VISCERAL ANEURYSM MANAGEMENT
WHICH ENDOVASCULAR OPTION?

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Conflict of Interest

- NONE
Splanchnic Artery Aneurysms

- Uncommon, but clinically important.
- 22% present emergently, with an overall mortality of 8.5%.
- Incidence is increasing as imaging improves, but distribution is constant.
- One-third will have associated non-visceral aneurysms as well—such as aortic, renal, iliac, lower extremity, and cerebral.

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RHA Right hepatic artery
LHA Left hepatic artery
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Splenic Artery Aneurysms
Four Segments: Suprapancreatic; Pancreatic; Prepancreatic; Prehilar:
The splenic artery divided into two or three lobar arteries, which supplied it corresponding lobe; Each lobar artery subsequently divided into two to four lobular
Splenic Aneurysms: Risk Factors

- **Fibromuscular Dysplasia:**
  - Those with renal dysplasia are 6x more likely to have splenic aneurysm.

- **Portal Hypertension with Splenomegaly:**
  - Splenic Aneurysms found in 10-30% of patients.
  - Often multiple aneurysms.

- **Multiple Pregnancies:**
  - 40-45% of female patients in case series were grand multiparous
  - Thought to be secondary to both hormonal effects and increased splenic arteriovenous shunting during pregnancy.

- **Other:**
  - Nearby inflammation: e.g. chronic pancreatitis -> false aneurysms.
  - Mycotic aneurysms from endocarditis from IVDA.
  - Trauma.
Splenic Aneurysm: Treatment Indications

- **Indications for Treatment:**
  - Symptomatic Aneurysms
  - Aneurysms > 2 cm.
  - Pregnant patients or those who want to conceive:
    - Maternal mortality post rupture –70%, fetus- 75%.

- **Not associated with increased risk for rupture:**
  - Calcifications
  - Age >60
  - Hypertension.
Splenic Aneurysms: Treatment Options

- Aneurysmectomy, Aneursymorrhaphy, Simple ligation-exclusion without arterial reconstruction. Restoration of splenic artery continuity is rarely indicated.
- Endovascular Coiling—still with unsure failure rates, risk of splenic infarction.
- Stent Grafting—rare when splenic flow is needed for other therapeutic reason like mesocaval shunting.
33 YEAR-OLD PATIENT WITH MULTIPLE SPLENIC ANEURYSM

- HPC:
  - 33 year old female in 3\textsuperscript{rd} trimester of pregnancy
  - Initially presented to GP with hoarse voice
    - Pregnancy otherwise uncomplicated
  - Referred to ENT for further investigation
    - Paralysed vocal cord
    - CT scan post-delivery (base of skull)
      - Incidental finding of large splenic artery aneurysms
  - Asymptomatic
- Asthma as a child
- G2P2
  - 3 years and 4 month old
  - Vaginal deliveries
  - Normal pregnancy
    - Back pain
- Ex-smoker
- Occasional ETOH
CT angiogram: Coronal section visualising multiple splenic artery aneurysms

Three aneurysms seen on the distal splenic artery. Largest measuring approximately 25mm in diameter
HEPATIC ARTERY ANEURYSM
INCIDENCE

- 20% of splanchnic aneurysms.
- 1/3 associated with splenic aneurysms.
- Male: Female 2:1.
- Most common in patients in their 50s.
- Normally solitary
- Average >3.5 cm. Those >2cm tend to be saccular.
- 80% Extrahepatic, 20% intrahepatic.
  - Common hepatic: 63%
  - Right hepatic: 28%
  - Left Hepatic 5%
  - Right and Left hepatic: 4%.
Hepatic Aneurysms: Treatment

- Common Hepatic Artery:
  - Extensive collaterals allow aneurysmectomy or exclusion without reconstruction.
  - However, 5 minute occlusion trial recommended to confirm flow to prevent necrosis.
  - Those with already existing parenchymal disease may need reconstruction.
Aneurysm $\geq 5\text{cm}$ present a much larger risk of rupture and treatment is imperative.

They are challenging to treat secondary to the often grossly distorted anatomy and the operative approach needs to be tailor-made to the patients.

Endoluminal approaches with its reduced morbidity compared to previous open surgical options have increasingly become the treatment of choice.
A 75-year-old lady presented to our emergency department following concerns from her family physician following an incidental discovery of a 6.7cm mass on non-contrast CT during a routine investigation for a suspected diagnosis of sciatica.

Her co-mobidities were limited only to hypertension which was well controlled.

A CT angiogram revealed a 6.8x7.2 cm aneurysm arising from the common hepatic artery (figure 1). No outflow vessels could be visualised (figure 2). Furthermore small aneurysms of less than 2 cm were demonstrated at the origin of the celiac axis, splenic, superior mesenteric and right renal arteries (figure 3).
Initial coronal CT images of the giant hepatic artery aneurysm and the intra-mural thrombus.

Transverse CT image with mural thrombus illustrated within the common hepatic aneurysm.
Intra-operative access to hepatic artery aneurysm via the right common femoral artery and left brachial artery b) Guidewire into aneurysm neck via the left brachial artery (top down approach) c) Insertion of Hydrocoils and Framing coils into the aneurysm and around the intra-mural thrombus d) Insertion of Pushable Helical coils into the aneurysm neck
Coronal CT view of hepatic artery aneurysm day 2 after coil embolisation c) 3D CT image showing no distal flow d) Transverse CT view with coils in-situ
• Via a 5Fr puncture in the right groin a pigtail catheter was placed above the celiac axis for continuous imaging.

• A left brachial access was used to get access to the CA, using a triaxial system. Using a 6F reinforced Terumo Destination sheath (65 cm).

• A selective angiogram of the HAA was performed with a Hinck catheter, then exchange to a Glidecath 100 cm. No direct arterial outflow from the aneurysm into the liver was visualised.

• Only a moderate size gastroduodenal artery (GDA) could be demonstrated. It was assumed that the main blood supply was maintained via the portal vein and it was deemed safe to coil embolise the aneurysm. A 100 cm Glidecath® was introduced into the aneurysm and guided into the proximal GDA.
• To achieve precise coil placement 3 AZUR® helical HydroCoils® (4mm/10cm) were deployed in the GDA. After successful embolization of the GDA the HAA itself was coiled with multiple AZUR® detachable Framing Coils (from 14 mm/34cm to 20 mm/50 cm) as well as larger size AZUR® helical HydroCoils® (from 6mm/20 cm to 10 mm/20 cm),

• The completion angiogram showed complete occlusion of the aneurysm with satisfactory position of the framing coils within the aneurysmal sac.

• The splenic and the left gastric arteries remained patent.
Before attempting any form of treatment, it is mandatory to attain proper stability of the vascular access platform. Whichever exclusion method is chosen, the use of a triaxial system is recommended. The setting should comprise a reinforced vascular sheath (65–70 cm), a 6-F guiding or 5-F diagnostic angled catheter, and a microcatheter. Before treatment, the sheath should be introduced into the parent artery for good intraprocedural angiographic control. If this cannot be achieved on a support guidewire, the balloon technique can be used in which a balloon is inflated in the major parent artery and deflated while introducing the sheath, allowing it to easily slide into the vessel.
The splanchnic vascular bed, because of the numerous redundancy arches, often allows for the liberal use of trapping to exclude the aneurysm from circulation. One of the most common settings where aneurysm exclusion by isolation is performed is in pseudoaneurysms of the gastroduodenal or pancreaticoduodenal arch, which are supplied by both the celiac axis and the SMA. A similar approach can be used while excluding aneurysms of the proximal celiac axis or SMA (vice versa connected through the gastroduodenal artery and pancreaticoduodenal arch) and the splenic artery (the spleen after proximal exclusion remains supplied by blood via the short gastric and gastroepiploic artery).

In order to achieve aneurysm exclusion, it is necessary to effectively terminate both afferent and efferent vessels. Exclusion balloons may be used when coiling a vessel in a high-flow vascular bed to lower the blood pressure and ensure proper deployment of all necessary coils.
Fusiform or saccular true aneurysms, which occur at main branches in easily accessible locations, may be treated by implanting a balloon-expandable covered stent (such as the Atrium V12 covered stent, Maquet Vascular Systems, Hudson, NH), or self-expandable stents (such as the Viabahn device, Gore & Associates, Flagstaff, AZ; Fluency device, Bard Peripheral Vascular, Inc., Tempe, AZ; or Wallgraft device, Boston Scientific Corporation, Natick, MA). Most of these systems run on a 0.035-inch platform and unfortunately are fairly rigid, making them difficult to use in visceral vessels with tortuous access. A fairly recent development is the introduction of the 0.014-inch Atrium V12 RX covered stent and the 0.014- and 0.018-inch Viabahn covered stents (although market availability may vary), which in some cases, can overcome this disadvantage.
Aneurysms with a narrow neck can usually be approached with the isolation and packing technique. Currently, there are numerous peripheral detachable coils available that make the approach much easier and the procedure safer, such as the PGLA- or nylon-coated Concerto coil (Covidien, Mansfield, MA) the Azur Ruby detachable coils (Penumbra, Inc., Alameda, CA). In cases of a wide aneurysm neck, a similar technique to the one employed in neurovascular interventions can be used in which the neck can be supported by the use of a wide, open-cell, self-expandable stent. A neurovascular stent can be adapted for this purpose (such as the Solitaire stent, Covidien), but in most cases, a viable, although off-label, option is the Xpert stent (Abbott Vascular, Santa Clara, CA). After securing the neck, the aneurysm can then be coiled with either a microcatheter that was previously trapped under the stent or by placing the catheter through the stent cells.
In the case of complex aneurysms involving arterial bifurcations, another neurovascular technique (eg, Y-configured double-stent-assisted coil embolization) can be used. In such cases, two stents are inserted into the major branches of the bifurcation, with the aneurysms packed afterward with detachable coils (Figure 1).

Whichever packing method is chosen, it is necessary to use an appropriate packing density to prevent aneurysm recurrence on follow-up.⁷

The latest technology in the field of aneurysm exclusion is multilayered stents (flow diverters). These stents are placed in the aneurysm neck and keep the aneurysm sac from filling with blood. Although their use is still to be proven in the peripheral vascular system, the decrease in laminar blood flow in the aneurysm sac is thought to minimize the chances of aneurysm rupture. The technology has future prospects that still remain to be validated, as the current literature is limited to a few case reports and short series. Unfortunately, the only currently ongoing clinical trial for multilayered stents in the periphery only enrolls patients with thoracoabdominal aneurysms.
The Cardiatis stent: a new device for endovascular treatment of peripheral or visceral aneurysms.
Preliminary experience in Italy

Claudio Rabbia
Most common treatment options for peripheral or visceral aneurysms

Common iliac artery aneurysm exclusion by graft and internal iliac artery embolization with coils

Splenic artery embolization with coils
Limitations of current technology

- Using coils, artery has to be occluded
- Coil packaging (with or w/o stent) is preferred only for small aneurysms and tight necks
- Using stent-graft, side branches have to be occluded
- Some stent graft has a limited flexibility
- Bifurcated grafts have limited indications
A theoretical new option

Cardiatis Multilayer Stent is a self-expandable device with a tridimensional mesh made of metallic cobalt alloy wires interconnected in multiple layers: this structure allows the mesh layers number to adapt to diameter, morphology, dimension and course of the target artery.

The delivery consists of a guided-catheter with a minimally traumatic soft tip 0.018” (maximum 0.025”) compatible.

The sheath is connected by a hemostatic Y valve to the delivery: when the valve is closed, the sheath is fixed to the support, as a safety lock.
Key principles

- Vortex velocity control in aneurysm
  - Saccular Aneurysm With & W/O branch
  - Fusiform Aneurysm
- Laminates the flow in collaterals arising from aneurysm
- Maintains patency of side branches
Side branches arising from aneurysm

Flow Recirculation

Without Stent

Flow channeled to the branch

With Multilayer Stent
Splenic artery aneurysm

Cardiatis stent 7X60 mm
Common hepatic artery complex aneurysm

Left hepatic artery originating from the aneurysm

Left gastric artery not involved but originating close to the sac

Gastroduodenal artery originating from the sac

Too short proximal neck

Right hepatic artery originating from the sac

Courtesy of A Balderi and M Grosso, Cuneo
Complete sac thrombosis
Splenic artery bridged and patent
Right hepatic artery patent
Left hepatic artery bridged and patent
Gastroduodenal artery bridged and patent

CT 1 mo.

Courtesy of A Balderi and M Grosso, Cuneo
Technical issues

- Stent shortening is sometimes unpredictable
- Stent should be delivered through a flexible (hydrophilic) guiding catheter advanced distally to the lesion, than pulled back before stent deployment
- Overlapping should be done distal-to-proximal
- Sac thrombosis does not usually occur immediately
Final comments

- Multilayer stent may represent an alternative to current tools for the treatment of peripheral and visceral aneurysms
- Theoretical basic principles of the device are very attractive but..
- .. must be tested in a clinical setting
- Preliminary results are satisfactory
- Larger experience and long term follow-up are needed
Superior Mesenteric Artery Aneurysms

- 5.5% of all splanchnic aneurysms.
- Affects men and women equally.
- Affects the first 5cm of the SMA.
- Most often infectious in etiology: Nonhemolytic Strep- related to Left sided endocarditis.
- Dissecting aneurysms are rare, but more common than in other visceral aneurysms.
- Trauma- rare cause.
SMA Aneurysm: Presentation

- Most are symptomatic
- Intermittent upper abdominal pain progressing to constant epigastric pain.
- Half of patients have a tender pulsatile mass that is not rigidly fixed.
- Dissection or propagation can cause intestinal angina.
- 40% Rupture rate.
SMA Aneurysm: Treatment

- Aneursymorrhaphy or simple ligation without reconstruction is acceptable, but try temporary occlusion of SMA with assessment of bowel viability.
- Aneursymectomy hazardous secondary to surrounding SMV and pancreas.
- Distal lesions through transmesenteric route. Proximal lesions visualized through retroperitoneal.
- Interpostition graft or aortomesenteric bypass after exclusion is rarely accomplished/done.
- Transcatheter occlusion used, but stent-grafts generally not favored secondary to high infectious etiology percentage.
Drawing illustrates how coils are placed distal and then proximal to the aneurysm, thereby trapping the aneurysm and isolating it from the circulation, with resultant thrombosis of the aneurysm.

Nosher J L et al. Radiographics 2006;26:1687-1704
Drawing illustrates how large particles or small coils are used to occlude outflow from the aneurysm, followed by placement of coils proximal to the aneurysm, again trapping the aneurysm, with resultant thrombosis.

Nosher J L et al. Radiographics 2006;26:1687-1704

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Drawing illustrates a PHA aneurysm with inflow from the CHA and out-flow from the gastroduodenal artery and distal PHA. To preserve flow to the liver, a covered stent is placed across the aneurysm.
Surgical and endovascular treatment of VAA share the common goal of preventing aneurysm expansion and rupture. This goal is best accomplished by excluding the aneurysm from the arterial circulation and pressure. In the presence of adequate collateral flow, surgical management consists of ligation of the parent artery proximal and distal to the aneurysm. This approach is appropriate for splenic artery aneurysms (SAAs) with collateral flow from the short gastric arteries and gastroepiploic arteries to the distal splenic artery and spleen (1). The celiac trunk, proximal SMA, and common hepatic artery (CHA) may also be ligated, with collateral flow provided by the pancreaticoduodenal and gastroduodenal arteries. For a proper hepatic artery (PHA) and a main renal artery (MRA) that lack collateral flow, and for celiac arteries and SMAs with inadequate collateral flow, ligation must be accompanied by arterial bypass surgery.
Endovascular management should also achieve isolation of the aneurysm from the arterial circulation. This isolation can be accomplished in several ways. For aneurysms involving large arteries (eg, the splenic artery), the aneurysm can be “trapped” between coils placed in the parent artery distal and then proximal to the aneurysm, thereby eliminating both prograde flow and the potential for retrograde flow to the aneurysm (Figs 1, 2). For aneurysms involving smaller arteries, the distal parent artery or its branches can be occluded with large particles, followed by coil placement in the larger proximal parent artery, again trapping the aneurysm and isolating it from the circulation
39-year-old man with intense pressure abdominal pain. Abdominal aortogram shows large pseudoaneurysm of superior mesenteric artery (SMA).
39-year-old man with intense pressure abdominal pain. Oblique selective SMA angiogram shows marked anterior SMA deviation and contrast agent jet (arrow) into pseudoaneurysm cavity
39-year-old man with intense pressure abdominal pain. Selective angiogram obtained after stent-graft implantation (arrowheads) shows two SMA branches (ileojejunal and ileocolic) occluded proximally.
Flow diverter stents in the treatment of intracranial aneurysms: Where are we?

**Conceptual basis**

Flow redirection: the flow diverter crosses the aneurysm neck and diverts the blood flow from the aneurysm sac, thus reducing shear stress on the aneurysm wall and promoting intra-aneurysm flow stasis and thrombosis. This phenomenon is affected by the amount of metal surface area coverage provided by the stent. The pore density of flow diverters, rather than porosity, seems to be a critical factor modulating device efficacy [
tissue overgrowth: the flow diverter provides a scaffolding for the development of endothelial and neointimal tissue across the aneurysm neck. As with flow direction, the magnitude of this effect is proportional to the amount of metal surface area coverage. It also depends on the structure and composition of the stent material.
The precise indications of flow diversion are not yet precisely established. In the series published in the literature, flow diversers were mainly used in the series already published in the literature in large and giant aneurysms, wide neck aneurysms, and recurrent aneurysms. A small series has suggested the value of flow diversion treatment in very small aneurysms untreatable by standard coiling technique [23Kulcsar Z, Wetzel SG, Augsburger L, Gruber A, Wanke I, Rüfenacht D. Effect of flow diversion treatment on very small ruptured aneurysms. Neurosurgery 2010;67:789–93.

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