Splanchnic Artery Aneurysms: Diagnosis, Imaging, and Management

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Objectives

• Appreciate Incidence, Risk Factors, and Variations in Presentation
• Imaging Studies
  – Cross-Sectional
  – Angiography
• Outline the Management Strategies
  – Surgical
  – Non-surgical
  – Emerging
• Case Presentation(s)
• Questions/Discussion
FIGURE 1. Distribution of splanchnic artery aneurysms (AA). Prevalence (percentage of all splanchnic artery aneurysms) and sites of splanchnic artery aneurysms are indicated.
Visceral Artery Aneurysms (VAAs)

- Incidence: 0.1-10%
- Most are asymptomatic
- 22% present as emergencies
  - GIB
  - Rupture
- Mortality after rupture
  - Variable & dependent on location
Splenic

- 60% of VAAs
- Most are Asymptomatic
  - Incidental findings in <1% of angiographic studies
  - Multiple in 20%
- Males 4x>Females
- Risk Factors
  - FMD
  - Portal HTN
  - Pregnancy → 40% with >6 gestations (Mean 4.5)
  - Atherosclerosis
  - Liver Transplant
- Etiology
  - Trauma
  - Pancreatitis
  - Collagen Vascular Disease
  - NF
- 72% True aneurysms
  - Saccular>Fusiform
  - Occur at bifurcations
- Risk for rupture = 2%
- Mortality
  - Maternal = 70%
  - Fetal = 75-95%
  - Surgical = 40%
Splenic

• Presentation
  – Asymptomatic
  – Abdominal pain
    • To shoulder
  – “Double Rupture”
    • Lesser sac with progression to the Greater sac

• Recommendations for treatment
  – >2cm
  – Enlarging
  – Symptomatic
  – Child-bearing age
Splenic

• Treatment
  – Proximal or Mid
    • Ligation (surgical or endovascular)
    • Stent-graft
    • Coiling
  – Distal/Hilus
    • Surgical ligation with splenectomy
Hepatic

• 20% of VAAs
• 6\textsuperscript{th} decade
• Males 2x> Females
• Etiology
  – Atherosclerosis (1/3)
  – Medial degeneration (24%)
  – Trauma (22%)
  – Mycotic
    • Txplant, IVDU, endocarditis
  – PAN

• Usually Solitary
  – 80% extrahepatic
  – 20% intrahepatic
• 50% False
  – True 4x>False when extrahepatic (CHA)
• Fusiform @ <2cm; Saccular @ >2cm
• Risk for rupture = 20-30%
  – Mortality = 35%
Hepatic

- **Presentation**
  - Majority asymptomatic
  - RUQ pain + obstructive jaundice + hemobilia

- **Treatments**
  - Prox to GDA = aneurysmectomy/ligation (i.e. in CHA)
  - Distal to GDA = revascularization (graft/EEA)
  - Intrahepatic = surgery with possible hepatectomy OR endovascular (coils/particles)
Celiac

- 4% of all VAAs
- No sex predilection
- Etiology
  - Medial degeneration
  - Atherosclerosis
  - Trauma
  - TB/Syphilis
- Associations
  - 18-67% with peripheral arterial aneurysms
- Risk of rupture = 13%
  - Mortality = 50%
- Treatment
  - Aneurysmectomy with vascular reconstruction (bypass or reimplantation)
  - Coils, stent-grafts
Superior Mesenteric

- 5.5% of VAAs
- 90% symptomatic
  - Thromboembolic intestinal angina
- No sex predilection
- Etiology
  - Infection (>50%)
  - Medial degeneration
  - Atherosclerosis
  - Trauma

- 50% present with rupture
  - 35-50% mortality
- Treatment
  - Ligation with EEA, bypass, or reimplantation
  - Stent-graft
PDA/GDA

- PDA 2%; GDA 1.5% of VAAs
- Males 4x> Females
- Etiology
  - Pancreatitis
    - 60% of GDA
    - 30% of PDA
  - Trauma
    - “Friend”-ogenic
    - Iatrogenic
- Associations
  - Celiac artery stenosis
- Risk of rupture
  - Inflammatory = 75%
  - Non-inflammatory = 50%
  - Mortality = 21-50%
- Presentation
  - Hemobilia
  - Hemosuccus pancreaticus
  - “Sentinel bleed” from drain s/p Whipple.
PDA/GDA

• **Treatment**
  – Ligation proximal and distal
  – Embolization
    • Less durable
  – Stent-graft
Imaging

- **US**
  - Screening exam
    - Hepatic transplant
    - Splenic artery
  - Operator dependent
  - Interpretation dependent
  - Body habitus dependent
  - Most often followed by CT or MRI
    - Confirmation
    - Anatomic delineation
  - Findings
    - Vessel wall thickening
    - Aliasing
    - “Yin-Yang” ➔ swirling

*Fig. 1. Celiac artery aneurysm – color mode examination by visualizing the turbulences inside the vascular dilatation (by courtesy N. Rednic, CFR Universitary Hospital Cluj Napoca).*
MRI/MRA

- MRI
  - Multiplanar capability
  - Contrast enhanced modality of choice
    - ??NSF??
  - Limited by devices
    - Pacers, etc.
  - Susceptibility artifact
  - Motion artifact
    - Not useful in the acutely ill pt
    - Observation patients likely the best candidates.
  - Lesser resolution than DSA and CTA both
CT Angiography

- CTA
  - Sub-mm data acquisition
  - Isotropic data sets
  - Radiation
  - Contrast mandatory

- Sample Protocol
  - Single breath hold
    - Dome of diaphragm to Ischial tuberosities
  - 120cc contrast @3-5cc/s
    - Arterial = 30s; Venous = 60-80s
  - Collimation = 0.6mm
    - 0.5mm reconstruction intervals
  - MIP and 3D-VR
    - Intervention/surgical planning

- Vascular evaluation
  - Sagittal plane for origins
  - Coronal and (multiple) Oblique Coronal for course of vessels.
Pulli et al. 2008 (Italy)

- Retrospective (N = 55)
- Pro-operative
  - demographics
  - risk factors
  - comorbidities
  - anatomy
- Work-up = CT and/or DSA
- Surgery
  - approach
  - type of reconstruction
  - associated procedures
- Post-operative
  - outcome
  - complications
  - imaging

- Diagnosis
  - Incidental = 94.6%
  - Palpable Mass = 1.8%
  - Acute Abdomen or Hypotension or Decrease H&H = 3.6%

## Results

### Table. Intraoperative data and early results

<table>
<thead>
<tr>
<th>Site</th>
<th>No. of lesions</th>
<th>Kind of intervention</th>
<th>Perioperative mortality</th>
<th>Perioperative major complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splenic artery</td>
<td>30</td>
<td>Resection with end-to-end anastomosis (22)</td>
<td>1 (3.3%)</td>
<td>2 (6.6%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Splenectomy and ligature (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aneurysmorrhaphy (1)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Partial resection with arterial ligature (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Endovascular exclusion (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal artery</td>
<td>9</td>
<td>Aortorenal bypass (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resection with end-to-end anastomosis (3)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Resection and patch closure (1)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Aneurysmorrhaphy (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatic artery</td>
<td>7</td>
<td>Aneurysmectomy and primary closure (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aneurysmectomy and arterial ligation (2)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Aneurysmectomy and patch closure (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aneurysmorrhaphy (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celiac trunk and mesenteric arteries</td>
<td>6</td>
<td>Resection and tube graft (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aneurysmectomy and primary closure (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aneurysmectomy and patch closure (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripancreatic arteries</td>
<td>5</td>
<td>Aneurysmectomy with end-to-end anastomosis (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastric and bowel arteries</td>
<td>2</td>
<td>Aneurysmectomy and patch closure (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aneurysmectomy and primary closure (1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Due to distal location

All with concurrent AAA

Involved Pancreas and Giant (>6cm)

Pancreatitis and Death

**Results**

Overall 30-day mortality = 1.8%
Overall 30-day morbidity = 5.4%

Follow-up
- 6 deaths (no aneurysm related)
- mean f/u of 82 months

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**Fig 5.** Long-term survival (Kaplan-Meier curve with number of patients at risk and SE values).

**Fig 6.** Long-term, aneurysm-related, complication-free survival (Kaplan-Meier curve with number of patients at risk and SE values).

Recommendations

• Renal Artery
  – Saccular & prox = aneurysmectomy w/ patch OR end-to-end anastamosis (EEA)
  – Saccular & mid/distal = prosthetic bypass graft
• Splenic Artery
  – Old school = splenectomy
  – Saccular prox/mid = aneurysmectomy with EEA, OR splenic artery ligation
  – Hilar/parenchymal = splenectomy not avoidable
• Hepatic Artery
  – Proximal to GDA = ligation
  – Distal to GDA = bypass or aneurysmectomy with EEA
  – Intraparenchymal = may require resection
• Celiac/Mesenteric
  – Aneurysmectomy with patch or EEA
  – Bypass graft
  – Coils or stent-grafts
• GDA/PDA
  – Ligation
  – Aneurysmectomy with EEA
• Stent-grafts = specifically in cases of adjacent organ involvement

Ikeda et al. (Japan)

- Retrospective: N = 22 (4/02 – 5/07)
  - True aneurysms only (PSA excluded)
  - Unruptured only
- Imaging = 16-MDCT @ 3cc/s; 1.5mm collimation

Table II. Indication of transcatheter coil embolization for visceral artery aneurysms

<table>
<thead>
<tr>
<th>Site of aneurysm</th>
<th>Factors for treatment indication</th>
<th>Treatment is indicated if</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splenic artery aneurysm</td>
<td>(1) More than 3 cm in size</td>
<td>Present three factors from (1) to (3) or present (4) and two factors from (1) to (3)</td>
</tr>
<tr>
<td></td>
<td>(2) No calcification in an aneurysmal wall</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3) No intracavitary thrombus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4) With chronic liver disease</td>
<td></td>
</tr>
<tr>
<td>Renal artery aneurysm</td>
<td>(1) More than 1.5 cm in size</td>
<td>Present three factors from (1) to (3) or present (4) and two factors from (1) to (3)</td>
</tr>
<tr>
<td></td>
<td>(2) No calcification in an aneurysmal wall</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3) No intracavitary thrombus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4) With hypertension, steroid treatment, or pregnancy</td>
<td></td>
</tr>
<tr>
<td>Proper hepatic artery aneurysm</td>
<td>(1) More than 2 cm in size</td>
<td>Present all three factors</td>
</tr>
<tr>
<td></td>
<td>(2) No calcification in an aneurysmal wall</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3) No intracavitary thrombus</td>
<td></td>
</tr>
<tr>
<td>Pancreaticoduodenal arcade aneurysm</td>
<td>Any pancreaticoduodenal arcade aneurysms require treatments</td>
<td></td>
</tr>
</tbody>
</table>

Ikeda et al.

- **Angio**
  - Confirmed collateral flow with occlusion balloon
  - Coils = 3D GDC and IDC

- **Technical Success**
  - No flow post-embolization AND
  - No flow @ 1wk MRA AND
  - Patent native vessel flow

- **Complications**
  - End-organ infarct regardless of presence/absence of symptoms
Results

- Technical Success = 72.7%
- Complications
  (all due to coil migration)
  - Renal infarct (n=2)
  - Splenic infarct (n=1)
- Recommendations
  - Saccular = packing to preserve native flow
  - Fusiform = proximal and distal coils

Stent-Grafts: Rossi et al. (Italy)

- Rossi et al. (Italy)
  - N=4 (3 splenic; 1 hepatic)
  - Work-up
    - MDCT with MPR & 3D-VR
  - Post-procedure
    - ASA 300mg PO QD

- Results
  - All excluded
    - Patent and excluded to 24 mos
  - Cx: splenic infarct (n=1)
  - 1 death (pancreatitis/sepsis)

- Findings
  - Predictors of rupture
    - No calcification, young age, and no beta-blockers

- Notes
  - Need stable carrier system
  - Flexible stent-graft
  - Precision of deployment

Rossi et al. Cardiovasc Intervent Radiol 2008;31:36-42
Endovascular Strategies: Tulsysan et al. (CCF)

• Retrospective: N=90
  – Endovascular (48) & Operative (42)
    • Excluded those with associated AAA
  – True and Pseudo-aneurysm
    • 30% and 89% symptomatic respectively
  – Imaging: CT, MR, and/or US
  – Embolization techniques
    • Coils (81.3%) + n-BCA (4.2%) + both (15%)
    • Stents → excluding coil pack (n=2); dissection (n=1)
    • Technical success
      – Deployed, excluded, cessation of bleed, flow maintained
  – Imaging Artifacts on f/u
    • CT/MR
      – I = no scatter
      – II = moderate scatter beyond intervention site
      – III = severe
Results

- **Endovascular**
  - 98% technical success
  - 8.3% 30 day mortality
  - 40% end-organ infarct (n=6)
    - No infectious or hematological sequelae

Table II. Distribution of elective and urgent interventions for visceral artery aneurysms and pseudoaneurysms with associated perioperative results

<table>
<thead>
<tr>
<th>Arterial bed</th>
<th>Urgent vs elective</th>
<th>No.</th>
<th>Mean size (mm)</th>
<th>Technical success (%)</th>
<th>30-day mortality (%)</th>
<th>End-organ ischemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splenic</td>
<td>Urgent</td>
<td>3</td>
<td>63</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>17</td>
<td>28</td>
<td>100</td>
<td>0</td>
<td>5 (29)</td>
</tr>
<tr>
<td>Celiac axis branches*</td>
<td>Urgent</td>
<td>9</td>
<td>22</td>
<td>100</td>
<td>2 (22)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>5</td>
<td>32</td>
<td>80</td>
<td>0</td>
<td>1 (20)</td>
</tr>
<tr>
<td>SMA</td>
<td>Urgent</td>
<td>1</td>
<td>20</td>
<td>100</td>
<td>1 (100)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>1</td>
<td>22</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hepatic</td>
<td>Urgent</td>
<td>9</td>
<td>16</td>
<td>100</td>
<td>1 (11)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>3</td>
<td>53</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Except splenic/hepatic.

Tulsyan et al. (J Vasc Surg 2007;45:276-83)
• Imaging Artifact
  – CT
    • Grade I (n=5/33)
    • Grade II (n=11/33)
    • Grade III (n=17/33)
  – MR
    • Grade I (n=1)
    • Grade II (n=2)

Tulsyan et al. (J Vasc Surg 2007;45:276-83)
Endovascular Therapy: The NYU Experience (Saltzberg et al.)

- **Study Design**
  - Retrospective (1990-2003): N = 65
    - Observation
    - Endovascular
    - Surgical
  - Work-up
    - CT or MRA
    - DSA @ time of therapy
  - Outcomes
    - Technical success
    - M&M
- **Procedures**
  - Surg: 2 aneurysmectomy + 6 ligations
  - Endo: 15 coils + 3 stent-grafts

Results
- 16.9% symptomatic
  - 36.4% of these ruptured
- Mean diameter
  - Obs = 2.01cm
  - Surg = 5.52cm
  - Endo = 3.17cm
- Outcomes
  - Technical Success
    - 94% endovascular
  - Mortality
    - Surgery = 1 death
      **Old and Ruptured**
    - Endovascular = 0 deaths
    - Obs = no known deaths or ruptures
  - Complications
    - Splenic infarct (n=4)
• Recommendations
  – Size guidelines as previously described
  – Splenic lesions
    • Distal = surgery
    • All others = endovascular
  – Follow-up
    • Stent-graft = 1 & 6 mos, then annually
    • Coils = 6mos, then annually
Surgery v. Endovascular (Sachdev et al. NYC)

• Premise
  – Surgery remains gold standard therapy
  – Long-term durability and secondary procedure rate are not known for endovascular procedure

• Study Design
    • True and PSA included
    • Endovascular (n=35); Surgical (n=24)

Table III. Location and classification of aneurysms treated by either endovascular or open techniques

<table>
<thead>
<tr>
<th>Aneurysm*</th>
<th>Endovascular (n = 35)</th>
<th>Open (n = 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splenic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>True</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Pseudo</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Hepatic*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>True</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Pseudo</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Celiac trunk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>True</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Pseudo</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Gastroduodenal</td>
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<td>True</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pseudo</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Superior mesenteric artery</td>
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<td></td>
</tr>
<tr>
<td>True</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pseudo</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Pancreaticoduodenal artery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>True</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pseudo</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

*The P values for these aneurysms were not significant except for hepatic (P = .002).
Head to Head

• Results
  – Mean size
    • Endovascular = 3.28cm
    • Surgical = 4.35cm
  – No difference in presentation
  – Length of stay
    • Endovascular = 2.4d +/- 1.6
    • Surgical = 6.6d +/- 4.7
  – No difference in mortality, complications, or re-intervention rate
  – PSA more likely to treat endovascular
  – Primary treatment success = 89% in endovascular group
    • All 2nd attempts were successfully embolized

Table V. Complications, reinterventions, and 30-day mortality after open or endovascular repair of aneurysms involving branches of the celiac and superior mesenteric arteries*

<table>
<thead>
<tr>
<th></th>
<th>Endovascular (n = 35)</th>
<th>Open (n = 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Reinterventions</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Deaths ≤30 days</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

*The P values for these data are not significant.

Sachdev et al. (J Vasc Surg 2006;44:718-24)
Conclusions
- Hemodynamic status does NOT preclude endovascular treatment
- Endovascular treatment likely results in shorter admission
- Surgery may not be needed in the setting of endovascular failures
Summary

• Visceral artery aneurysms are likely more common than the current literature suggests
• Given the vague presentation, diagnosis may be delayed and mortality rates remain high
• US is a good screening tool, but CT/MR are the workhorse of diagnosis, monitoring, and procedural planning
• Treatment in asymptomatic patients is driven by frequent imaging evaluation.
• Surgery remains the gold standard in definitive treatment, but established and emerging endovascular techniques are now considered part of 1st line therapy, even in the unstable patient.
Case #1

• History
  – 37 y.o. AAF with 10 year history of intermittent abdominal pain. Pain is variable, including diffuse to “band-like” across the upper abdomen. Associated nausea at times is relieved by eructation.
• **Splenomesenteric Trunk**
  – <1% of all patients
  – Aneurysms very rare
  – Up to date, all but 2 (known) have been treated surgically (1st in 1966)

#1 = **Splenic Artery Aneurysm of the Anomalous Splenomesenteric Trunk: Successful Treatment by Transcatheter Embolization Using Detachable Coils**

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#2 = Case #1 above
References

Fin