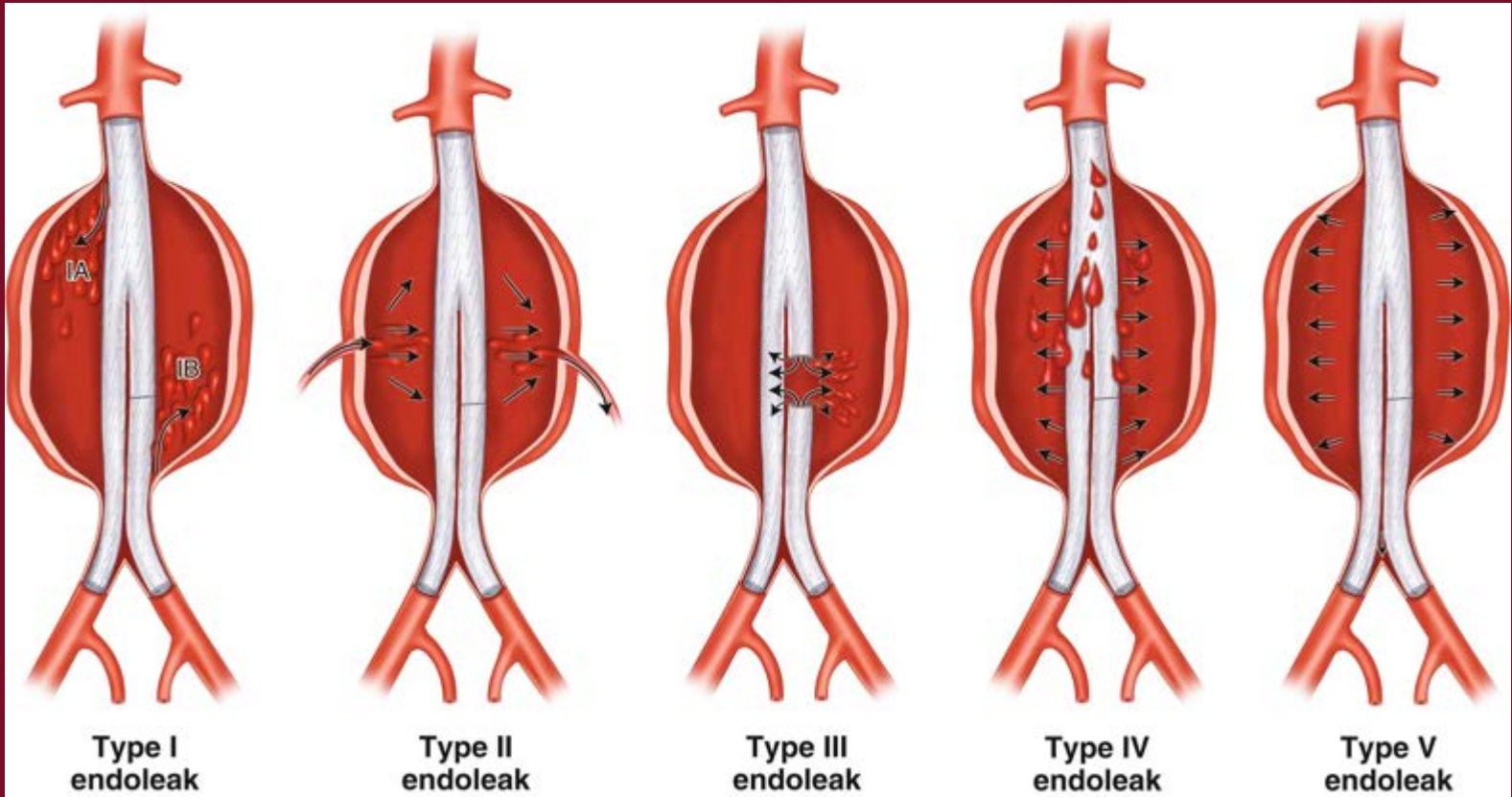


TEVAR Complications

- Endoleak (4-15% incidence)
 - Type I – proximal/distal seal zone (most common)
 - Ballooning
 - Type II – retrograde intercostal or left subclavian flow
 - Observation, embolization
 - Type III – junction of graft components
 - Ballooning, additional graft placement
 - Type IV – graft porosity
 - Observation
 - Type V – endotension (sac expansion despite no evidence of endoleak)
 - Re-lining, explant



Endoleak





TEVAR Complications

- Stroke – incidence of 4-8%, comparable to open
 - Higher risk
 - seal zone proximal to arch
 - mural thrombus
 - h/o CVA
 - PCA stroke d/t left subclavian (LSCA) coverage or embolization via subclavian



TEVAR Complications

- Paraplegia
 - Risk factors
 - Extensive coverage of thoracic aorta
 - Prior AAA repair
 - Coverage of LSCA
 - Post-procedure hypotension
 - Between 3% and 11% in large series
 - Comparable or lower incidence vs open repair

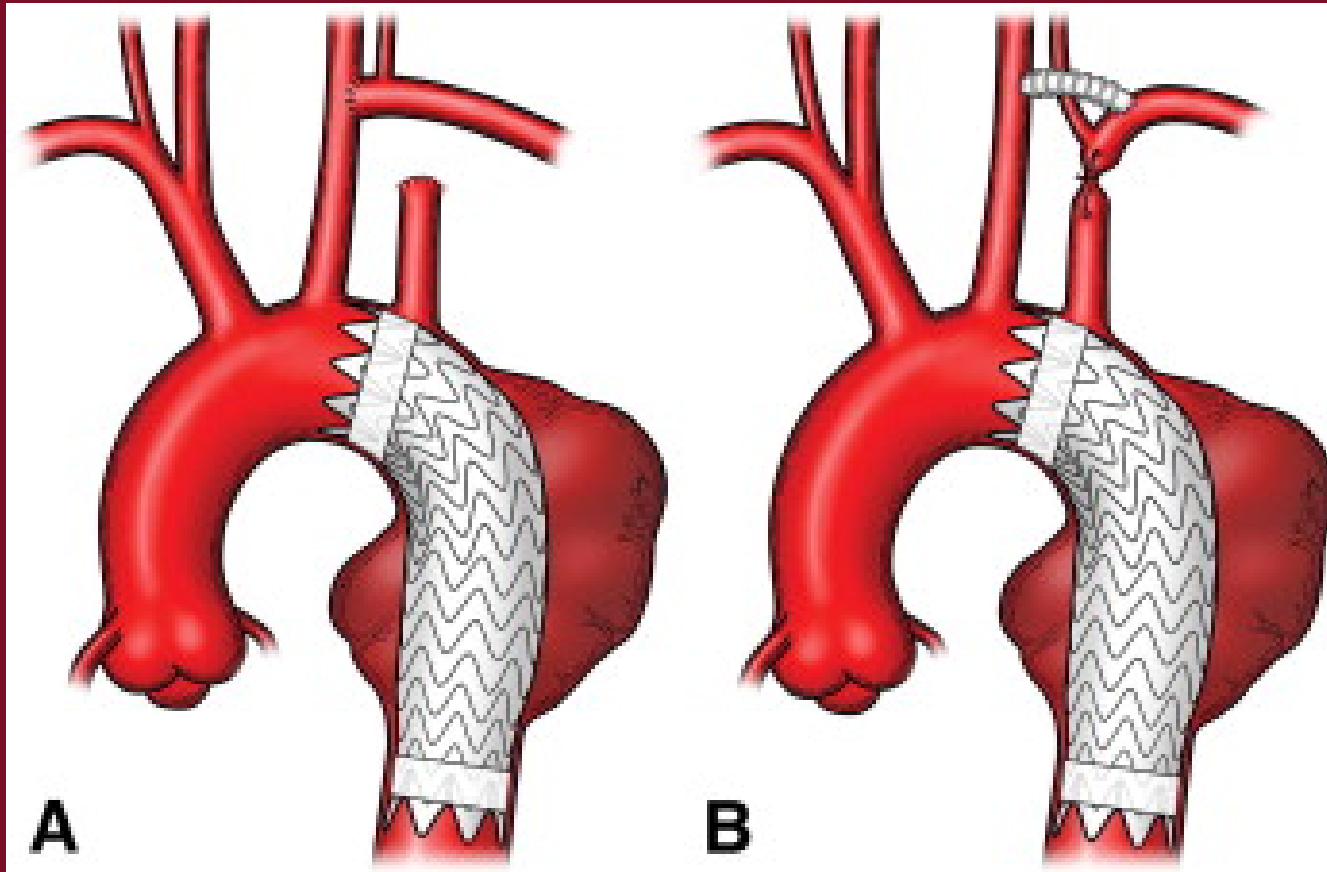


Avoidance of Spinal Cord Ischemia

- CSF drainage
 - Preoperative or immediately if symptoms
- Optimal BP management
 - MAP >80mmHg
- LSCA revascularization
 - carotid-subclavian bypass or transposition
 - Laser fenestration of graft
 - Chimney/snorkel technique
 - Branched endograft

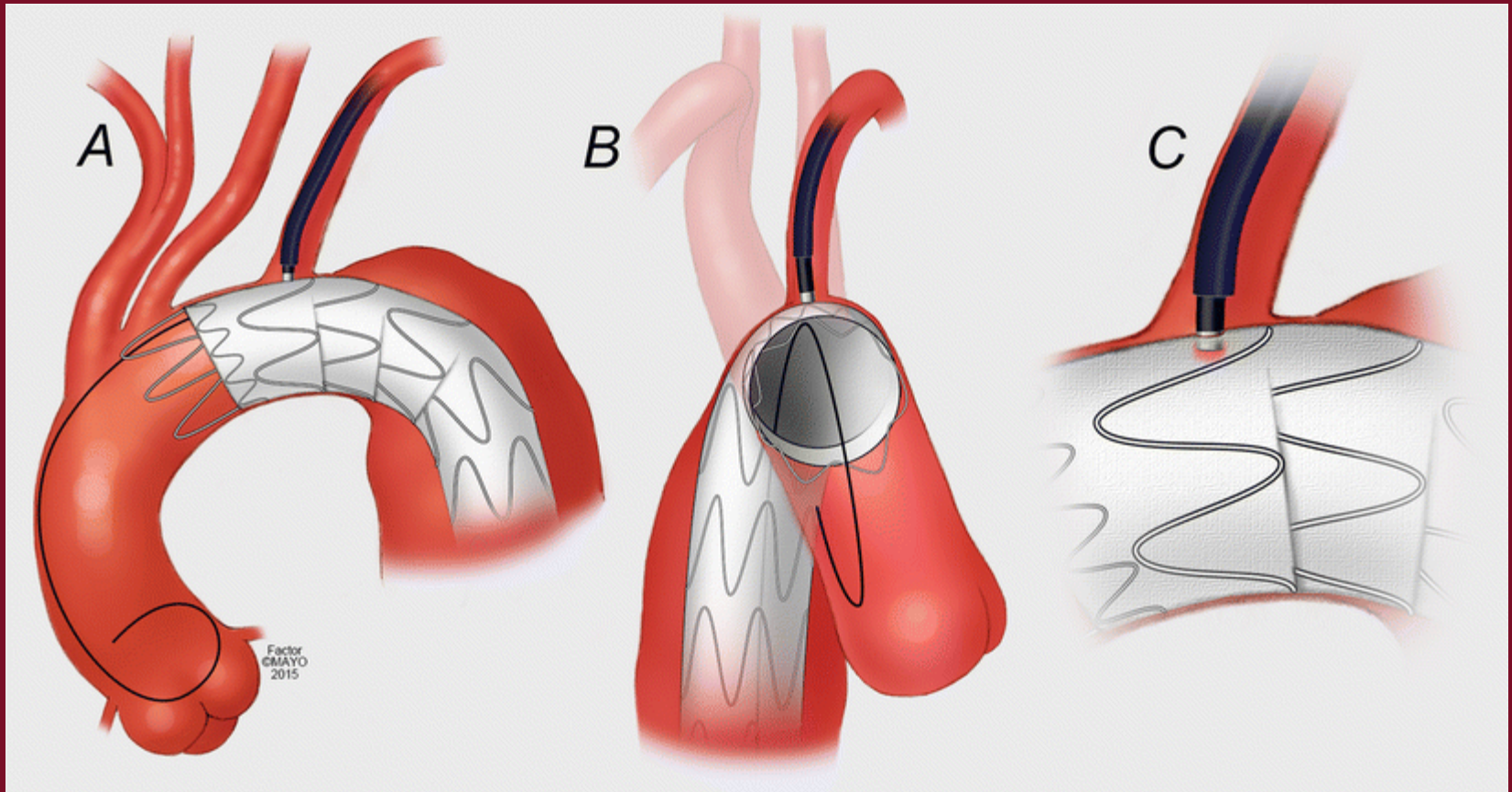


LSCA Revascularization

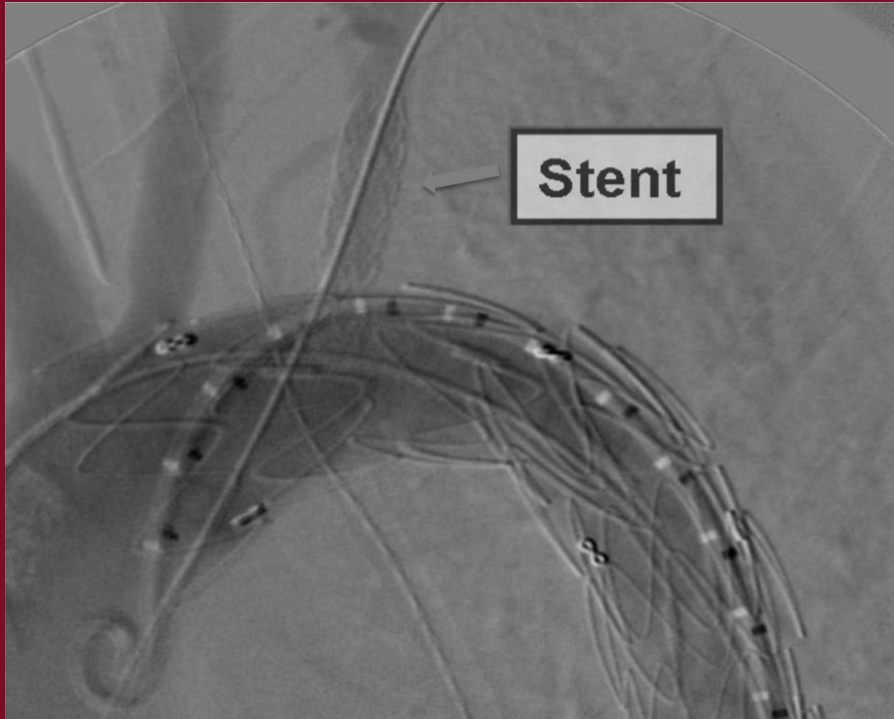




LSCA Revascularization

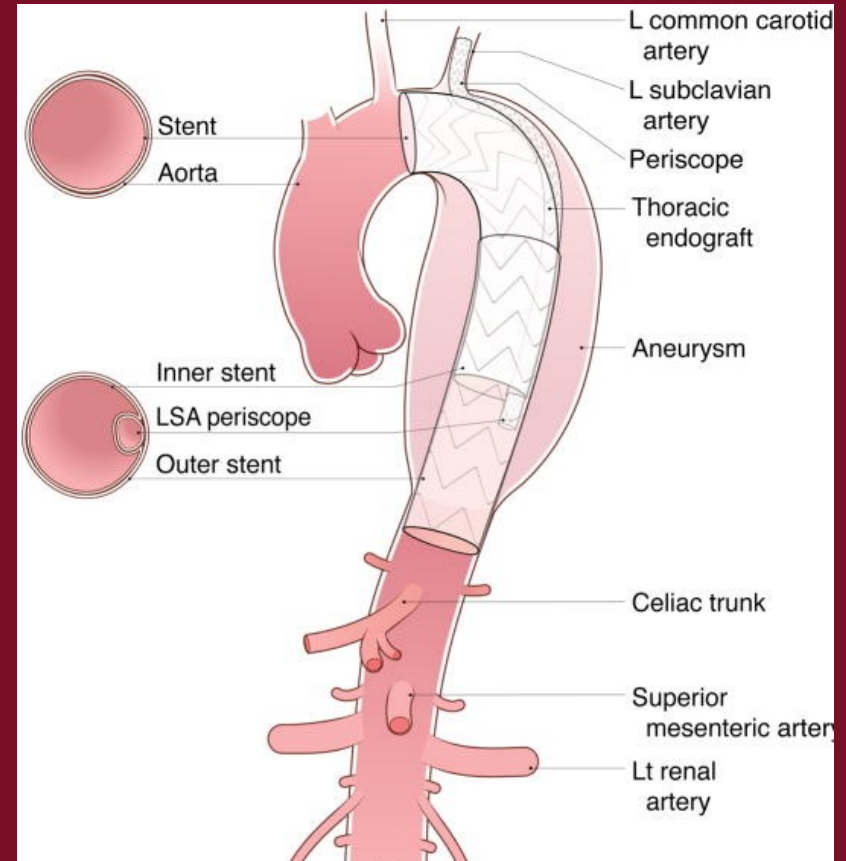
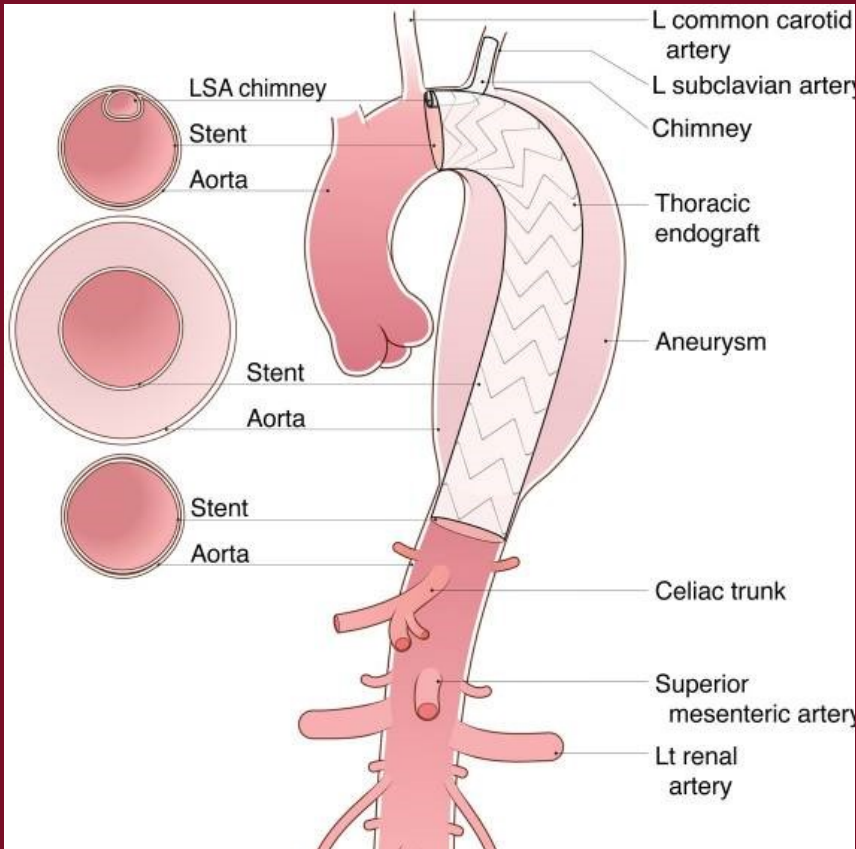


LSCA Revascularization





LSCA Revascularization





LSCA Revascularization

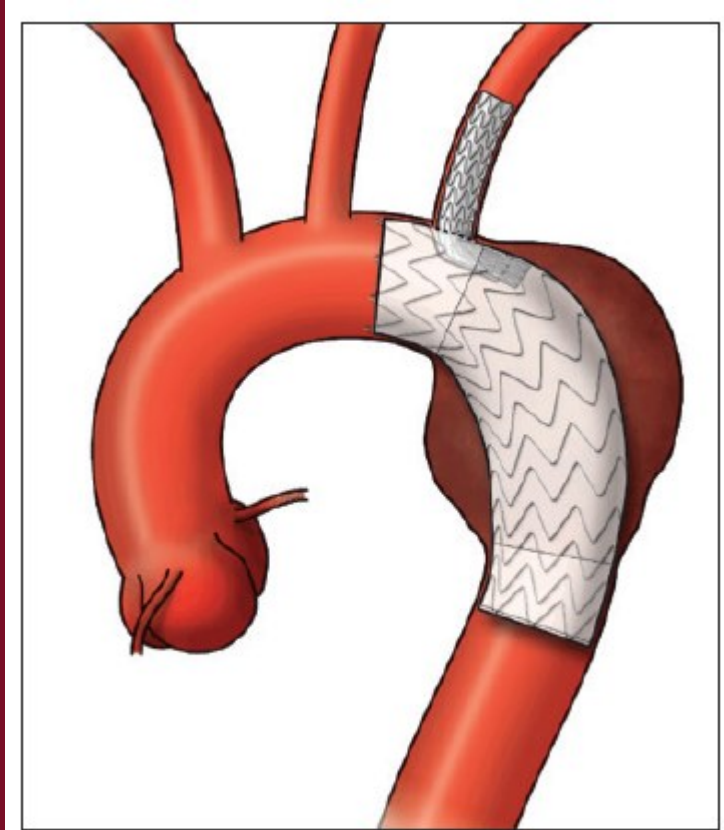


Figure 2. The GORE TAG Thoracic Branch Endoprosthesis placed in Zone 2 of the thoracic aorta.



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TEVAR Complications

- Retrograde type-A dissection (RTAAD)
 - 2.5% incidence
 - Every 1% of oversizing beyond 9% carries with it a 14% increased risk of RTAAD (*Canaud, et al. Annals of Surgery 2014*)



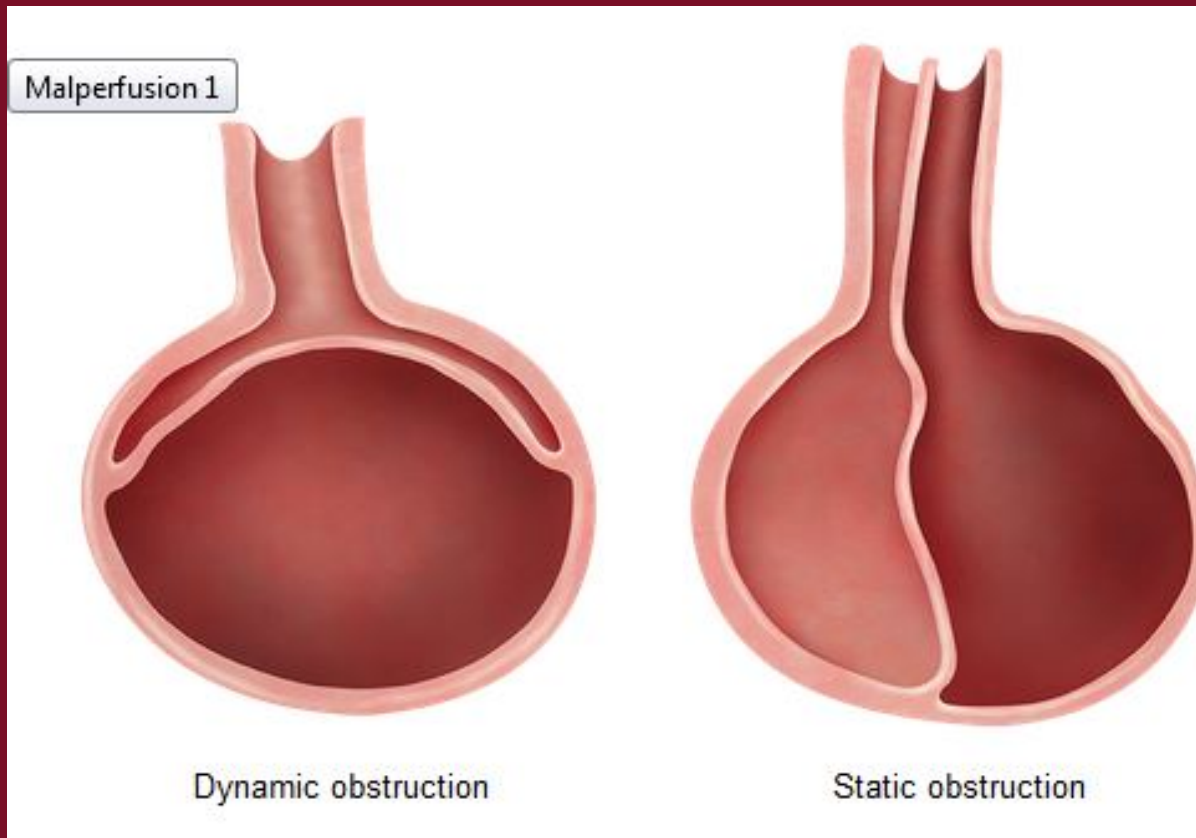


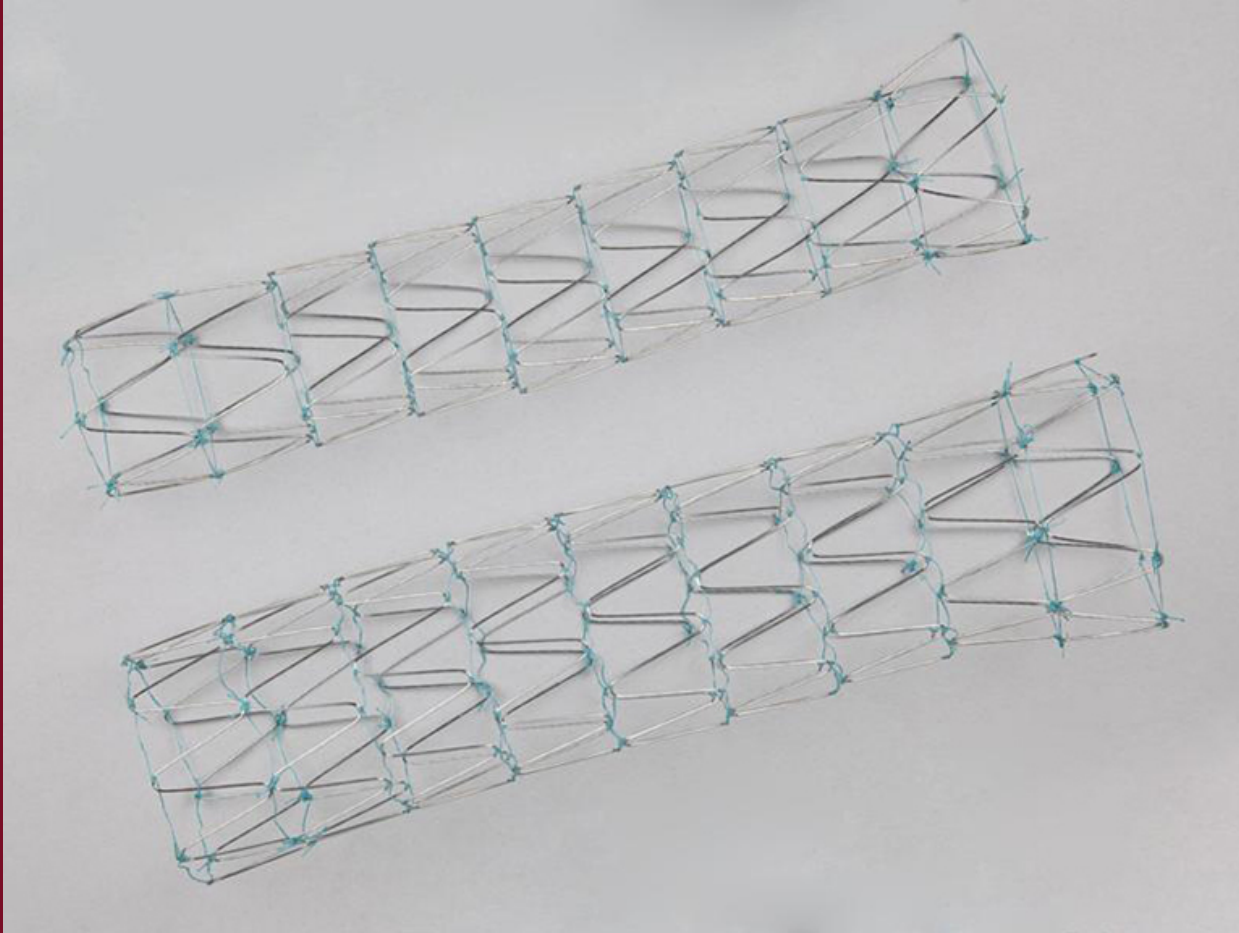
TEVAR Complications

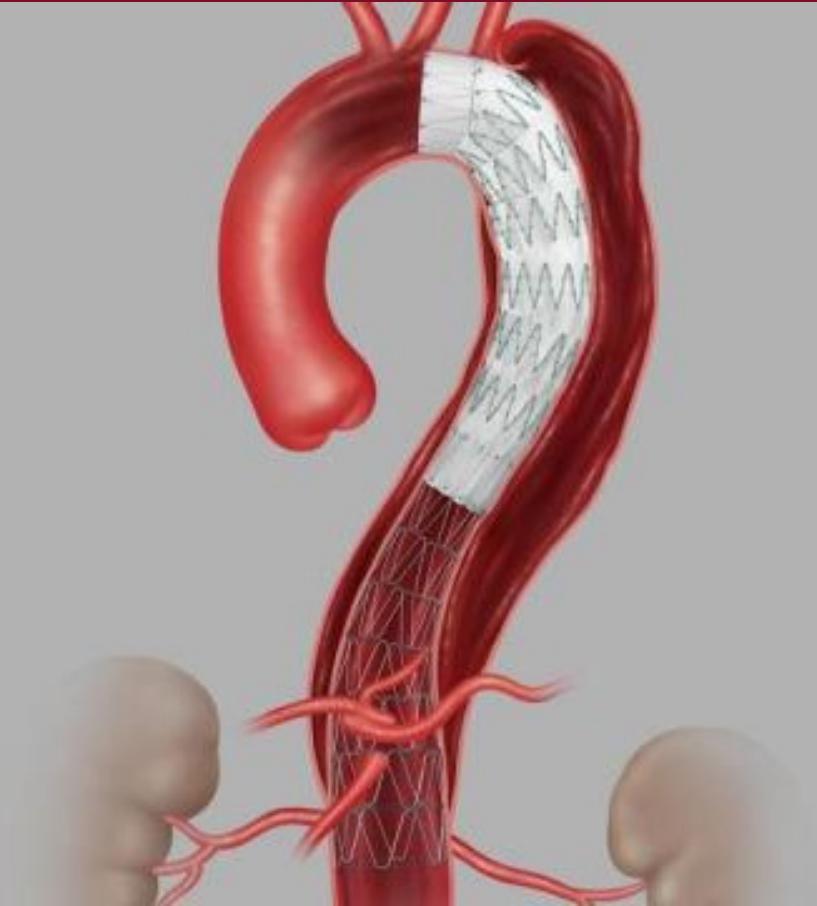
- Visceral ischemia
 - Accidental or intentional coverage of celiac origin
 - Less common if intact pancreaticoduodenal artery
 - Static malperfusion
 - Compression by false lumen or thrombosis
 - Dynamic malperfusion
 - Prolapse of septum into vessel ostium during cardiac cycle

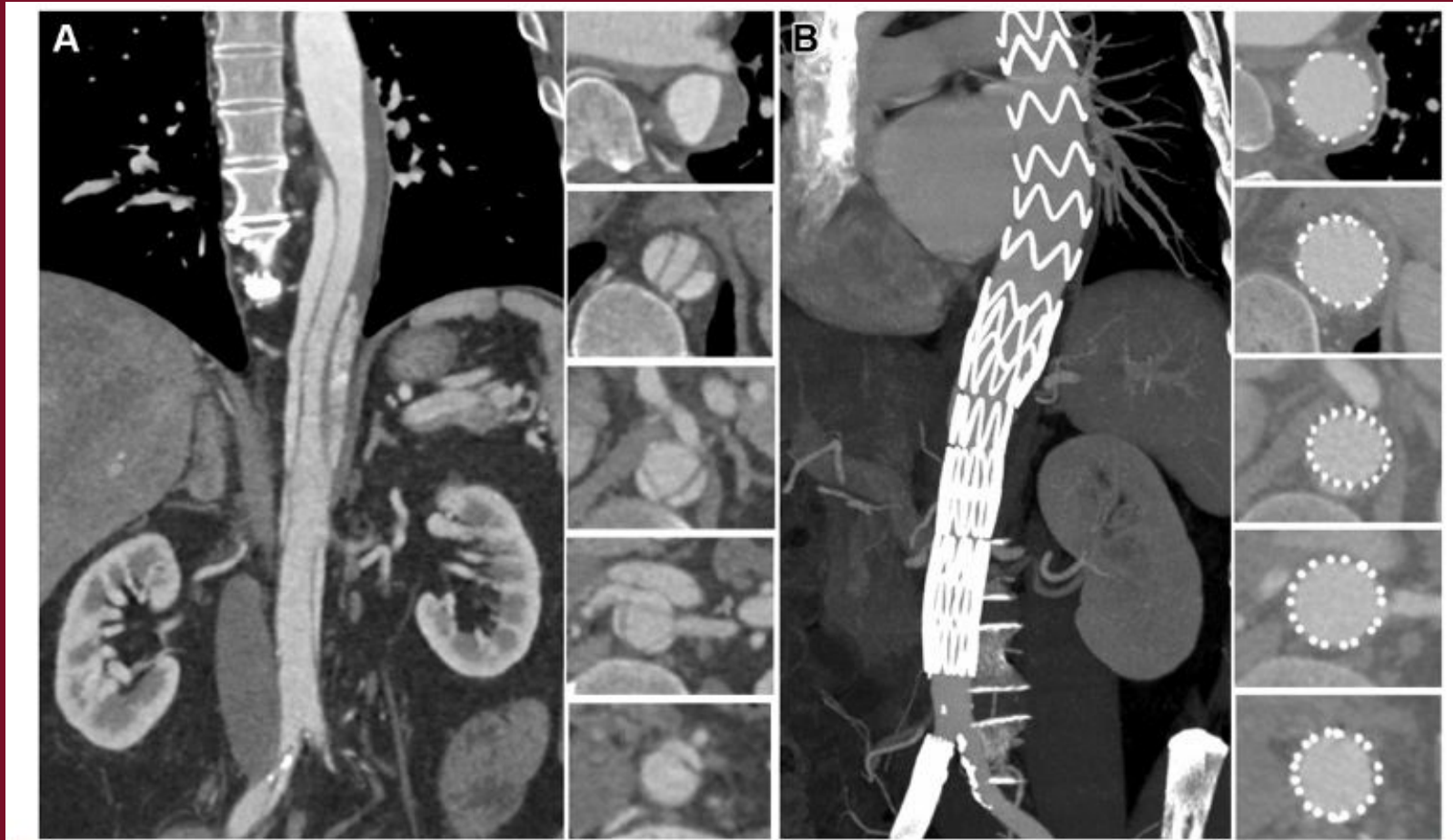


Malperfusion Syndrome











Malperfusion Syndrome

TEVAR + Bare Stent (40 patients) vs. TEVAR Alone (21 Patients)

- In hospital mortality: 5% vs 9%
- Aortic related mortality: 3% vs 9%
- Visceral Malperfusion Related Mortality: 0% vs 17% (p=0.02)
- Unplanned secondary interventions: 11% vs 43%
- Complete False Lumen Thrombosis
 - Thoracic: 72% vs 46%
 - Abdominal: 40% vs 15%
- PETTICOAT Technique
 - Provisional Extension to Induce Complete Attachment



TEVAR Late Outcomes

- 57.6 months median survival (Medicare database)
- Secondary intervention
 - Between 3.6% and 24% depending on follow-up
 - Dependent on Pathology
 - Acute TBAD 21.3%, chronic TBAD 16.7%, TAA 10.8%, PAU 1.5%

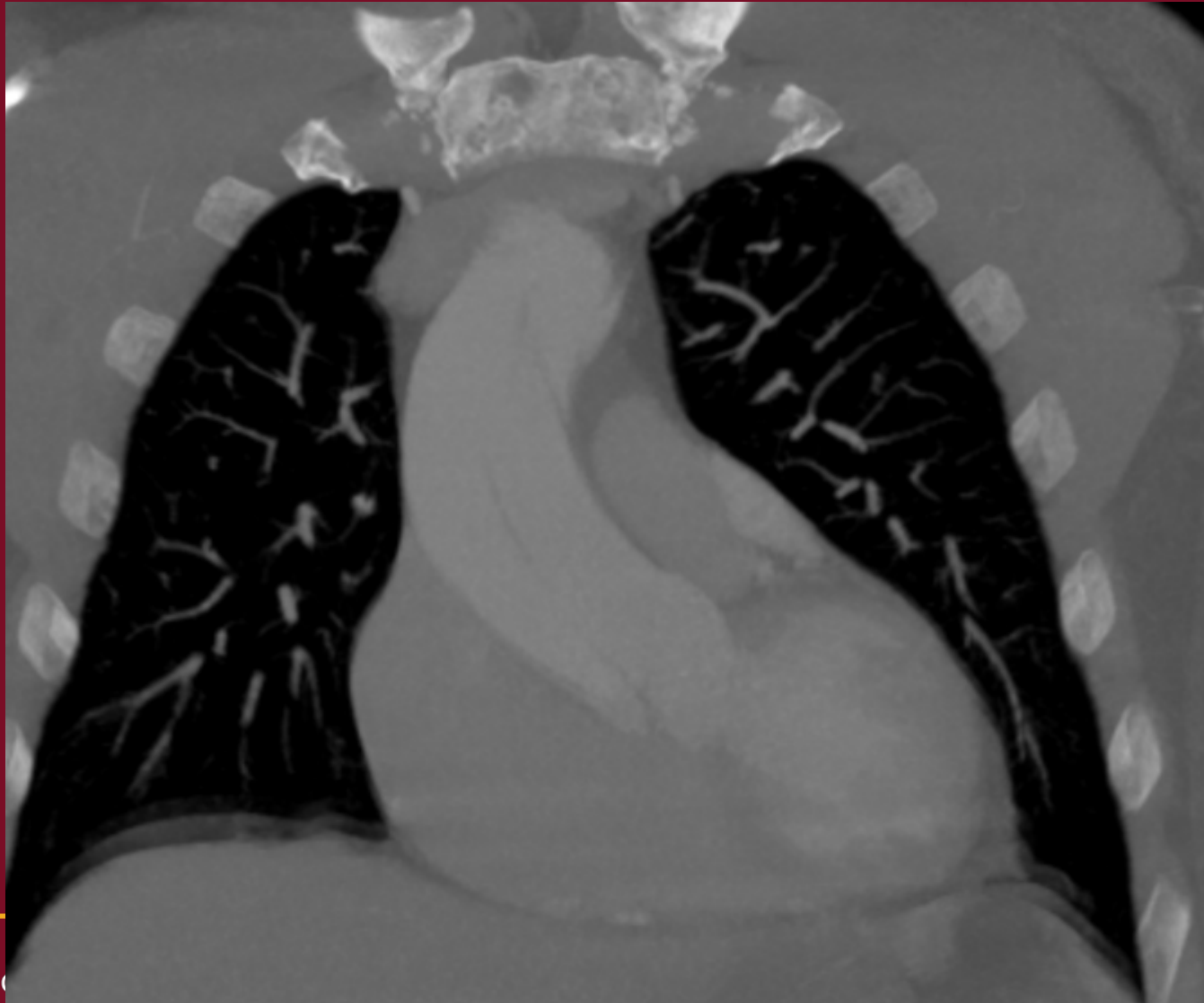


Case #1

- 77yo M
- PMH: HTN, hypothyroid
- p/w acute chest/back while playing tennis
- BIBA to ED
- c/o pain to back and LLE
- Unable to move left foot, cool/mottled



Case #1





Case #1

- CT - DeBakey type I, Stanford type A dissection with involvement of left subclavian artery, celiac axis, SMA and left renal artery and markedly collapsed true lumen



Case #1

- Emergent ascending and arch replacement with 32mm graft, debranching of innominate and left carotid with 10mm graft, ligation of LAA



Case #1

- Postoperative Course
 - Immediate return of lower extremity pulses
 - Persistent LLE weakness, unable to ambulate
 - Developed delayed toe ischemia bilaterally
 - Required HD initially with subsequent return of UOP
 - Delayed decrease in UOP and rising Cr
 - Reinstated HD



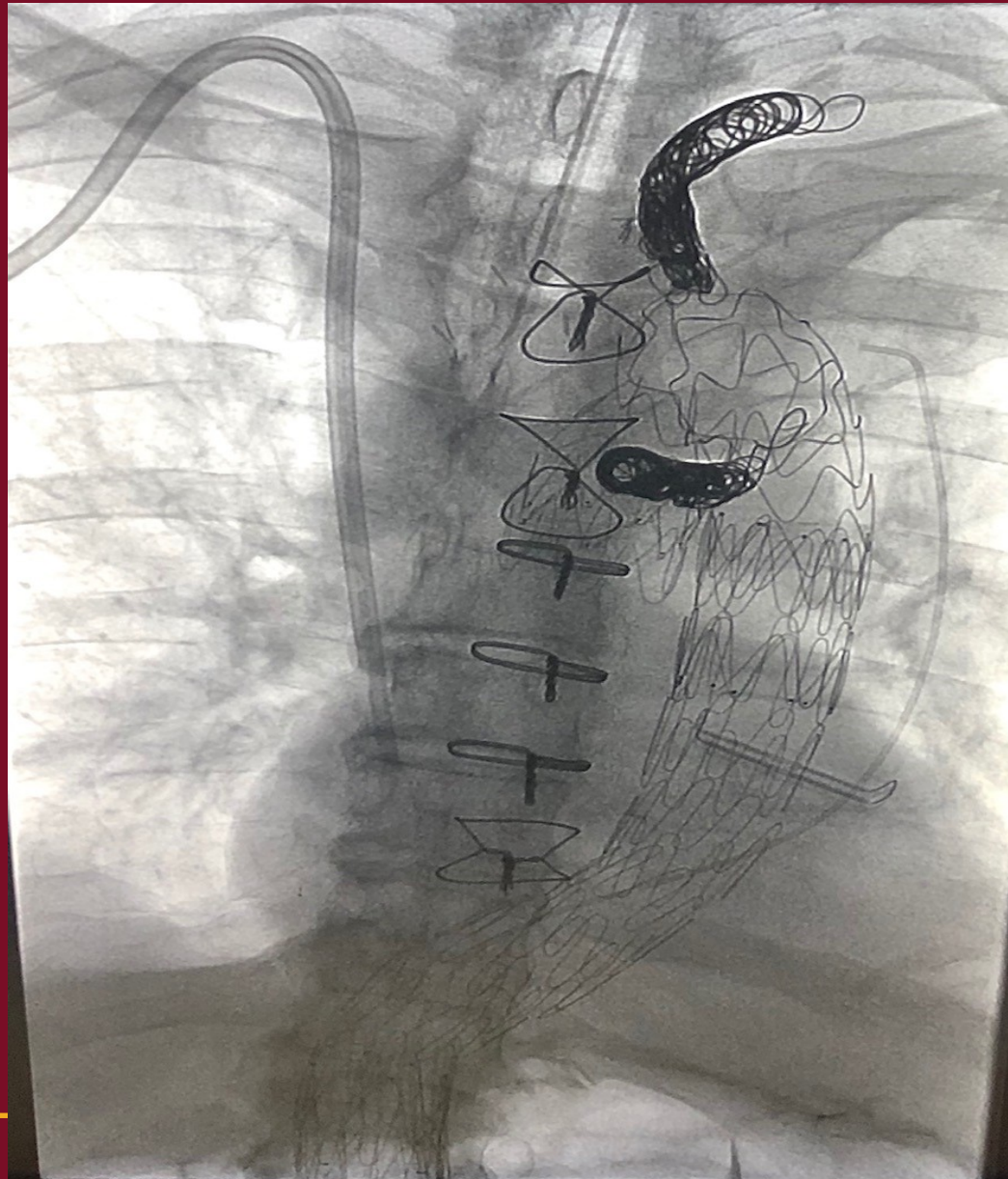
Case #1

- Repeat CTA POD #21
 - Stable surgical repair with innominate/carotid debranching
 - No dissection of RSCA, RCCA, LCCA
 - Residual dissection flap involving LSCA and descending thoracic aorta
 - Descending thoracic aorta 4.3x4.5cm, stable from preop
 - non-aneurysmal abdominal aorta with residual dissection flap
 - Patent renal arteries bilaterally (Left – true lumen, Right – false lumen), patent celiac (false/true), patent SMA (true), patent IMA (false)
 - Dissection flap terminating in left external iliac artery and right common femoral artery
- Vascular Duplex
 - High grade stenosis of left external iliac
 - Normal waveforms in right external iliac and distally



Case #1

- POD #25
 - TEVAR with 40x217mm endograft
 - TEVAR with 46x185 dissection stent
 - Left carotid – subclavian bypass with 8mm PTFE graft





Case #1

- POD #27
 - Off hemodialysis

- POD #72
 - Clinic follow-up
 - Remains off HD
 - Ambulatory without cane



- THANK YOU