Cutting Edge Technology for Aortic Aneurysms

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Aortic Aneurysms
How Big is the Problem?
- 10th – 18th leading cause of death in the USA
- 2/3 of patients who suffer a ruptured aneurysm will die before even reaching the hospital.
- 90% mortality with ruptured AAA

Source: Society of Thoracic Surgeons

Normal Size of Aorta

<table>
<thead>
<tr>
<th>Size</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root</td>
<td>3.5–3.91</td>
</tr>
<tr>
<td>Ascending</td>
<td>2.86</td>
</tr>
<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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</tbody>
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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 it’s expected normal
- With gradual enlargement, the aorta becomes increasingly weakened, leading to possible dissection and rupture.

Aortic Aneurysm (AA)
- 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
Abdominal Aneurysm

Thoracic Type A Aneurysm

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 aneurysm.

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
### 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
    - Intercapsular 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

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

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.

You suspect a dissecting/rupturing aneurysm....

Now What??
Rapid Triage & Treatments
• Aortic Center Aortic Pathway
Methodist Hospital Houston, TX

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

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

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

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

**Abdominal**
- Diameter $\geq$ 5 cm
- Diameter $\leq$ 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!

- 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: Abdominal Endovascular Graft

- Synthetic, two piece bifurcated graft, that lines the aorta and extends from below the renal arteries into both the iliac arteries
- First implanted 1997
- FDA approved November 2002

Abdominal Endovascular Graft

- Gore Excluder
- 28 french

Endologix PowerLink System

- Strong, thin walled ePTFE
- One piece bifurcated stent graft
Aneurysm Before & After Endografting

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
Thoracic TAA
2003
Starting treating TAA with endografts in Peoria
2005 FDA approved
Morbidity of Open Repair

Thoracic Aorta
Abdominal Aorta

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

Approved by the FDA on March 23, 2005.

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

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: 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

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

Hybrid:
Bentall’s Procedure with TAG

TAG prior to Bentall

Bentall Ring & TAG

DISEASE REPLACEMENT

Pre TAG & Bentall

Bentall and TAG POD #2

lateral Bentall & TAG
Type A Dissection
- Immediate operating room intervention

Acute Type B dissection
- Follow-up after 4 y.

Acute Type B Complicated Dissection
- Goal is to have the true lumen re-expand 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
- If repair 3-5 days after dissection → significant re-dissection
- If wait longer than 9 days, then the true lumen may not re-expand

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

Chronic Type B Dissection
- Medical management is currently the most appropriate treatment
- Acute < 14 days

Images courtesy Rodger White, MD
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
- Caudal neck
- Femoral artery/runoff

Intravascular Ultrasound
Proximal Neck
- 1.99cm x 1.94cm
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

Postoperative Assessment, Complications & Care
- Endoleaks
- Extremity Ischemia
- Urinary Retention
- Renal Failure
- Bowel Ischemia
- Abdominal Compartment Syndroms
- Spinal Ischemia (TAA)
- Stroke
- Metabolic Acidosis
- Respiratory Complications

Endoleak
Aneurysm sac remains pressurized

Endoleak Significance
Endoleak = Endopressure ≠ Protection

Perigraft Flow/Endoleak: Definitions*
Type I
Attachment leak
Type II
Branch flow
Type III
Defect in graft or modular disconnection
Type IV
Fabric porosity

Post-operative Detection of Endoleak

Assessment of aneurysm diameter & volume
- Abdominal four view xrays 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

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)
### Bowel Ischemia
- 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)

#### 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

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

### 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 Cerebral Spinal Fluid Drain

Purpose
Prevent paraplegia

The "Zero" reference point must be positioned at the level of the catheter insertion site

Adjust drip chamber height until black level is at the proper drainage resistance. Frequently 10 cm H₂O

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

Complications of CSF Drain

- Infection
- Overdrainage
  - Subdural hematoma
  - Herniation
- Spinal cord hematoma
- Headache
- Pneumocranium (from air entering system)

Complications of 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!

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

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

What would you do?

<table>
<thead>
<tr>
<th>Patient A</th>
<th>Patient B</th>
</tr>
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<tbody>
<tr>
<td>ph</td>
<td>7.29</td>
</tr>
<tr>
<td>pCO₂</td>
<td>60</td>
</tr>
<tr>
<td>pO₂</td>
<td>132</td>
</tr>
<tr>
<td>TCO₂</td>
<td>31</td>
</tr>
<tr>
<td>O₂ %</td>
<td>98</td>
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<tr>
<td>BE</td>
<td>-1</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

References
