Hybrid Surgery and Endovascular Grafts: Cutting Edge Technology for Aortic Aneurysms

Objectives
- Explain the new technology of endovascular stent grafting and debranching for thoracic and abdominal aortic aneurysms.
- Outline nursing plan of care for endovascular stent graft patients.
- Explore assessment cues and complications associated with endovascular stent grafts.

Aortic Aneurysms How Big is the Problem?
- 1 - 5% of general population affected
  - Incidence is increasing
- AAA: 100,000 – 250,000 new cases each year in the U.S.
- TAA: approximately 15,000 new cases each year
- 43,000 – 47,000 deaths per year (CDC)
  - Twice as many deaths from thoracic aortic dissection and rupture than abdominal

Aortic Aneurysm (AA)
- Abnormal dilation of the aortic wall that alters the vessel shape and blood flow
  - 50% increase in the diameter of a vessel in comparison of its expected normal
- With gradual enlargement, the aorta becomes increasingly weakened, leading to possible dissection and rupture.

Normal Size of Aorta

<table>
<thead>
<tr>
<th>Size in CM</th>
<th></th>
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<tbody>
<tr>
<td>Root</td>
<td>3.5–3.91</td>
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<tr>
<td>Ascending</td>
<td>2.86</td>
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<tr>
<td>Mid Descending</td>
<td>2.39–2.64</td>
</tr>
<tr>
<td>Diaphragmatic</td>
<td>2.43–2.69</td>
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Aortic Aneurysm (AA)

- Thoracic TAA

- Abdominal AAA

Risk Factors

- Hypertension
- Increasing Age
- Smoking
- Cocaine or other stimulant use
- Weight lifting or other valsalva maneuver
- Trauma
- Deceleration or torsional injury
- Family history
- Marfan’s syndrome
- Loeys-Dietz Syndrome
- Turner Syndrome
- Pheochromocytoma
- Coarctation of the aorta
- Bicuspid valve

Smoking

- Current smokers are seven times more likely to develop AAA than non-smokers.
- Former smokers are three times more likely.
- Strongest modifiable risk factor for development of aneurym.

Risk

- Aortic aneurysm disease is rare under the age of 50.
- Mean age of patient undergoing repair is 70.

Precipitating Events of onset of acute aortic dissection

- Extreme exertion
  - Weight lifters (Yale)
  - Extreme elevation in BP
- Episode of severe emotional upset

Screening

- Aortic imaging recommended for 1st degree relatives of patient with TAA and/or dissection to identify asymptomatic disease (Class 1B)
- 20% of AAA patients have a relative with the condition.
Aortic Aneurysm Rupture
- A tear in the vessel wall near or at the location of the ballooning of the weakened area of the aorta allowing blood to hemorrhage into the chest or peritoneal cavity
- Rupture carries a 90% mortality

Dissection
- Tear in the intimal layer of the aortic wall
- Blood passes into the aortic media through the tear separating the intima from the surround media and/or adventitia, creating a false channel within the aortic wall

Dissection
- Acute Dissection
  - Diagnosed within 14 days of the onset of symptoms
  - The risk of death is greatest during this acute period
- Chronic Dissection
  - Diagnosis after two weeks of the onset of symptoms

A Silent Disease
- 40% of individuals are asymptomatic at the time of diagnosis
  - Often discovered on a routine CXR or abdominal sonogram
- Only 5% of patients are symptomatic before an acute aortic event.
  - The other 95%, the first symptom is often death

AA Dissection Symptoms “The Great Imitator”
- S/S depend where the dissection occurs and what area is not getting oxygen
- Confused with:
  - Kidney stones
  - Gallstones
  - Paralysis -- think neuro diagnosis
  - Myocardial infarction

AA Symptoms
- Abrupt onset of excruciating pain in chest, back, or abdomen
  - Ascending Dissection
    - Retrosternal pain that is not exertional in nature
  - Descending Dissection
    - Interscapular chest pain
    - Severe flank pain
    - Epigastric pain
- Ripping, tearing, stabbing and or sharp quality of pain
High Risk Examination Features

- Pulse deficit
- Systolic BP limb differential >20mm Hg
- Focal neurologic deficit
- Murmur of aortic regurgitation
- Hypotension or shock state

Biomarkers

- D-dimer will elevate in aortic dissection
- D-dimer is extremely nonspecific as it elevates with any thrombosis
- If D-dimer is not elevated = no aortic dissection

Thoracic Dissection Symptoms

- Severe tearing pain of sudden onset
- Pain has a tendency to migrate from its point of origin to other locations following the path of dissection

You suspect a dissecting/rupturing aneurysm….

Rapid Triage & Treatments

- Aortic Center Aortic Pathway
  Methodist Hospital Houston, TX

2010 ACCF/AHA/AATS/ACR/ASA/SCA/SCAI/SIR/STS/SVM Guidelines for the Diagnosis and Management of Patients with Thoracic Aortic Disease


Endorsed by the North American Society for Cardiovascular Imaging.
### Diagnostics
- 12 Lead EKG to r/o STEMI
- Chest x-ray – not very helpful as no abnormalities noted
- CT scan

### Aortic Dissection Classification: DeBakey and Stanford Classifications

#### DeBakey Classification:
- Type I: Aortic dissection that extends into the coronary arteries
- Type II: Aortic dissection limited to the ascending aorta
- Type III: Aortic dissection limited to the descending thoracic aorta

#### Stanford Classification:
- Type A: Aortic dissection that involves the ascending aorta
- Type B: Aortic dissection limited to the descending thoracic aorta

### Dissections
- 62% are Type A
- Type B are typically older than Type A
  - Immediate operation room intervention
  - Type A
  - Medical management

### Acute AoD Management Pathway
**STEP 2: Initial management of aortic wall stress**

1. **Intravenous rate and pressure control**
   - Rate/Pressure Control
   - Intravenous beta blockade or Labetalol
     - (If contraindication to beta blockade, substitute diltiazem or verapamil)
     - Titrate to heart rate <60

2. **Pain Control**
   - Intravenous opiates
   - Titrate to pain control

3. **Hypotension or shock state?**
   - **Systolic BP >120mm HG?**
     - **Yes**
       - Secondary pressure control
         - Intravenous vasodilator
         - Titrate to BP <120mm HG
         - (Goal is lowest possible BP that maintains adequate end-organ perfusion)

### Indications for AA repair
**Thoracic**
- Symptomatic
- Diameter 5.5 - 6 cm
- Diameter 4.4 - 5 cm associated with genetic disorder (Marfan’s syndrome)
- Symptoms suggesting expansion or compression of surrounding structures
Indications for AA repair

Abdominal

- Diameter ≥ 5 cm
- Diameter ≤ 4 cm needs regular follow up
- Diameter 4 – 5 cm, management is controversial

Indications for AA repair

Both: TAA & AAA

- Rapidly expanding aneurysms
  - growth rate > 0.5 cm/year
- Symptomatic aneurysm regardless of size

Size --- It really does matter!

Annual Incidence of Rupture

- At 6 cm – aorta becomes a rigid tube
- It cannot stretch in systole
- Results in high wall stress
- 34% risk of rupture
  - TAA at 6 cm
  - AAA at 7 cm

Repair of AA

Traditional:
Open surgical repair

Evolving Trend:
Endoluminal grafting (ELG)

Surgical Repair for AAA

- > 50 years since first repair
- Average mortality 4%
- Significant short & long-term morbidity
- Causes of aneurysm related death well defined

Functional Outcome after Open Repair of Abdominal Aortic Aneurysm

Operative Mortality 4% (154 pts.)
Mean LOS 10.7 days
ICU LOS 4.6 days
Ambulatory Post-op 64% (25 mos.)
Decreased Functionality 33%
Time to Recovery 3.9 mos.
Unrecovered 33%
Again? 18% - No

Williamson, et al – Portland, Oregon
J Vasc Surg 2001;33:913-20
Evolving Trend: Endovascular Graft

- The Endovascular graft is intended to exclude the aneurysm by placing the endovascular graft inside the diseased aorta to make a new path for the blood to flow.
- FDA approved for both Abdominal and Thoracic Aneurysms

Abdominal Endovascular Graft

Synthetic, two piece bifurcated graft, that lines the aorta and extends from below the renal arteries into both the iliac arteries

Aneurysm Before & After Endografting

Fenestrated Endografts

- Holes in the fabric that are positioned adjacent to the aortic branch arteries
- Deploy smaller covered stents through the branched fenestrations and into the targeted arterial branches

Branched Endografts

- Pre-attached limbs or cuffs targeted for the aortic branches.
- Cuffs are deployed in the targeted branch
TAG Thoracic Endograft

TEVAR: Thoracic Endovascular Aneurysm Repair

INDICATIONS:
Thoracic Aneurysms
Acute and Chronic Thoracic Dissection

TEVAR

2003
Starting treating TAA with endografts in Peoria
2005
FDA approved

Morbidity of Open Repair

Gore TAG
Deploys from the middle to the end
This prevents windsock
Windsock can move graft 3 – 5 cm

Medtronic Talent Stent Graft

Push pull method to open
Can migrate during cardiac cycle while deploying.
Use Adenosine to stop heart while deploying.
Deploys proximal to distal

Approved by the FDA on March 23, 2005.
**Definition of Hybrid**

An offspring resulting from cross-breeding.

**Hybrid Open/Endovascular Aneurysm Repair**

- Hybrid approach: combines standard operative approaches and endografts and/or conduit creation/de-branching.
- De-branching: the transposition of the origin of critical branch vessels to facilitate a seal zone.

**Aortic Debranching**

Extra-anatomical Bypass

- Aortic Debranching: The transposition of the origin of the critical branch vessels to facilitate a seal zone.
- Aortic Debranching is used to provide blood flow around the arch arteries that become occluded when a TAG is placed in the ascending aorta.

**Photos courtesy of Dr James Bertram Williams**

- A board-certified cardiothoracic and vascular surgeon Peoria, IL
- Principal investigator in a number of U.S. clinical device trials for endovascular devices.
- Endovascular Therapies Fellowship Training (ETFT) Program, a six-week visiting fellowship program [www.etft.org](http://www.etft.org)
TAG inserted covering the subclavian artery.

Pre TAG  Post TAG

Aorto bi-carotid bypass: Y graft to the left & right common carotids and the infrarenal abdominal aorta

Aortic Banding

A ‘hybrid’ technique to create seal zones for treatment of aortic aneurysmal disease with endoluminal technology

Type A Dissection

- Immediate operating room intervention

Acute Type B dissection

- Goal is to have the true lumen reexpand and the false lumen to resolve
- Need to understand anatomy of the dissection to know what the true lumen vs false lumen is feeding
- Prefer to wait 8 - 9 days to treat as will have less complications

Complicated Type B Dissection
- If repair 3-5 days after dissection → significant re-dissection
- If wait longer than 9 days, then the true lumen may not re-expand
- Best to repair at 8-9 days to treat as will have less complications

Acute, Uncomplicated Type B Dissections
- Medical management is currently the most appropriate treatment
- Acute < 14 days

Chronic Type B Dissections with False-lumen Aneurysm Formation
- No consensus from TEVAR roundtable (Oct 07) on ideal means of treating.
- Slight majority favored open vs TEVAR

Nursing Care
Preoperative Care

- Usually AM admit
- Hydrate with NS at 125 -150 ml/hour
- If Creatinine > 1.6 may give Mucomyst or Bicarbonate infusion (3 amps Bicarb/1000ml D5W at 3 ml/hr x 6 hours --- start 1 hour preop)
- Permit to include possible resection of aortic aneurysm
- Teaching

Preop Diagnostics
To measure length & diameter of the arteries

- Duplex scan
- CT (without contrast)
- Aortogram (with calibrated catheter)
- Spiral CT
- Intravascular ultrasound
- 3-D CT Reconstruction

Numerous Pre-procedural Assessments

- Celiac axis
- SMA
- Cephalad neck
- Length
- Kinking
- Lumbars
- IMA
- Diameter
- Iliac artery
- Int iliac artery
- Femoral artery/runoff

Intravascular Ultrasound
Proximal Neck

TAA
Pre-procedural Assessments

Postop Nursing Care
**Management TAG/ELG vs Debranching**

**TAG & ELG**
-hourly neurovascular checks to extremities
-Immediate notification if decreased movement or sensation in legs--may need to insert cerebral spinal catheter
- Lactate levels
- Pulmonary Toilet

**TAG with debranching**
- Volume resuscitate. Keep CVP high
- If hypotensive & hypovolemic, grafts can clot off
- Treat like a trauma or open abdominal surgery --- treat with hypotension with fluids not inotropes until tanked up.
- If Carotid arteries bypassed, hourly neuro checks

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**Postoperative Assessment, Complications & Care**

- Endoleaks
- Extremity Ischemia
- Urinary Retention
- Renal Failure
- Bowel Ischemia
- Abdominal Compartment Syndromes
- Spinal Ischemia (TAA)
- Stroke
- Metabolic Acidosis
- Respiratory Complications

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**Endoleak**

Aneurysm sac remains pressurized

Endoleak Significance

Endoleak = Endopressure ≠ Protection

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**Endoleaks**

Aneurysm sac remains pressurized

- Type I:
  - Attachment site of graft either proximally or distally does not seal in vessel due to undersizing or poor apposition to vessel wall--Treat right away!
- Type II:
  - Native ileo lumbar vessels coming off the aneurysm sac remain patent. Non-emergent -- can be watched. Usually thrombosis after heparin is reversed or within a few months

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**Endoleaks**

Aneurysm sac remains pressurized

- Type III:
  - Leaks between components of graft (rare)
- Type IV:
  - Hole in the fabric of the graft
- Type V:
  - Increase in endotension

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**Perigraft Flow/Endoleak: Definitions**


- Type I: Attachment leak
- Type II: Branch flow
- Type III: Defect in graft or modular disconnection
- Type IV: Fabric porosity
Intraoperative Detection of Endoleak

- Current standard: Angiography
- Emerging technology:
  - Color flow IVUS
  - Intra-sac pressures

Post-operative Detection of Endoleak

- Assessment of aneurysm diameter & volume
- Abdominal four view x-rays POD #1
- CT with 3-D reconstruction
- Duplex Scan
- For severe endoleak = hemodynamic instability

Extremity Ischemia

- Due to thrombosis of graft or groin hematoma at insertion site
- Assess pedal pulses, sensation, color, and temperature of extremities every 15 minutes x 4 and then hourly.
- Assess for pain in the hip(s) or leg(s) during walking
- Ankle brachial indexes bilaterally POD #1

Urinary Retention

- Due to enlarged prostate
- Discontinue foley in OR or immediately upon admission to unit to prevent urinary retention

Renal Failure

- Due to occlusion of renal arteries by graft
- Due to atheroembolism
- Due to contrast induced nephropathy
  - 200 – 250 mg of contrast used per procedure case
  - HYDRATE preoperative

Pre existing Chronic Renal Failure & TEVAR

- Significant impact on:
  - Early and late death
  - Stroke
  - Paraplegia
Bowel Ischemia

- Mesenteric Artery ischemia
  - Due to occlusion or hypoperfusion of mesenteric artery ischemia
  - Due to atheroembolism
  - Will do bypass if think graft may cover mesenteric artery

- Paralytic ileus
  - Gastric distention
  - Retroperitoneal bleeding
  - Mesenteric ischemia
  - Drugs (narcotics)

- Assess for
  - Loose stool or diarrhea
  - Bright red blood per rectum, blood streak stool
  - Abdominal pain out of proportion to physical findings

- Decompress bowel with nasogastric tube and keep NPO

Mesenteric ischemia

- Early diagnosis and treatment are essential to lower mortality
- Mortality generally exceeds 50%
- When ischemia is prolonged, irreversible intestinal necrosis may occur within hours
- Emergency abdominal exploration is indicated if bowel necrosis is suspected

Intra-abdominal hypertension (IAH) and Abdominal Compartment Syndrome (ACS)

- In high risk patients, measure intra-abdominal pressure (IAP) via bladder pressure measurements
  - Get baseline
  - Measure every 2 – 6 hours
- IAH = IAP ≥ 12 mmHg
- ACS = IAP > 20 mmHg and associated organ failure/dysfunction

Signs of Intra-abdominal hypertension (IAH) and Abdominal Compartment Syndrome

- Cardiac
  - Low CO with ↑ CVP/PAD
- Renal
  - Low urine output
- Pulmonary
  - Dyspnea
  - ↓ tidal volumes
  - ↑ intrathoracic pressures
- GI
  - Nausea/vomiting
  - Abdominal pain
  - Abdominal distension
- Neuro
  - ↑ ICP
  - Anxiety
  - Confusion
  - Lethargy
**Spinal Cord Ischemia (SCI)**

- The spinal cord like the brain
  - No room for anything but the cord and CSF
  - And it is unyielding to increased spinal pressures
- Paralysis
  - Occurs in about 3 - 6% of all repairs of the descending thoracic aneurysm
  - Due to interference in the blood supply to the spinal cord
- May occur immediately postop or from 1 – 21 days

**Spinal Cord Ischemia**

- Ischemia to the cord
  - Leads to cord edema
  - Can cause the lumbar ICP to rise & impede normal flow of CSF within the spinal canal
- Thoracic or lumbar spinal cord damage causes paraplegia
- Similar to muscular ‘compartment syndrome’

**Spinal Cord Ischemia (SCI)**

- The mechanisms leading to SCI:
  - The interruption of multiple branch vessels that provide spinal cord perfusion.
- Hypotension - MAP < 70 - 90
  - Periop &/or postop
  - Can be a precipitating factor causing SCI

**At risk for permanent and transient paraplegia**

- Complicated Type B dissection
- Hybrid aortic procedures
- Aortic transection
- Chronic renal failure
- Smoking

**Prevention of Spinal Cord Ischemia**

- Prevent Hypotension MAP < 70 - 90
  - Treat with fluids to keep CVP > 6

**Treatment Spinal Cord Ischemia**

- Drainage of the lumbar CSF can reduce the risk of cord damage when reducing pressure to < 7 – 10 mmHg
- Keep MAP > 90 - 99 mmHg
Lumbar Cerebral Spinal Fluid Drain

- Also called:
  - Lumbar drain, Lumbar subarachnoid catheter, intrathecal catheter, CSF drain
- Placed in the Lumbar Subarachnoid space
- Use for those at high risk for paraplegia
  - Previous infrarenal repair
  - Long segments of spinal cord
  - Spinal pressure > 10 cm H₂O

Lumbar CSF Drain Safety

- Place CSF transducer on opposite side of bed as hemodynamic pressure monitoring
- Must be a nonflush pressure system
- Turn drainage system off when getting patient up to chair
- Level after repositioning patient
- Remember to unclamp
- Aseptic technique is a must!

Spinal Ischemia Assessment

- Record CSF output hourly
- Notify MD if CSF drainage is > 20 – 30 ml/hr
- Note color of CSF
- Hourly spinal cord assessment for changes in sensation and/or movement

CSF Drainage

- Maintain CSF pressure 10 – 15 mmHg for the first 24 hours
- Then let rise to 15 mmHg
- If CSF pressure goes up above normal, blood flow to the spinal cord goes down, resulting in cord ischemia

Complications of CSF Drain

- Infection
- Overdrainage
  - Subdural hematoma
  - Herniation
- Spinal cord hematoma
- Headache
- Pneumocranium (from air entering system)
Complication of CSF Lumbar Drain Overdrainage

- Low pressure headache
- Radiculopathy
- Pneumocephalus
- Sagging Brain / intracranial hypotension
- Hemorrhage
- Subdural, intradural Hematoma
- Cranial nerve palsies
- Tension Pneumocephalus
- Brainstem herniation

Post removal of Lumbar drain

- Cap 24 hours prior to removal
- Assess for lower extremity weakness or loss of sensation
- SCI can occur up to 30 days post op.
- Teach patients to come to ED immediately for aggressive treatment if they notice any change, numbness, or weakness in their legs.

Stroke

- 4- 7% risk
- Routine neuro checks

Respiratory Complications

- Due to general anesthesia and smoking
  - Incentive Spirometry every 1- 2 hours while awake
  - Aggressive Activity
    - HOB 30°
    - Chair when stable
    - Ambulate 200’ evening of surgery
    - Then Ambulate 4- 6 times per day
- Left Pleural Effusion
  - Something may be bleeding

Admission ABGs

<table>
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<th>Patient</th>
<th>ph</th>
<th>pCO₂</th>
<th>pO₂</th>
<th>TCO₂</th>
<th>O₂ %</th>
<th>BE</th>
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<td>132</td>
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<td>41</td>
<td>100</td>
<td>22</td>
<td>98</td>
<td>-6</td>
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Type A Lactic Acidosis

Ongoing Metabolic Acidosis means something is not being perfused

- Serum lactate levels used to assess the acid-base state and adequacy of tissue perfusion
- By product of anaerobic metabolism if tissue hypoxia exists
The Value of Lactate
Serial lactate levels predictor of perfusion
- Normal <2.5mmol/L
- Mild acidosis 2.5-4.9mmol/L (mortality 25-35%)
- Moderate acidosis 5.0-9.9mmol/L (mortality 60-75%)
- Severe acidosis > 10mmol/L (mortality > 95%)


Serum Lactate levels
- Serum Lactate levels every 4 hours x 24 hours
- Level will be around 4 – 5mmol/L on admission
- Lactate levels need to decrease
- May be the first indication that something is wrong

Discharge
- Abdominal – POD #1 from CVICU
- Thoracic -- POD #2 or 3
- Teaching
- 10 days post procedure the patient should be back to normal activities
- MRI conditional up to 3 Tesla

Follow-up
- CT scan at 1, 2, 6, and 12 months and then annually to assess for aortic growth
- Teaching
  - Avoidance of exertional activities
  - Betablockers blunt pressure spikes
  - Avoidance of extreme emotional upsets

Specific Lifestyle Recommendations
- Avoidance of strenuous lifting, pushing or straining that would cause Valsalva maneuver. Class IIa B
  - When the Valsalva maneuver is used for the lifting of heavy weights, there is a superimposed increase in intrathoracic pressure, followed by an often dramatic increase in systemic arterial pressure, with systolic pressures reaching 300 mmHg or more

Functional Outcome after Open Repair of Abdominal Aortic Aneurysm
- Operative Mortality 4% (154 pts.)
- Mean LOS 10.7 days
- ICU LOS 4.6 days
- Ambulatory Post-op 64% (25 mos.)
- Decreased Functionality 33%
- Time to Recovery 3.9 mos.
- Unrecovered 33%
- Again? 18% - No

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J Vasc Surg 2001;33:913-20
EVAR for AAA > 5 cm
- Reduces 30 day aneurysm related mortality
- Lower length of stay
- Surgical benefits from less morbid procedure
- Long term benefits are less clear
  - Continued surveillance
  - Increased re-intervention rates


TEVAR Reintervention
- 3.6 – 22%
  - From endoleaks
  - Progression of the aortic pathology

References