Current Management of Aortic Aneurysms and Aortic Dissections

Nebraska Medicine

SERIOUS MEDICINE. EXTRAORDINARY CARE.

Aneurysm

Aneurysma (Greek) - "a widening"

Permanent localized dilatation of an artery, having at least a 50% increase in diameter compared with the expected normal diameter

Infrarenal aorta>>thoracoabdominal aorta>descending thoracic aorta > aortic arch

Aneurysmal disease is primarily degenerative in nature and it is thought to be due to the active digestion of the aortic media by endogenous proteases

Other causes
- chronic aortic dissection
- trauma
- Infections
- Collagen vascular disease

Figure 96. A lateral view of an infrarenal aortic aneurysm shows elongation and forward displacement with a retroaortic space visible between the prevertebral fascia and the posterior juxtarenal aorta.

Abdominal Aortic Aneurysms

Etiology

- **Atherosclerotic, degeneration**
- **Genetic role due to high incidence in family member (11-fold risk in 1st degree relative, sisters RR 22x), 25 % male siblings**
- **Pathogenesis unknown: MMPs, collagen/elastin abnormalities, immunologic, flow disturbances**

Epidemiology and Natural History of AAA

- Ultrasound screening and autopsy series indicate that the prevalence of AAAs (>3 cm) is 3% to 10% for patients older than age 50 in the Western world
- Veterans Administration (VA) screening study of more than 73,000 patients 50 to 79 years old the prevalence of AAAs 3 cm or greater was 4.6% and AAAs 4 cm or greater was 1.4%
- 360,000 undetected small AAAs in the United States
- **15th leading cause of death** overall in United States – 9,000 deaths/year

Risk Factors

- Smoking
- Family history
- Atherosclerosis
- Male:Female 4-5:1, 6-9% males >65 y
- Hypertension, COPD (↑ rupture rate)
- Decreased prevalence in African Americans and diabetics
- Increasing incidence

Screening

We recommend a one-time ultrasound screening for AAAs in men or women 65 to 75 years of age with a history of tobacco use.

Level of recommendation	1 (Strong)
Quality of evidence	A (High)

We suggest ultrasound screening for AAA in first-degree relatives of patients who present with an AAA. Screening should be performed in first-degree relatives who are between 65 and 75 years of age or in those older than 75 years and in good health.

Level of recommendation	2 (Weak)
Quality of evidence	C (Low)

We suggest a one-time ultrasound screening for AAAs in men or women older than 75 years with a history of tobacco use and in otherwise good health who have not previously received a screening ultrasound examination.

Level of recommendation	2 (Weak)
Quality of evidence	C (Low)

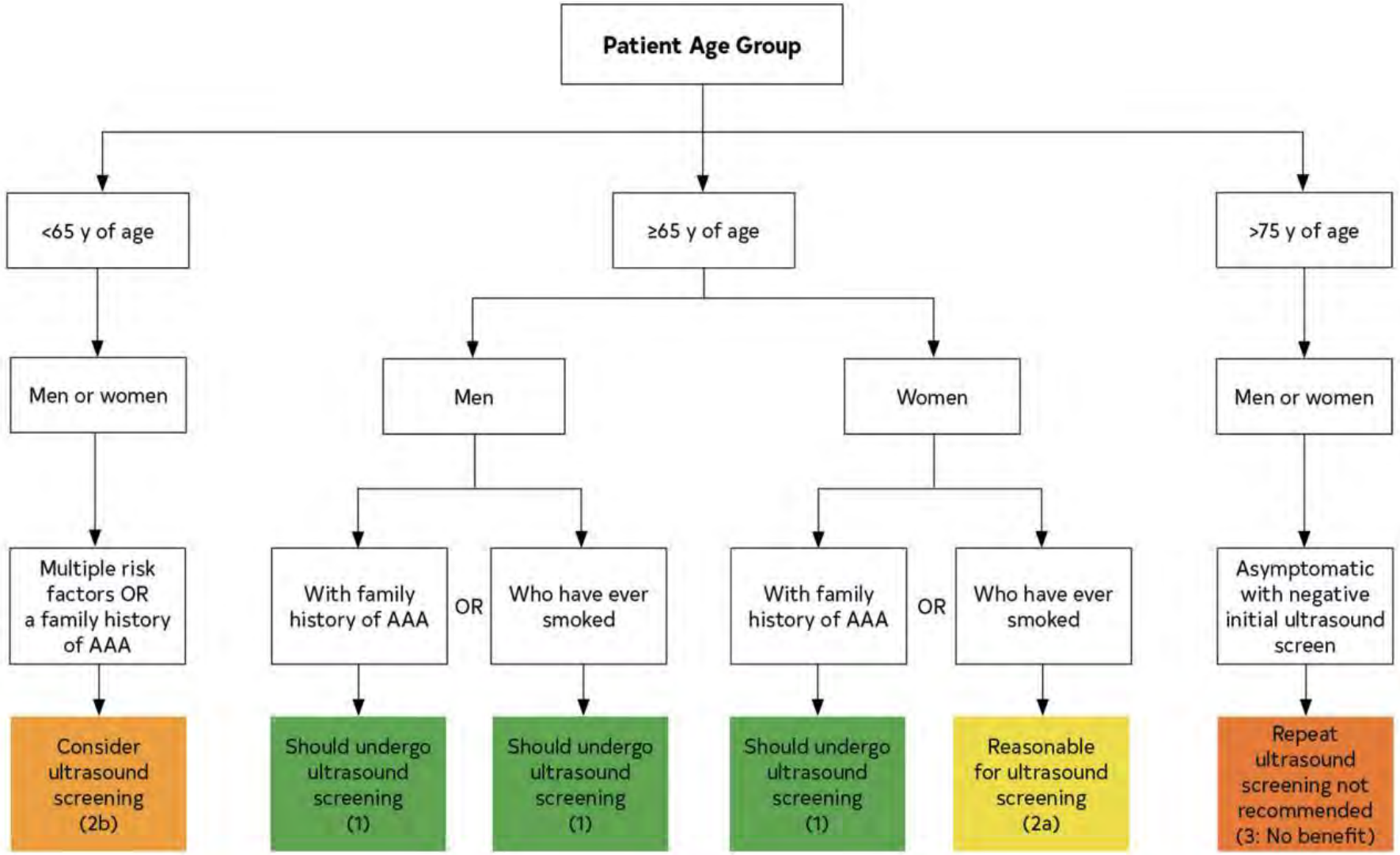
Abdominal Aortic Aneurysm: Screening

Release Date: December 2019

Recommendation Summary

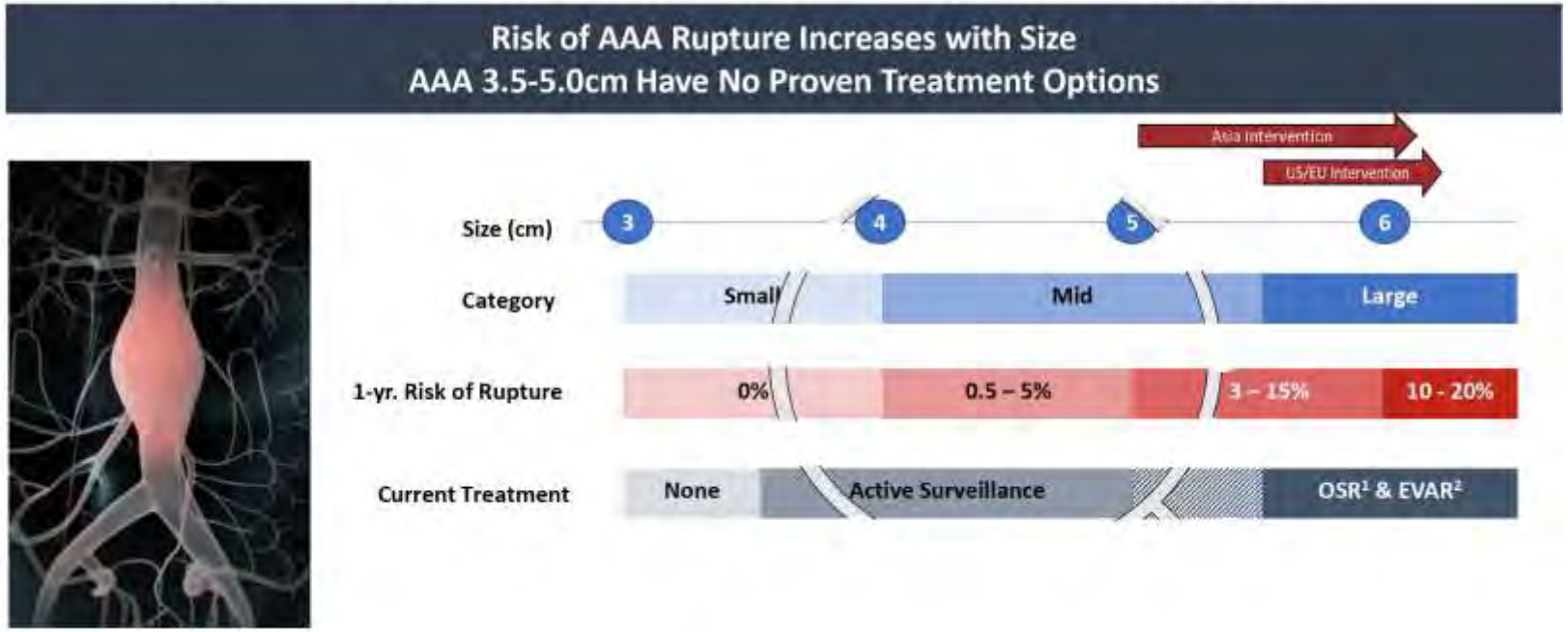
Population	Recommendation	Grade (What's This?)
Men aged 65 to 75 years who have ever smoked	The USPSTF recommends 1-time screening for abdominal aortic aneurysm (AAA) with ultrasonography in men aged 65 to 75 years who have ever smoked.	B
Men aged 65 to 75 years who have never smoked	The USPSTF recommends that clinicians selectively offer screening for AAA with ultrasonography in men aged 65 to 75 years who have never smoked rather than routinely screening all men in this group. Evidence indicates that the net benefit of screening all men in this group is small. In determining whether this service is appropriate in individual cases, patients and clinicians should consider the balance of benefits and harms on the basis of evidence relevant to the patient's medical history, family history, other risk factors, and personal values.	C
Women who have never smoked	The USPSTF recommends against routine screening for AAA with ultrasonography in women who have never smoked and have no family history of AAA.	D
Women aged 65 to 75 years who have ever smoked	The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of screening for AAA with ultrasonography in women aged 65 to 75 years who have ever smoked or have a family history of AAA.	I

Who To Screen For AAA?



Size and Risk

AAA: Rapid Progression with Increasing Risk of Rupture



Annual Rupture Risk

TABLE 70.2 Twelve-Month Risk of Rupture Based on Abdominal Aortic Aneurysm Diameter

AAA Diameter (cm)	Rupture Risk (%)
3.0–3.9	0.3
4.0–4.9	0.5–1.5
5.0–5.9	1–11
6.0–6.9	11–22
>7	>30

AAA, Abdominal aortic aneurysms.

Natural History of Large Abdominal Aortic Aneurysms (AAA) in Patients Without Timely Repair

Multicenter retrospective cohort study

3248 patients with large, unrepaired AAAs

Total: 3248 patients

Repaired: 2215

Not Repaired: 1033

3-Year Cumulative Incidence of Rupture

AAA* 5.0 – 5.4cm	AAA 5.5 – 6.0cm	AAA 6.1 – 7.0cm	AAA > 7.0cm
3.4%	2.2%	6.0%	18.4%

**Women Only*

Annual rupture rates of large AAAs were lower than previously reported, with possible increased rupture risk in women.

JVS Journal of Vascular Surgery
Official Publication of the Society for Vascular Surgery

Lancaster et al. *J Vasc Surg January 2022*

LinkedIn @TheJVascSurg @JVascSurg

AAA Risk of Rupture

	Low Risk	Average Risk	High Risk
Diameter	<5 cm	5-6 cm	>6 cm
Expansion	<0.3 cm/y	0.3-0.6 cm/y	>0.6 cm/y
Smoking/COPD	None, mild	Moderate	Severe, steroids
Family History	No relatives	One relative	Numerous
Hypertension	Normal BP	Controlled	Poorly controlled
Shape	Fusiform	Saccular	Very eccentric
Wall stress	Low	Medium	High
Gender		Male	Female

Aneurysm Imaging

Recommendation	Level of recommendation	Quality of evidence
If initial ultrasound screening identified an aortic diameter >2.5 cm but <3 cm, we suggest rescreening after 10 years.	2	C
We suggest surveillance imaging at 3-year intervals for patients with an AAA between 3.0 and 3.9 cm.	2	C
We suggest surveillance imaging at 12-month intervals for patients with an AAA of 4.0 to 4.9 cm in diameter.	2	C
We suggest surveillance imaging at 6-month intervals for patients with an AAA between 5.0 and 5.4 cm in diameter.	2	C
We recommend a CT scan to evaluate patients thought to have AAA presenting with recent-onset abdominal or back pain, particularly in the presence of a pulsatile epigastric mass or significant risk factors for AAA.	1	B

The Decision to Treat

Recommendation	Level of recommendation	Quality of evidence
We suggest referral to a vascular surgeon at the time of initial diagnosis of an aortic aneurysm.	Ungraded Good Practice Statement	
We recommend repair for the patient who presents with an AAA and abdominal or back pain that is likely to be attributed to the aneurysm.	1	C
We recommend elective repair for the patient at low or acceptable surgical risk with a fusiform AAA that is greater or equal to 5.5 cm.	1	A
We suggest elective repair for the patient who presents with a saccular aneurysm.	2	C
We suggest repair in women with AAA between 5.0 cm and 5.4 cm in maximum diameter.	2	B
In patients with a small aneurysm (4.0-5.4 cm) who will require chemotherapy, radiation therapy, or solid organ transplantation, we suggest a shared decision-making approach to decide about treatment options	2	C

Presentation

Asymptomatic

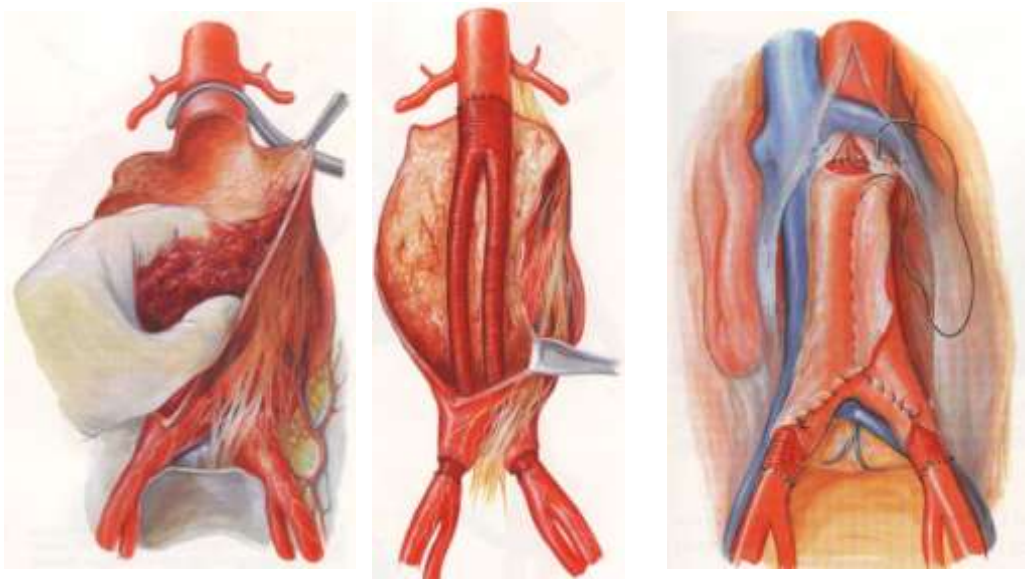
Symptomatic/Rupture

Local mass effect on GI tract, lumbar spine, ureters
Thrombose
Embolize : *Blue Toe Syndrome*

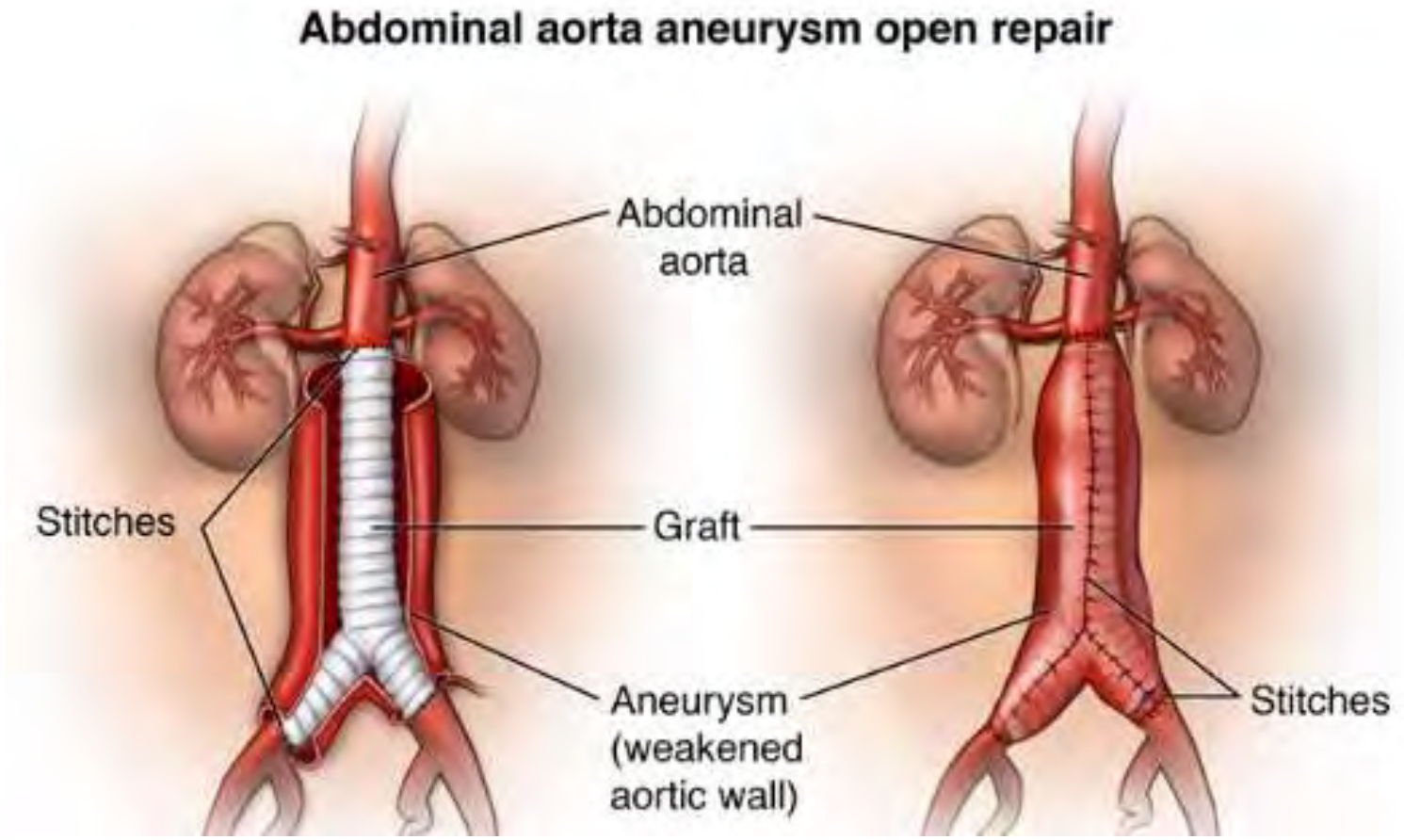
Treatment Options

Open aneurysmorrhaphy

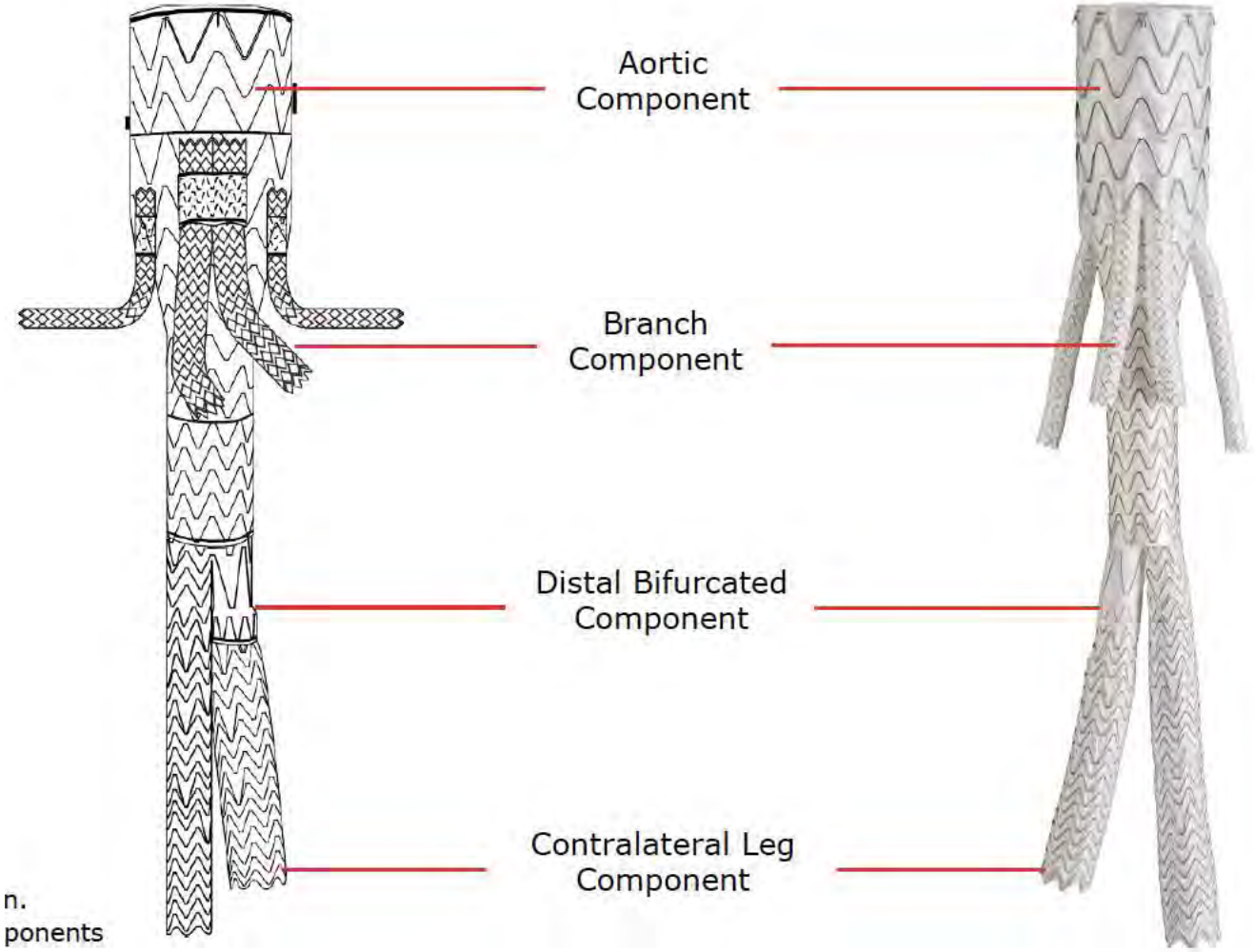
Endovascular aneurysm repair



1951 Charles Dubost



Commercially Available Branched Grafts



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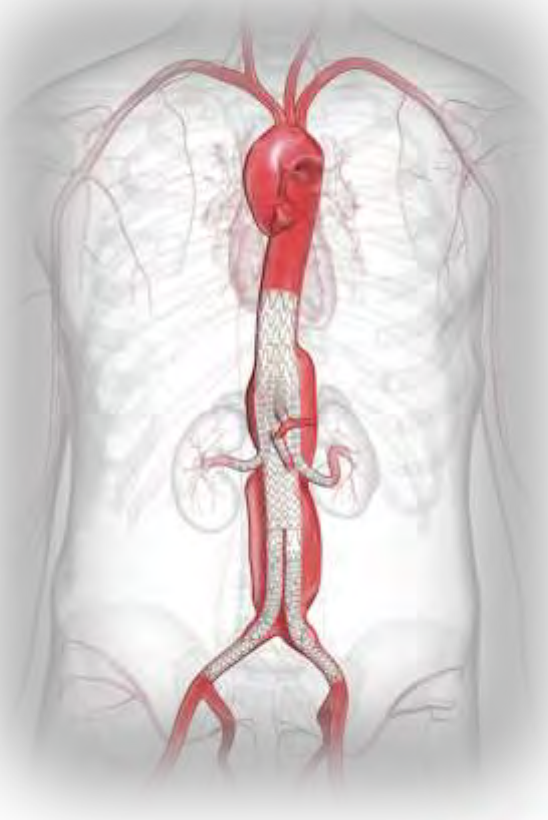
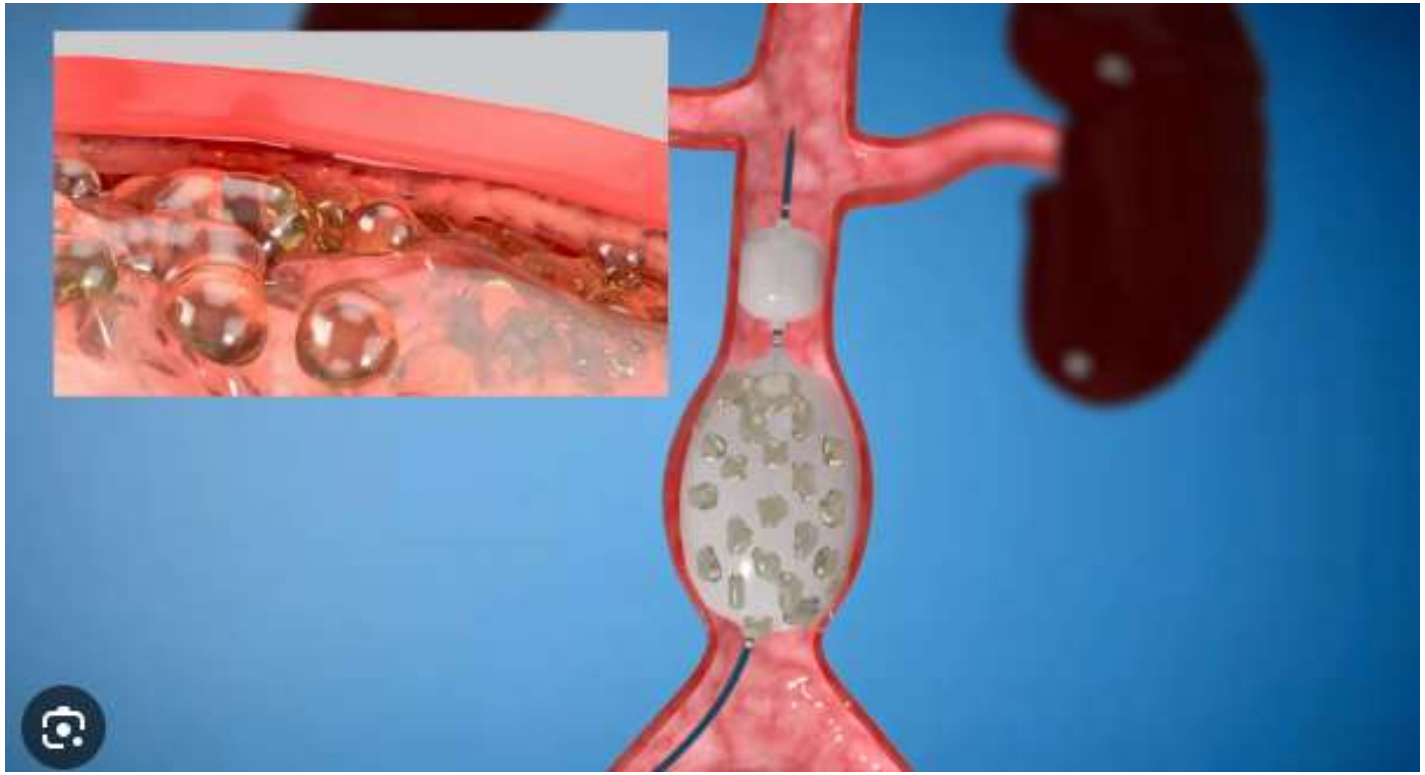


Research Areas

Pharmacologic Stabilization



Descending Thoracic Aortic Aneurysm Size Thresholds

Recommendations for Size Thresholds for Repair of Descending TAA
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	Recommendations
1	B-NR	1. In patients with intact descending TAA, repair is recommended when the diameter is ≥5.5 cm.[1,2]
2b	B-NR	2. In patients with intact descending TAA and risk factors for rupture (Table 17), repair may be considered at a diameter of <5.5 cm.[2-6]
2b	B-NR	3. In patients at increased risk for perioperative morbidity and mortality (Table 18), it may be reasonable to increase the size threshold for surgery accordingly.[7]

Recommendations for Size Thresholds for Repair of the DescendingThoracic Aorta

COR	LOE	Recommendations
1	B-NR	1. In patients with intact descending TAA, repair is recommended when the diameter is ≥5.5 cm.[1,2]
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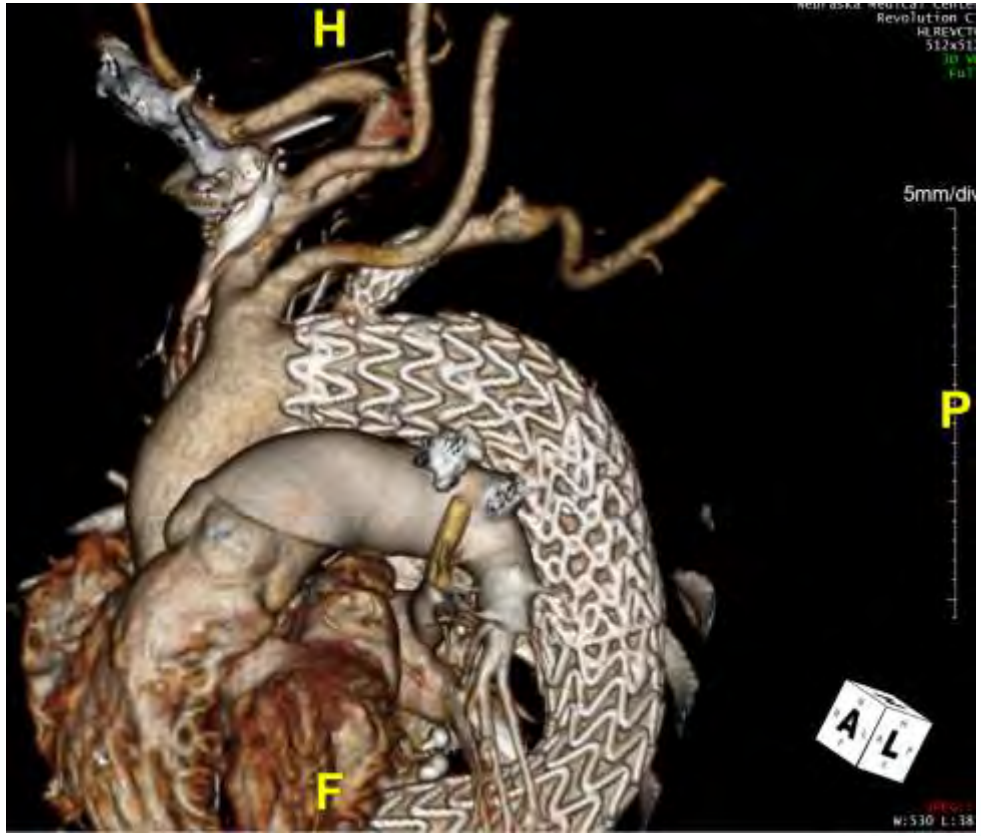
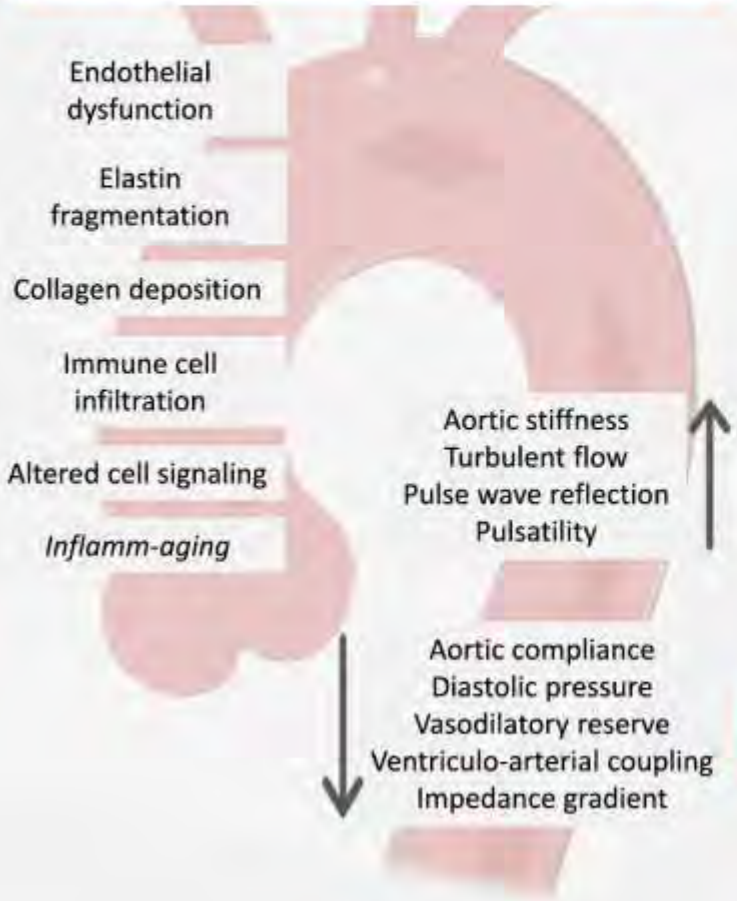
Commercially Branched Grafts



Female-specific considerations in aortic health and disease

Accelerated vascular aging in older women



Endothelial dysfunction

Elastin fragmentation

Collagen deposition

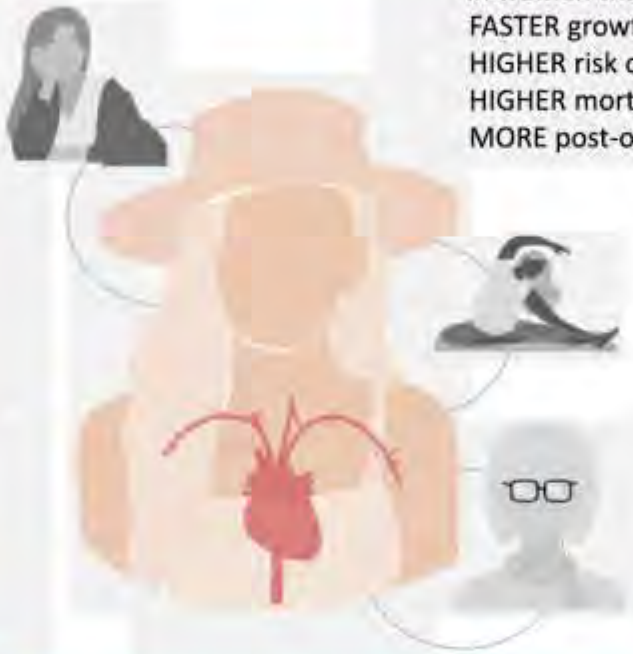
Immune cell infiltration

Altered cell signaling

Inflamm-aging

Aortic stiffness
Turbulent flow
Pulse wave reflection
Pulsatility

Aortic compliance
Diastolic pressure
Vasodilatory reserve
Ventriculo-arterial coupling
Impedance gradient



Aortic aneurysms

Thoracic and abdominal aortic aneurysms are less common in women than in men, but women experience:
FASTER growth rate
HIGHER risk of dissection, even at smaller diameters
HIGHER mortality
MORE post-operative complications

Aortopathy in pregnancy

- Multidisciplinary care
- Condition-specific cut-offs for pregnancy contraindication / pre-conception cardiac surgery (usually around > 4.0-4.5 cm of ascending aortic diameter)
- Target systolic blood pressure < 120-130 mm Hg
- Surveillance aortic imaging

Aortic dysfunction as a hallmark of many cardiovascular diseases in women

Hypertensive disorders of pregnancy

Heart failure with preserved ejection fraction

Coronary microvascular dysfunction

Further research is needed on the impact of sex on cardiovascular disease, response to cardiac devices and pharmacotherapy, interplay of psycho-social, cultural, and societal factors

Sex Differences in abdominal aortic aneurysms

Epidemiology

- Faster rate of growth
- 4-fold higher risk of rupture
- Smoking is a stronger risk factor

Repair

- Smaller aortic diameter at time of rupture
- 50% less likely to be repaired
- 20% less EVARs

Outcomes

- Higher mortality
- More perioperative complications
- Less likely to be discharged home

Sex differences in thoracic aortic aneurysms

Pathophysiology

- More disruption in aortic wall architecture
- Worse aortic hemodynamics
- Faster aneurysm growth rate

Outcomes

- TAA less common, but 40% increased mortality
- 3-fold increased risk of dissection

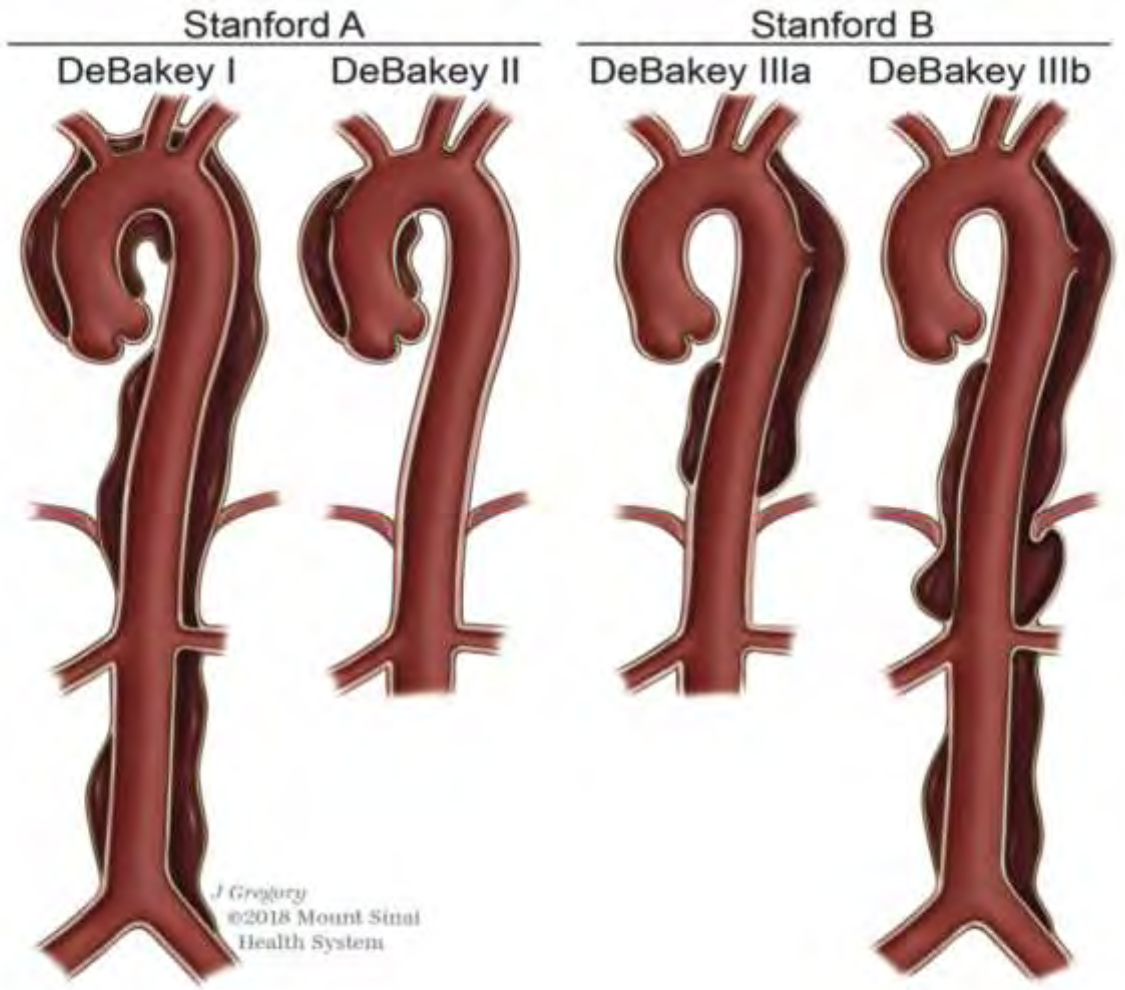
Post operative outcomes

- Higher mortality after elective or emergency surgery
- High rates of post-operative complications

Aortic Dissection

- Definition: Separation of the aortic wall layers with subsequent creation of a pseudo (false) lumen that may compress the true aortic lumen
- Incidence of 2.5-15/100,000
- Classified based on the site of origin of the intimal tear
- Stanford Type A: Surgical emergency
- Stanford Type B dissections further delineated based on chronology: Acute (0-14 days), Subacute (15 days- 3 months), Chronic (>3 months)
- Stanford Type B: Uncomplicated vs. Complicated

Anatomic Classification



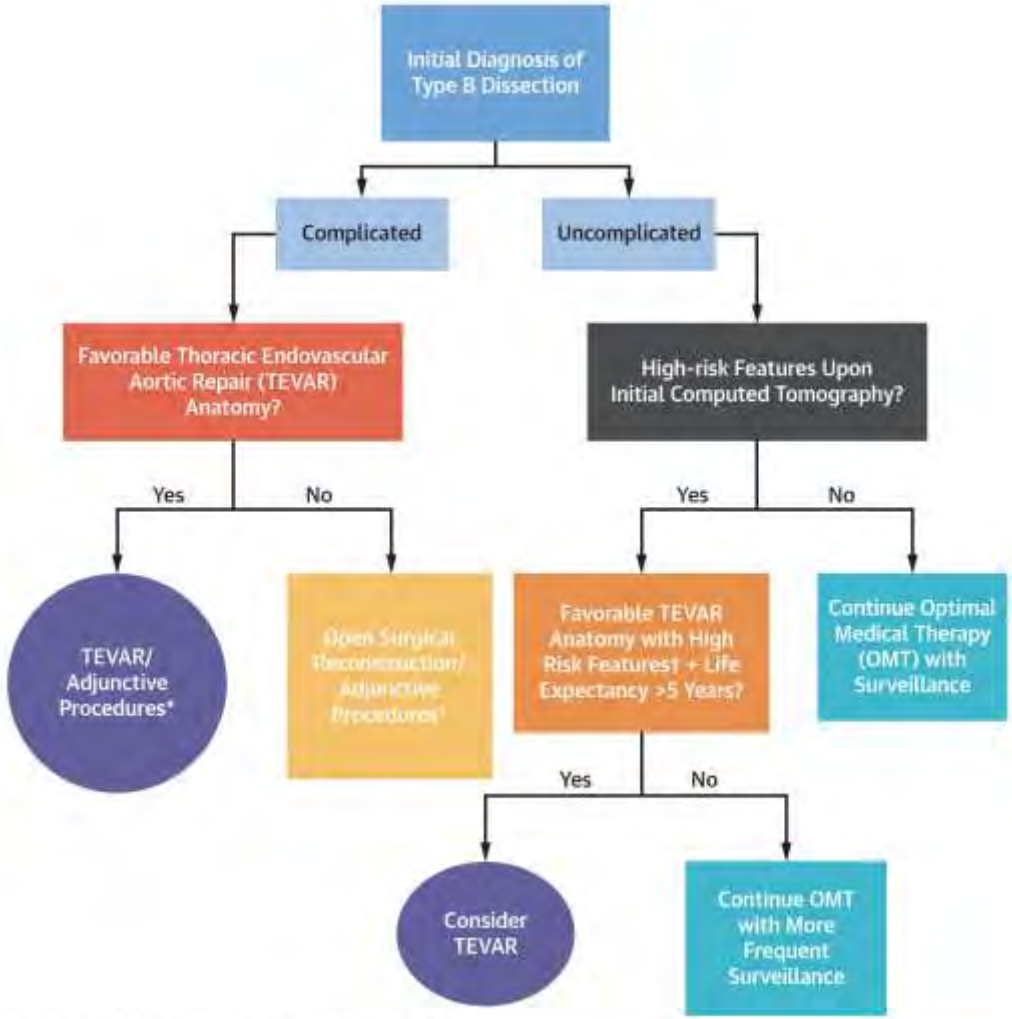
Factors That Increase the Risk of Aortic Dissection

Factor	Contributes to
Marfan syndrome	Medial degeneration
Loeys-Dietz syndrome	
Hypertension	Increased aortic wall stress
Physical trauma	
Smoking	

Acute Complications of Aortic Dissection

Feature	Comment
Aortic rupture[1]	This can be either free or contained (including hemothorax, increasing periaortic hematoma, or both; or mediastinal hematoma) and should be addressed promptly.
Branch artery occlusion and malperfusion[2]	Complete or partial occlusion of a major branch, with or without clinical evidence of ischemia; this includes visceral, renal, and peripheral arterial branches.
Extension of dissection[3]	Extension of the dissection flap either distally or proximally (ie, retrograde type A dissection)
Aortic enlargement	Progressive enlargement of the true, false, or both lumens while in the acute phase may require prompt intervention.
Intractable pain[15]	
Uncontrolled hypertension[15]	

Framework for Treatment of Type B Aortic Dissection

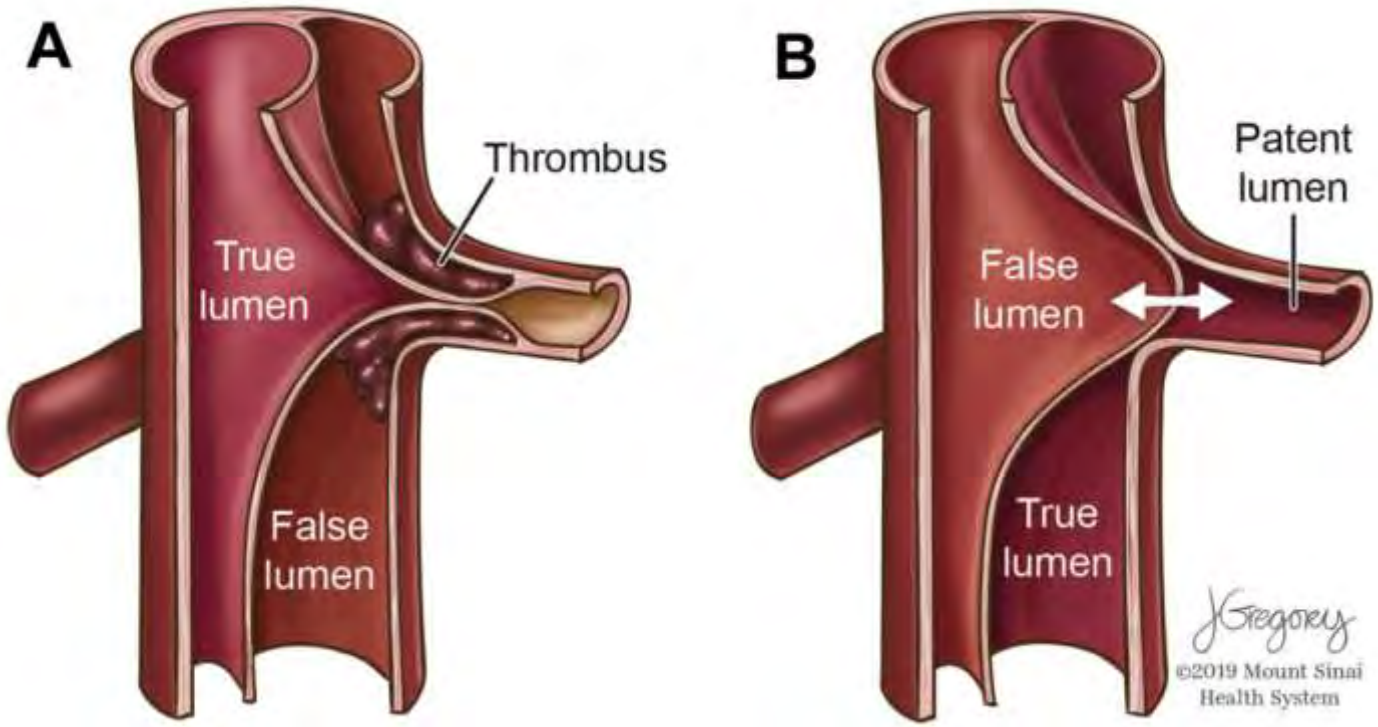


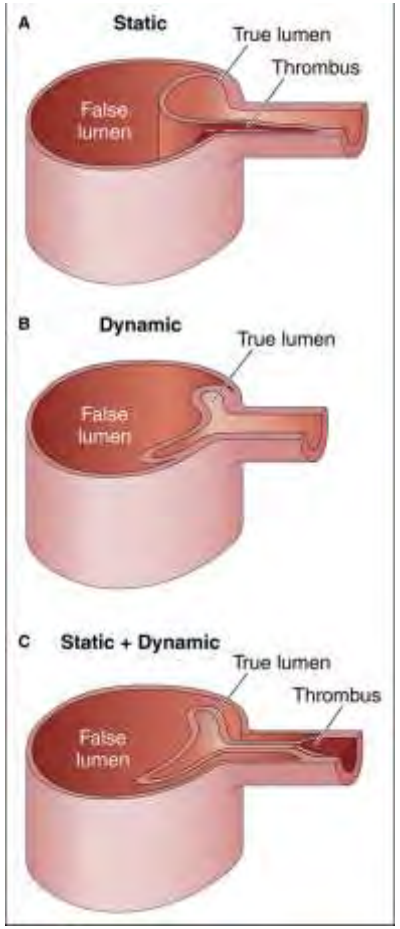
Tadros, R.O. et al. J Am Coll Cardiol. 2019;74(11):1494-504.

Criteria for Complicated vs. High Risk Type B Acute Aortic Dissections

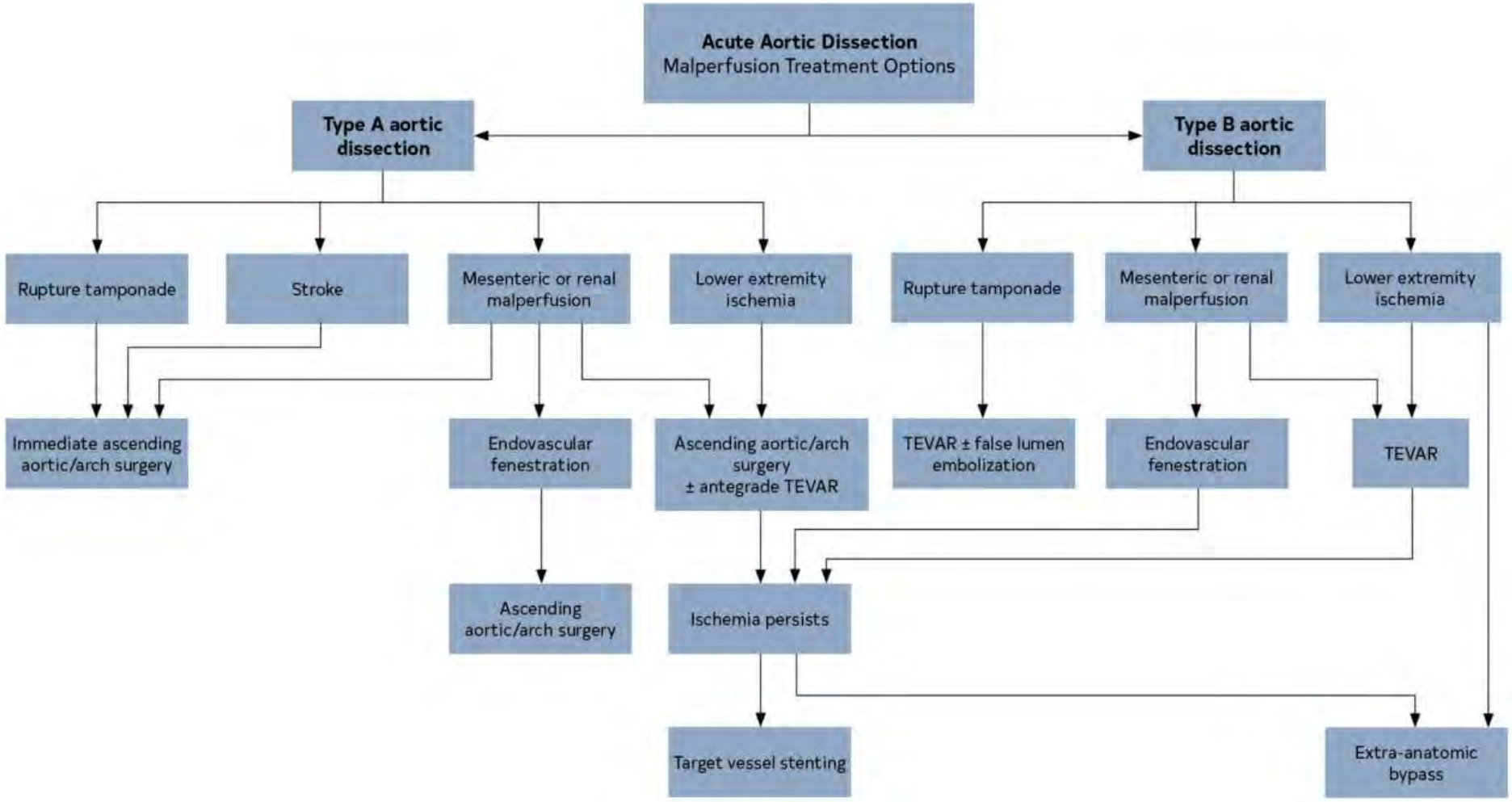
Complicated	High Risk
• Rupture (contained or free)	• Refractory pain >12 h despite maximal doses of pain medication
• Extension or enlargement of false lumen on interval imaging	• Refractory hypertension despite > 3 classes of antihypertensive at maximal doses
• Aortic diameter > 5 cm	• Aortic diameter > 4 cm
• Visceral malperfusion, clinically evident	• Radiographic only malperfusion
• Peripheral malperfusion, clinically evident	• Bloody pleural effusion
• Retrograde type A dissection	• False lumen diameter > 22 mm
	• Entry tear on lesser curvature

Static and Dynamic Obstruction in Malperfusion Syndrome

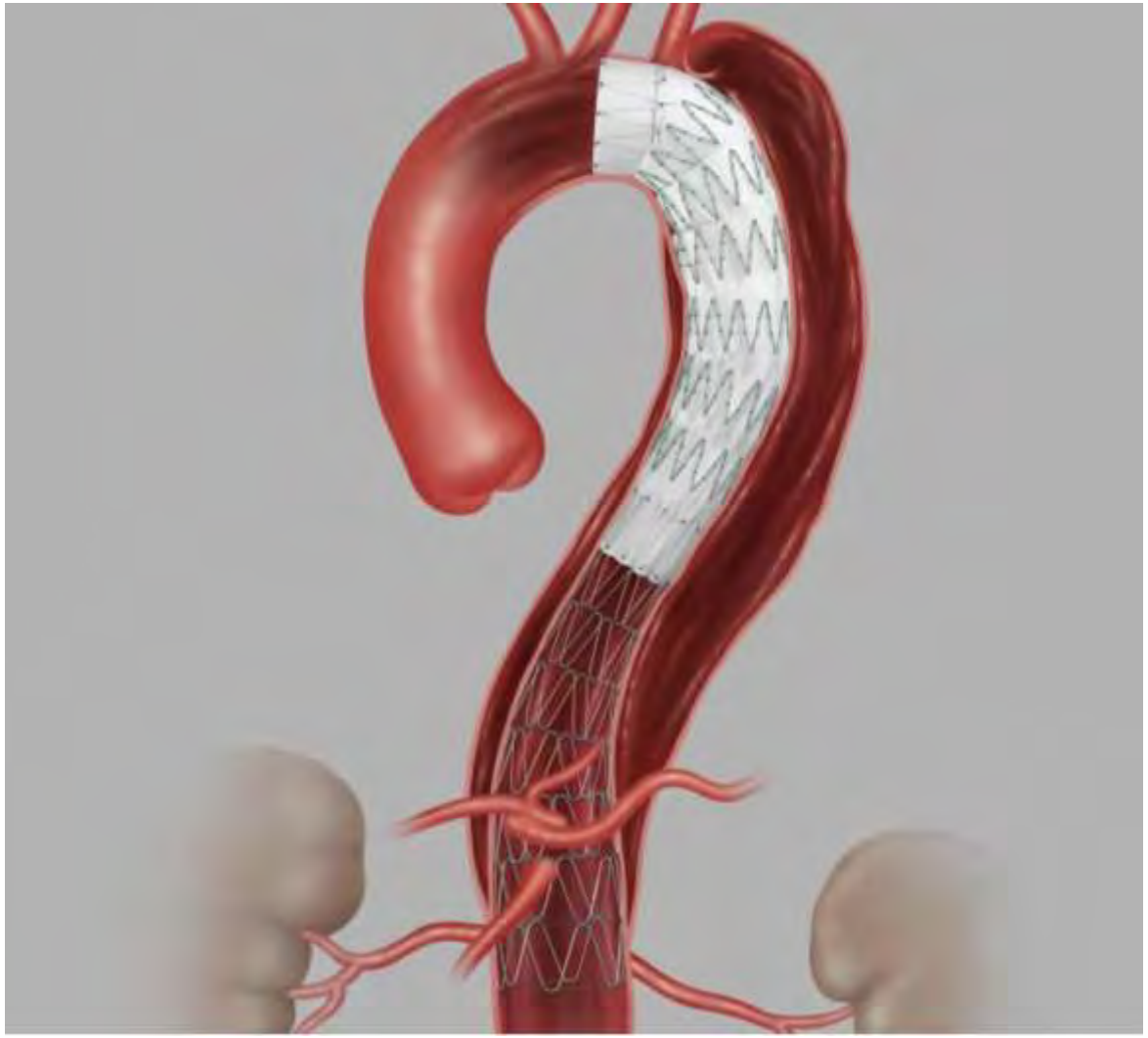


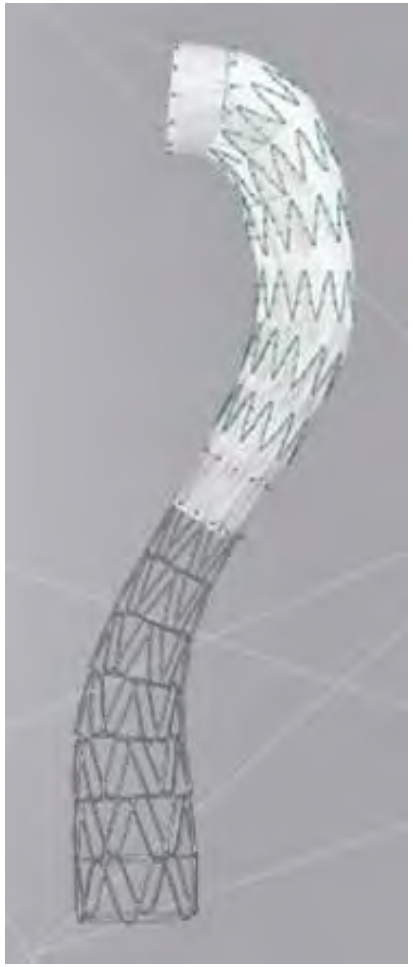


Malperfusion Treatment Options

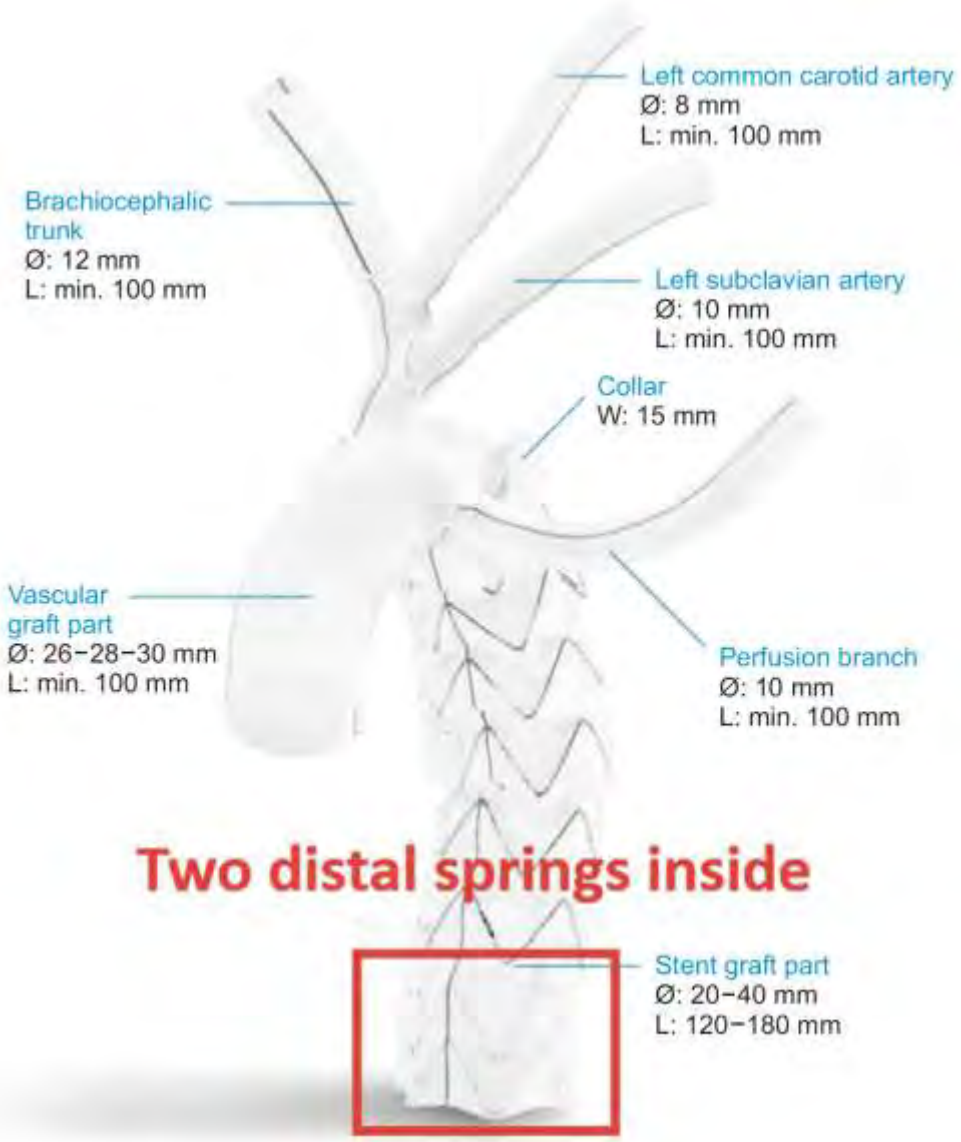


Aortic Dissection Specific Endovascular System





Frozen Elephant Trunk



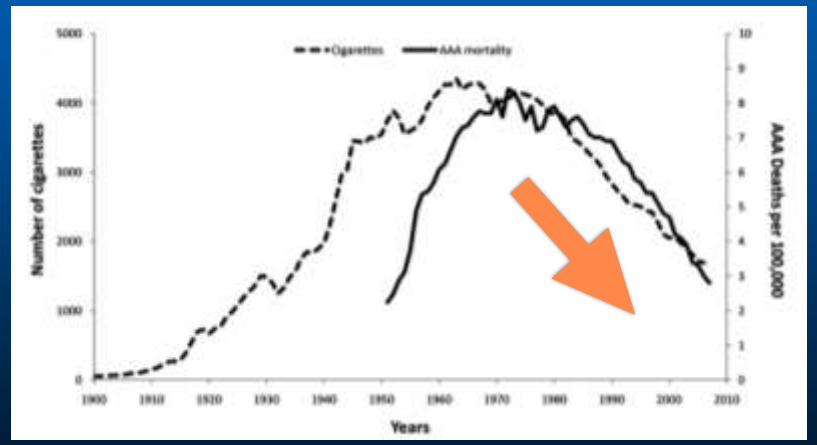
Aortic Pathologies

- Acute Aortic Syndrome
- Aneurysmal Disease
- Ehlers-Danlos syndrome
- Loeys-Dietz syndrome
- Marfan syndrome
- Takayasu's arteritis
- Giant-cell arteritis
- Lymphoma
- Adult congenital aortic disease (i.e. coarctation, congenital aortic valve, Turner syndrome)

Aortic Dissection: Increasing Incidence

Abdominal Aortic Aneurysm

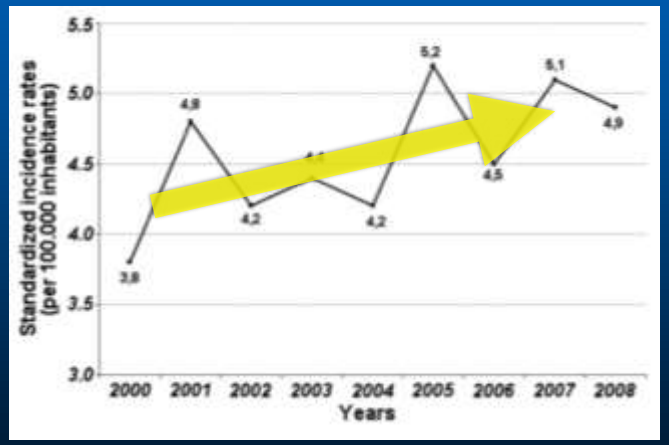
Decreasing



Lederle Circ 2011

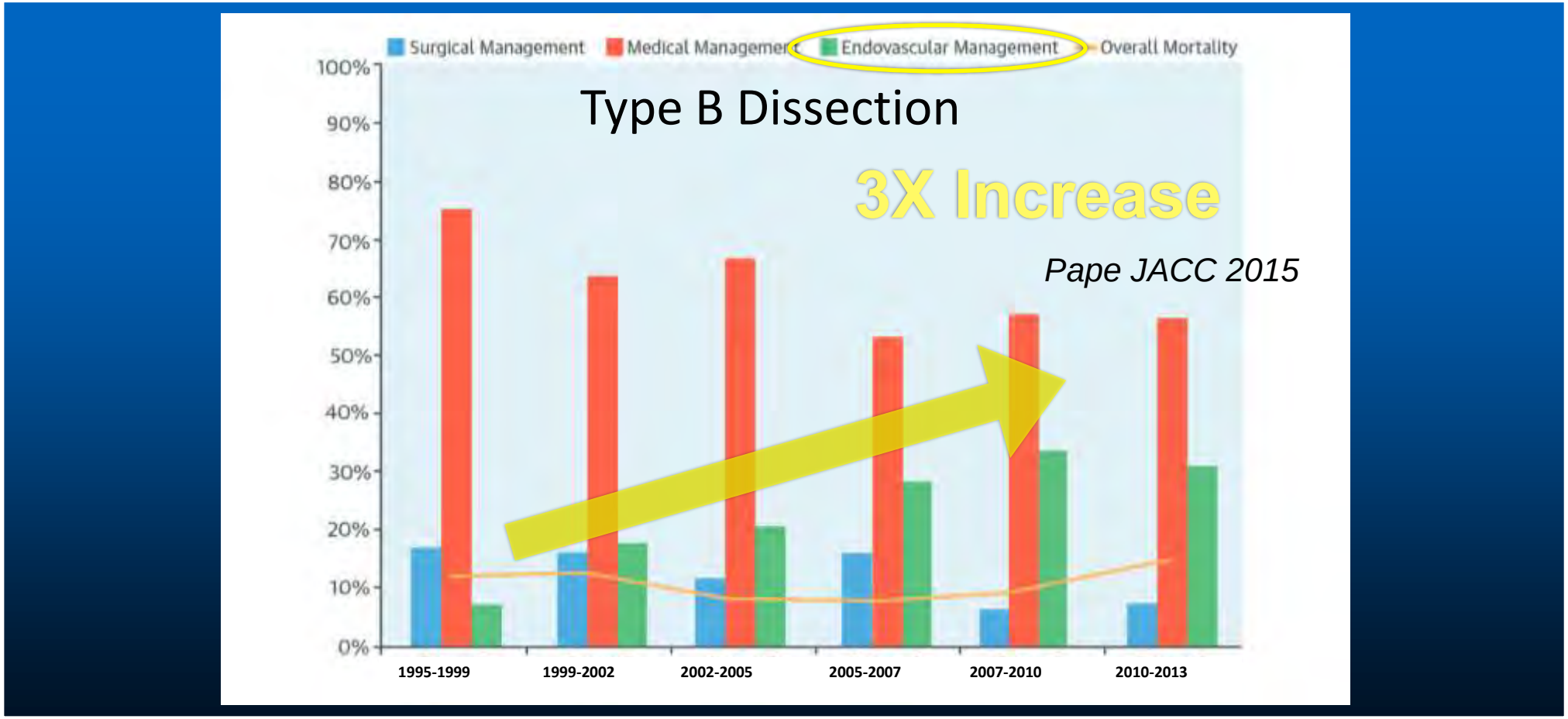
Aortic Dissection

Increasing

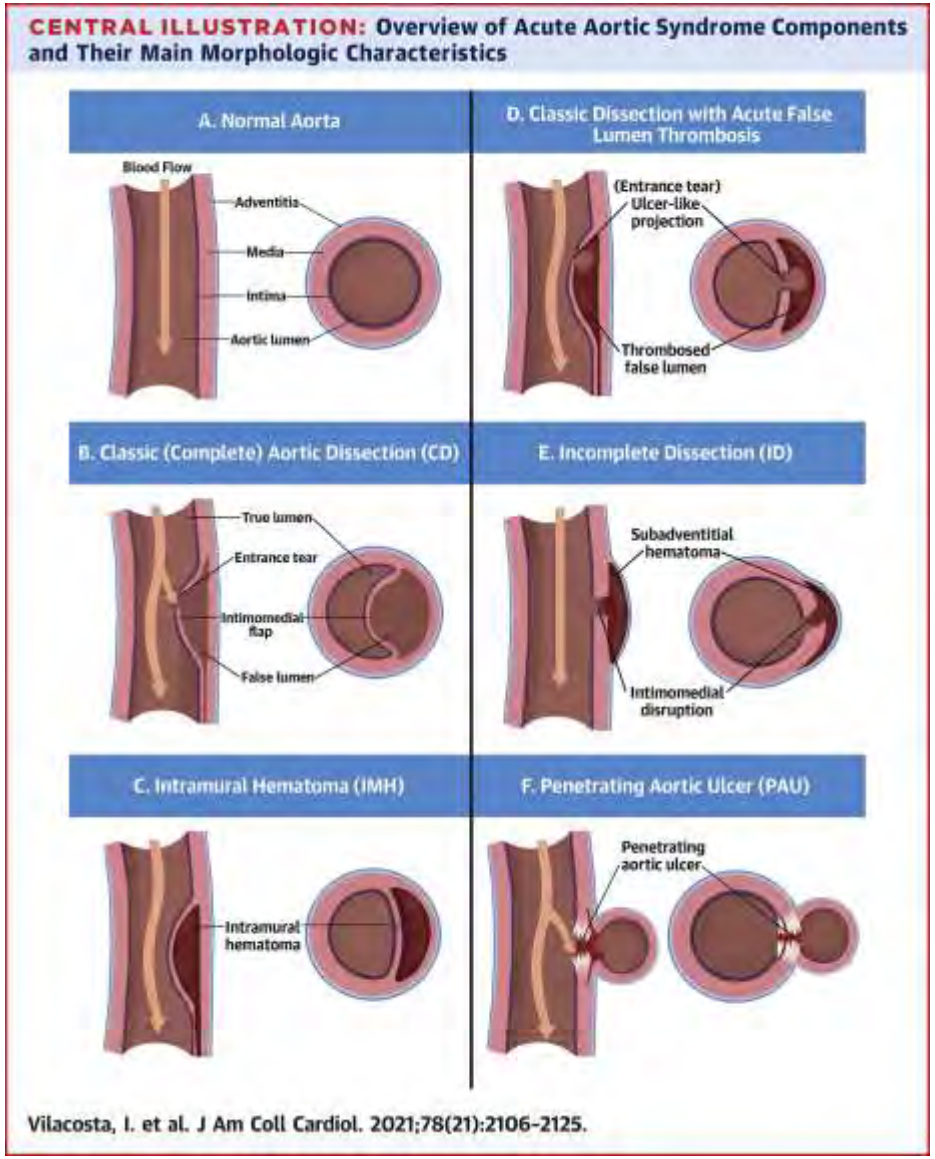


Pacini Int J Cardiol 2013

Aortic Dissection: Increasing Incidence



Acute Aortic Syndrome



A Team Approach to Aortic Disease

Nebraska Medicine

SERIOUS MEDICINE. EXTRAORDINARY CARE.

Philosophy Behind the Team

- Reduce early Mortality
- Avoid reoperations
- Improve long-term outcomes

- Ultimately, pooling numerous skill sets together to handle aortic emergencies and conditions carrying a high morbidity and mortality
- Need for a group to establish resources and infrastructure to handle both emergencies and long-term care of a chronic condition

SVS Consensus Document Highlights

first for SVS: suggested case volume threshold and outcome targets

NEW

- Elective EVAR to be performed in hospitals
  - with documented mortality and conversion rate to open surgical repair of ≤ 2%, and
  - that perform at least 10 EVAR cases/year.

NEW

- Elective Open AAA to be performed in hospitals
  - with a mortality rate < 5%, and
  - that perform at least 10 open aortic operations of any type/year.

*The volume threshold was discussed through a lengthy member and public comment period, and the final recommendation represents a **balance between the available evidence and the different practice environments** in which SVS members work.*

SVS Consensus Document Highlights

- A door-to-intervention time of < 90 minutes for emergency repairs.
- A one-time AAA ultrasound screening for men and women ages 65 to 75 who have a history of tobacco use.
  (Several other organizations recommend screenings for male smokers only)
- Recommendations for the treatment of endoleaks.
- Appropriate use of antibiotic prophylaxis in patients with an aortic prosthesis undergoing dental and other invasive

Team Members: Creating a Group to Standardize Optimal Care

- Vascular Surgeons
- Cardiac Surgeons
- Adult Congenital Cardiology
- Cardiology with a connective tissue disease focus
- Anesthesiologist
- Intensivists
- Neurosurgeons
- Imaging Specialists
- Rheumatology

Development of Dedicated Aortic Experience

- Open repair
- Branched Endovascular Aneurysm Repair
- Fenestrated Endovascular Aneurysm Repair
- Snorkel Endografts
- Physician Modified Endografts

- Creation of 3-D models

Multidisciplinary Conferences/Clinics

- Case discussion: management options, treatment algorithms, surgical plans
- Review of latest technology and literature
- Current treatment recommendations
- Coordinate multidisciplinary follow-up and surveillance plans

Education and Accessibility

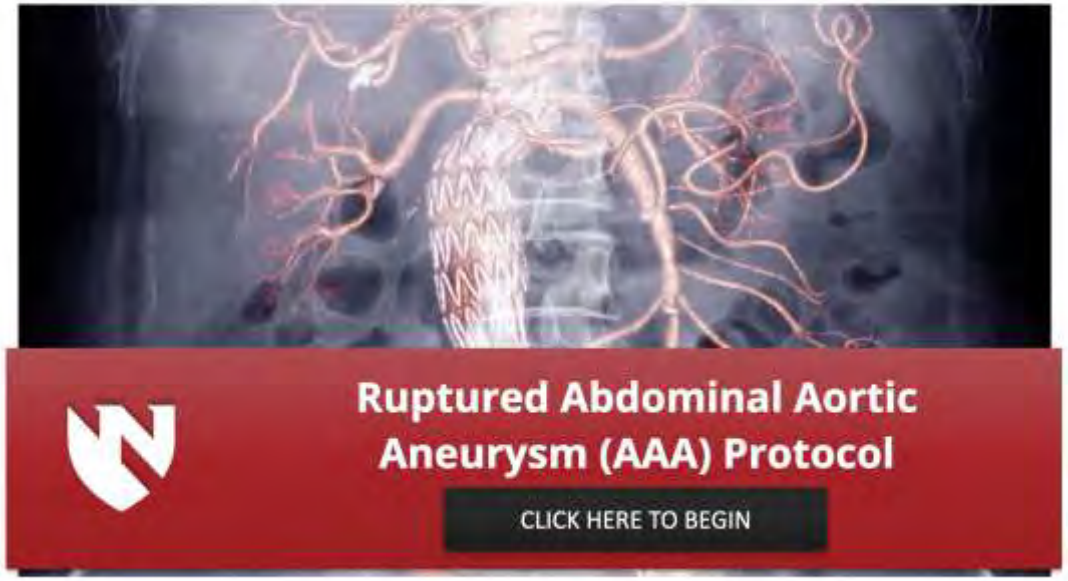
- Creation of dedicated hotline/centralized call center with ability for rapid transport arrangement

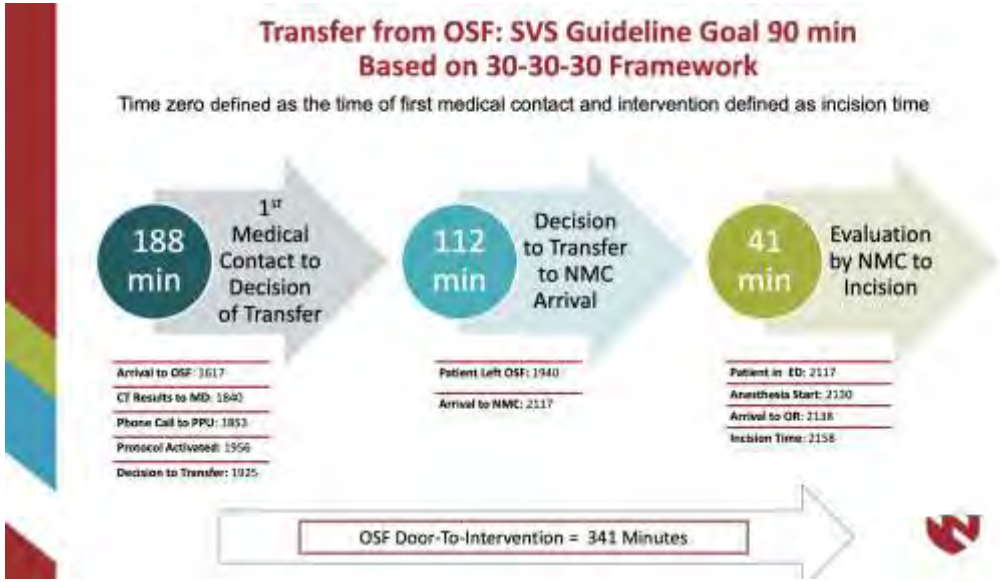
- Raising regional awareness through outreach, conferences, and lectures
  - Target small to medium size emergency departments

Aortic Emergency Program

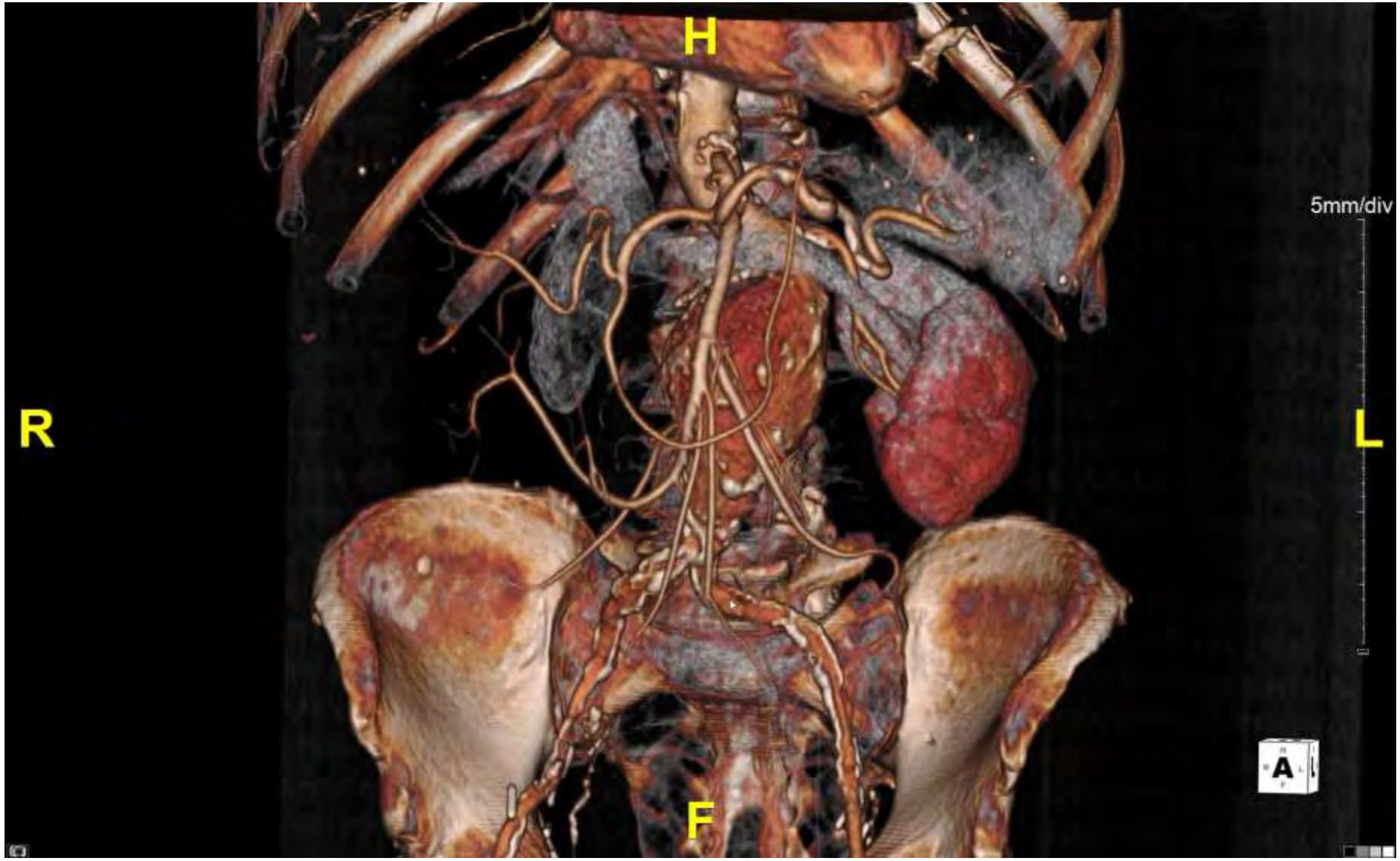
- In 2021 we identified a need to better streamline referrals for aortic emergencies including ruptured aneurysms

Ruptured AAA Protocol Education





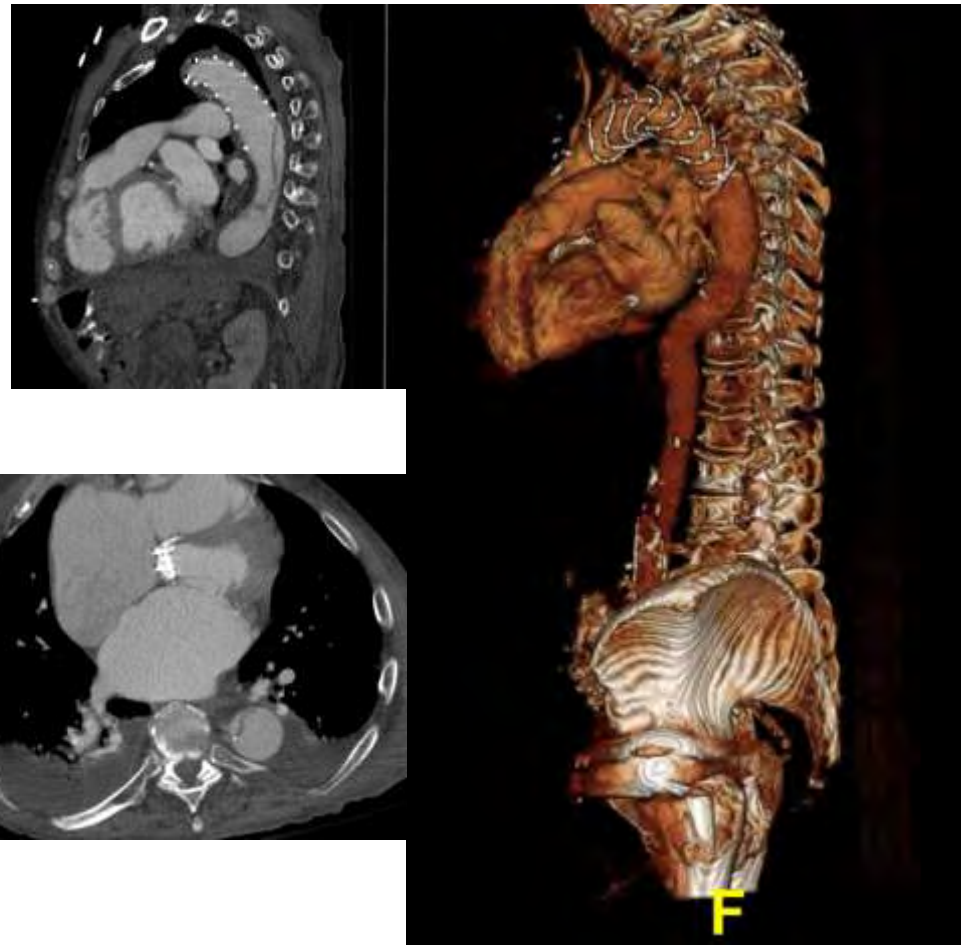
Automated Centerline Measurements



Physical Model from 3D Reconstruction

Aortic Dissection with Visceral Malperfusion and New Onset Heart Failure

- 73yo male with a history of an AVR, ascending aortic aneurysm repair(2007) and elephant trunk (2022)
- Presents with acute renal failure, elevated liver enzymes, abdominal pain, SOB
- Echo demonstrates severely depressed and dilated atria & ventricles with depressed systolic function
- CTA shows new onset aortic dissection with malperfusion



Aortic Dissection with Visceral Malperfusion and New Onset Heart Failure

- Initial stabilization then to the operating room
- Percutaneous placement of thoracic endograft to cover the largest aortic tear followed by placement of dissection stent over the visceral aorta
- Additional stenting in the SMA

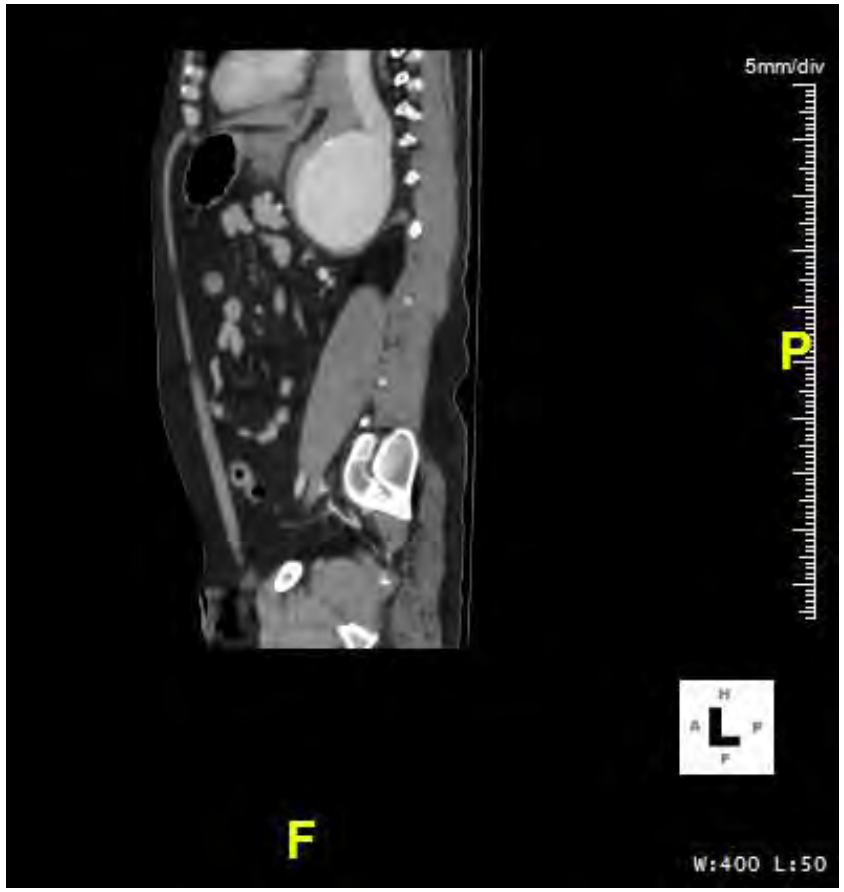
- Teams involved included Vascular Surgery, Heart Failure, Critical Care Anesthesia, Cardiac Surgery

Aortic Dissection with Visceral Malperfusion and New Onset Heart Failure

- Follow up at 6 months
- EF 45%
- Overall doing well with no physical limitations

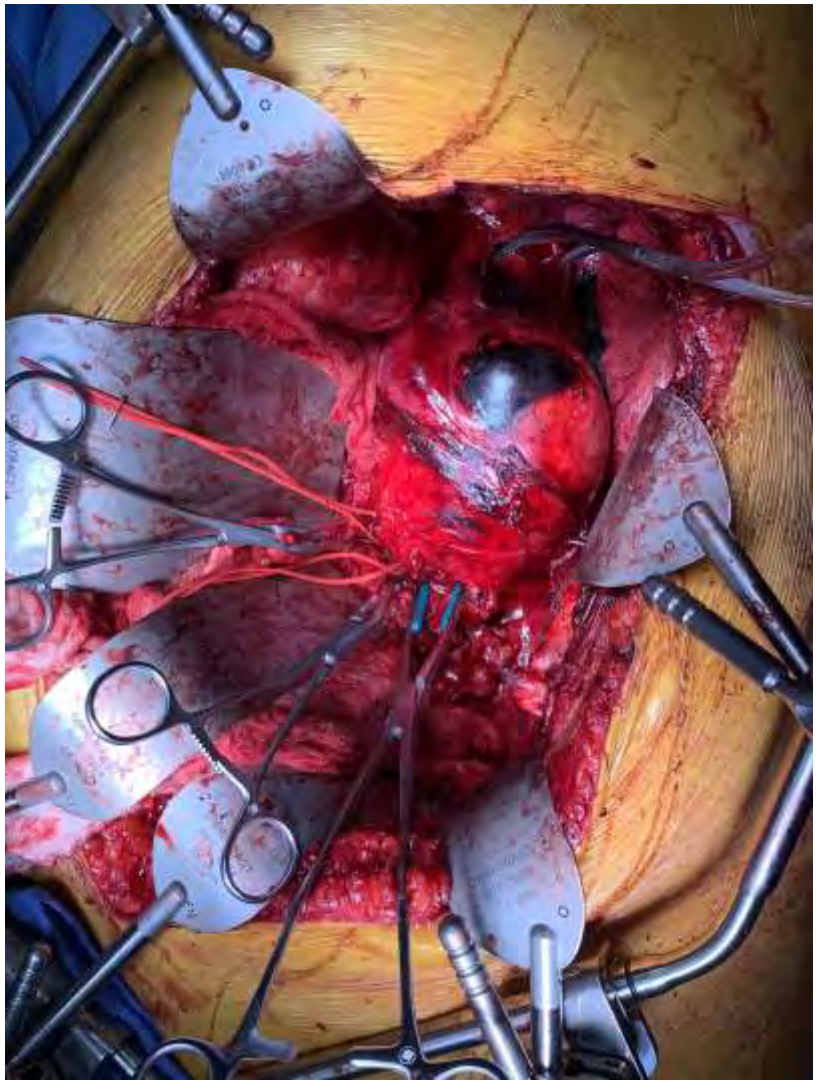
Rupture Thoracoabdominal Aortic Aneurysm-Open Repair

- Call to transfer desk, construction worker with crushing back pain presented to local ED
- Transfer to NMC, in the OR within 50 minutes
- Teams involved: Vascular surgery, Cardiothoracic surgery, Cardiac anesthesiology, Critical Care anesthesia, neurosurgery



Ruptured Thoracoabdominal Aortic Aneurysm-Open Repair

- Lumbar Drain
- Esophagogastroduodenoscopy
- Takedown of diaphragm
- Thoracoabdominal aortic aneurysm repair (Type 5) with Dacron graft
- Celiac artery bypass

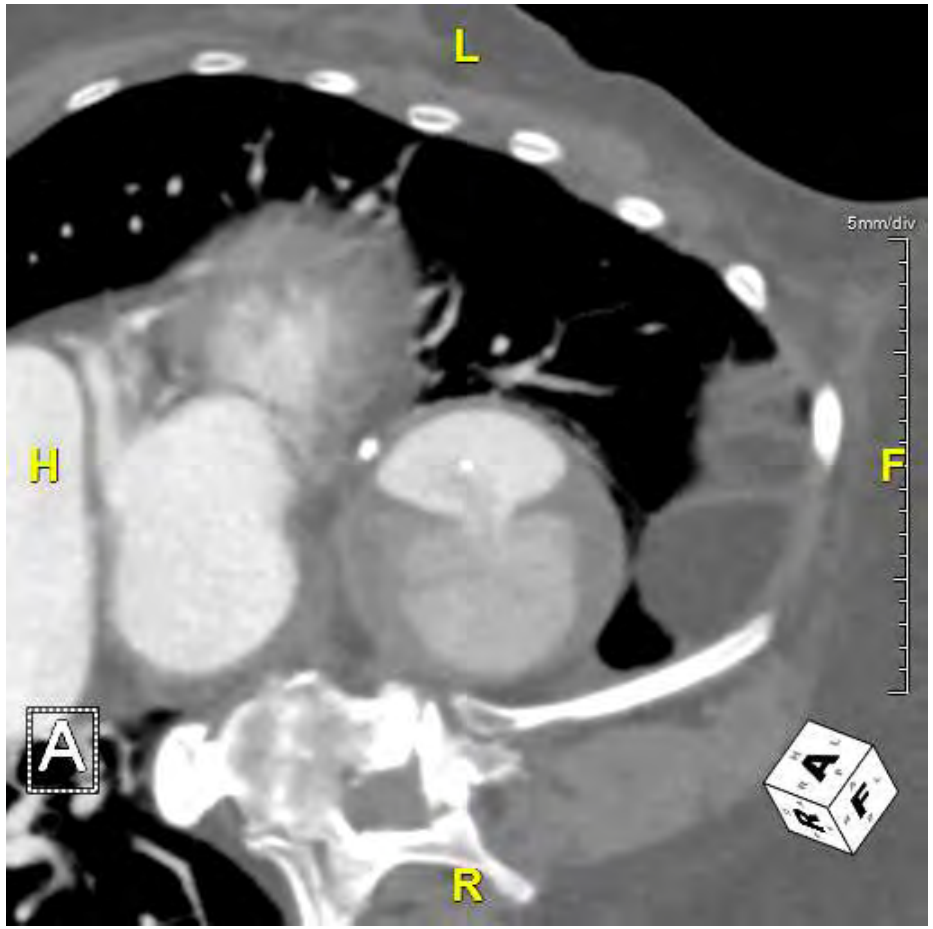


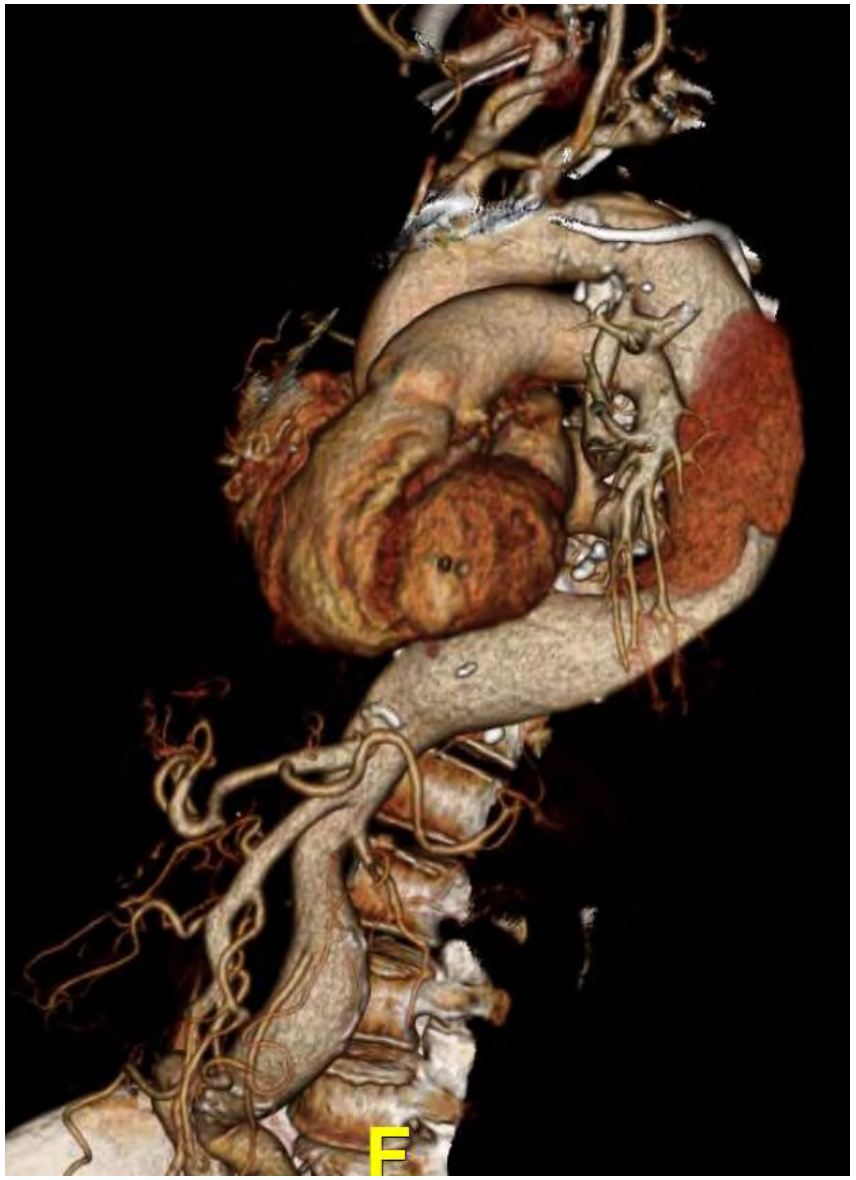
Ruptured Thoracoabdominal Aortic Four-year Follow-Up

Aortic Dissection with Aneurysmal Degeneration

- 2018 presentation with symptomatic intramural hematoma with conversion to a Type B aortic dissection
- Initial medical management
- Aneurysmal degeneration of dissection with maximal size of 6.4cm

Aortic Dissection with Aneurysmal Degeneration

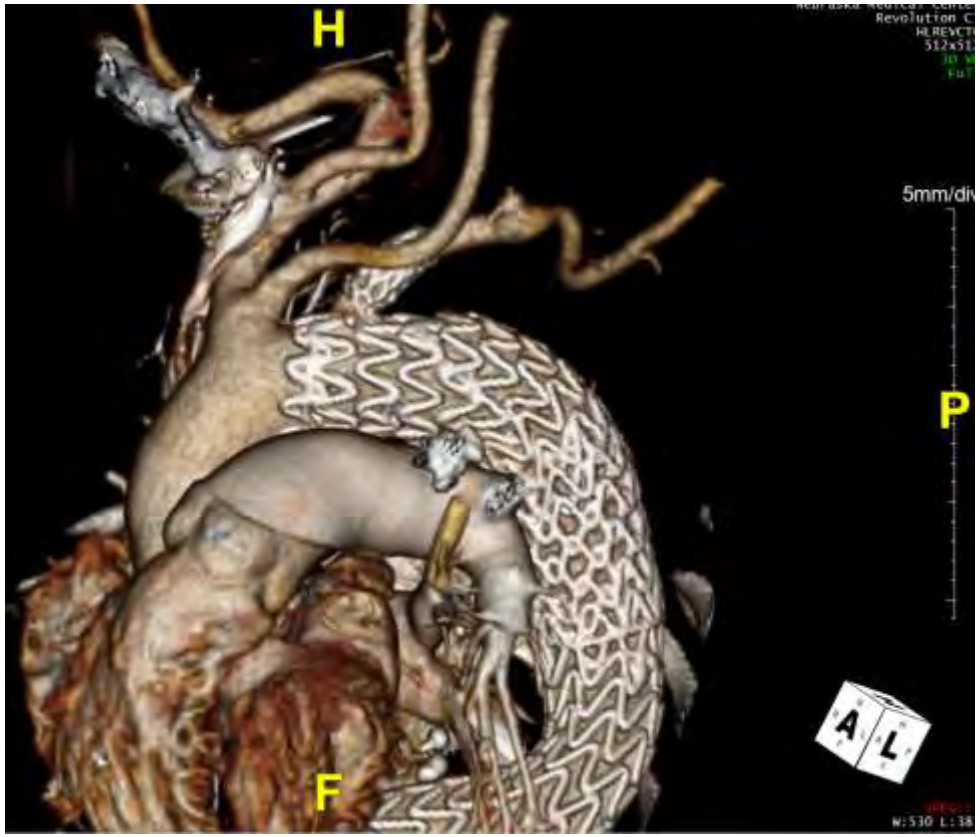




Aortic Dissection with Aneurysmal Degeneration

- Candidate for a branched aortic endograft
- Teams involved, vascular surgery, cardiac anesthesia, critical care anesthesia, neurosurgery

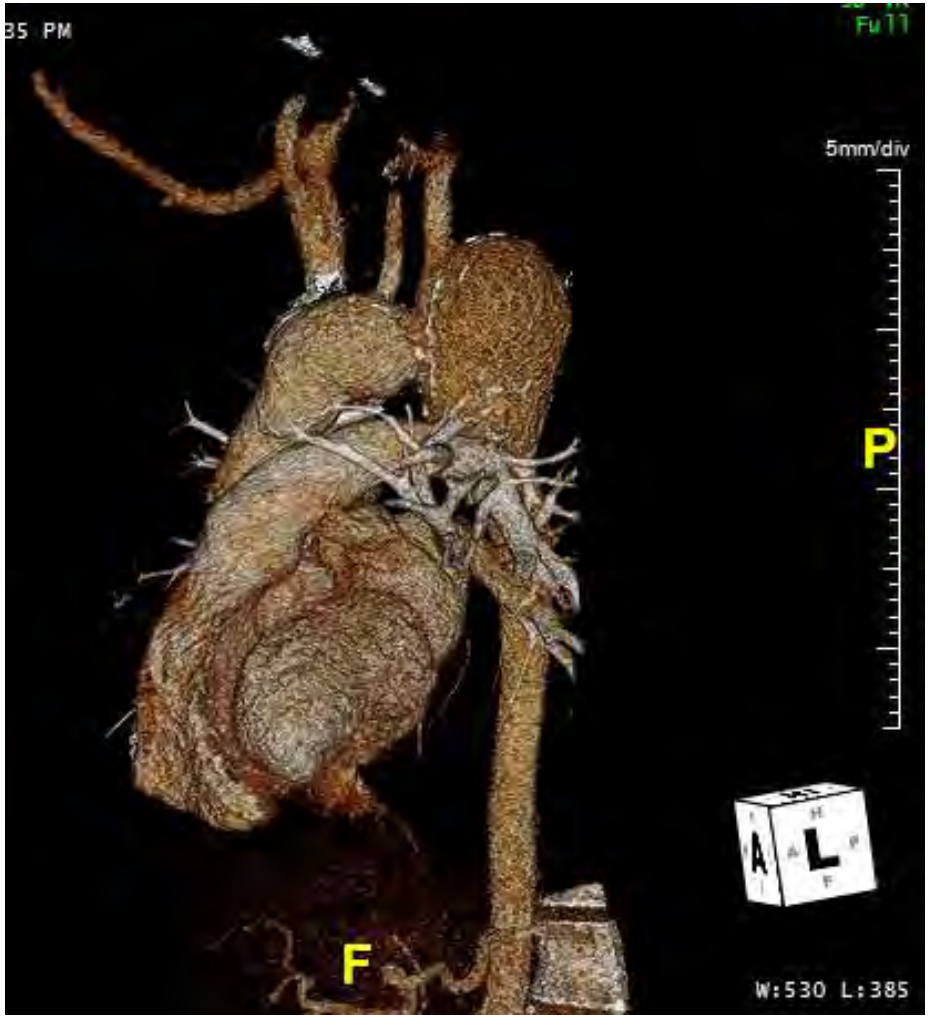
Aortic Dissection with Aneurysmal Degeneration



Aortic Coarctation

- History of aortic coarctation with repair at age 7 with Dacron graft
- Recurrent coarctation with repair by boomerang patch augmentation
- Presents with 5.7 post-stenotic thoracic aneurysm

- Teams involved include cardiac surgery, vascular surgery, cardiac anesthesia, critical care anesthesia, neurosurgery, pediatric and adult congenital cardiology



Aortic Coarctation

- Staged repair with debranching of the innominate artery, carotid to carotid bypass, carotid to subclavian bypass
- Thoracic aortic endograft via left CIA conduit

Summary

- There are a number of unique challenges posed by aortic pathology requiring multiple different specialties to contribute to achieve acceptable outcomes
- Team approach allows for care in the acute setting and the elective setting
- The patient population is increasing due to the increase in acute aortic syndromes and extended lifespan of the congenital heart disease patients
- Tremendous potential in the research arena for basic science, translational research, new device technology/trials