

Managing Visceral Artery Aneurysms

Current endovascular techniques and technologies for treating this increasingly encountered presentation.

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Previously considered uncommon, visceral artery aneurysms (VAAs) are now more often diagnosed due to the increased use of cross-sectional imaging and an aging population. The reported incidence is approximately 0.01% to 2% in autopsy and angiographic studies. The splenic artery is the most common site of VAA (60%) followed by the hepatic artery (20%), gastroduodenal and pancreaticoduodenal arteries (6%), superior mesenteric artery (SMA; 5.5%), and celiac artery (4%).¹⁻⁴

VAAs include true aneurysms and pseudoaneurysms. True aneurysms can be defined as the focal enlargement of the artery diameter, with integrity of all vascular layers, and are generally associated with atherosclerosis, fibromuscular dysplasia, or degenerative diseases affecting the vessel wall (eg, segmental arterial mediolysis). Although less common, congenital diseases (Ehlers-Danlos syndrome, Alagille syndrome, Marfan syndrome, and type I neurofibromatosis) can also be associated with true VAAs.

False aneurysms, on the other hand, can either be iatrogenic (after abdominal surgery or percutaneous biliary procedures) or develop on the grounds of vasculitis, trauma, or intra-abdominal inflammation (pancreatitis).

Indications for VAA treatment remain unclear, hindered by the lack of prospective studies evaluating the natural history of these lesions. Still, rupture is reported to be the main diagnostic feature in more than 20% of cases in current literature, with 8.5% of these cases resulting in death.⁵ There are no clear, evidence-based indications on when or how to treat these lesions, but the current universally accepted criteria include rapid aneurysm growth, aneurysms diameter > 2 cm, pain, and embolic or ischemic complications. Due to their specific nature, all pseudoaneurysms should be treated upon diagnosis without regard to size.

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VAAs can be treated by open surgery or endovascular treatment (EVT). Cochennec et al⁶ reported 956 cases of treated VAAs, with a mean mortality rate of 1.2% in elective treatment and 15.5% in ruptured aneurysms. In comparing EVT and open surgery, the mortality rate was equal for elective treatment; however, EVT had a lower mortality rate in ruptured aneurysms (2.7% vs 23.7%) but a higher recanalization rate (7.6%). They concluded that EVT of VAAs should be attempted as first-line treatment, especially in ruptured aneurysms, with surgery as backup. Surgical treatment strategies involve aneurysmorrhaphy, vessel ligation, or revascularization (in situ or extra-anatomical bypass).⁶

EVT TECHNIQUES

Patient selection for EVT involves aneurysm accessibility, the ability to deliver therapy, and the risk to the end organ. VAAs can either be thrombosed (isolated or isolated and packed) in the presence of collateral circulation to the end organ or excluded (using covered or multilayered stents) in cases when it is crucial for the parent artery to remain 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 hydrocoil (Terumo Interventional Systems, Somerset, NJ), the Retractable coil (Cook Medical, Bloomington, IN), and the

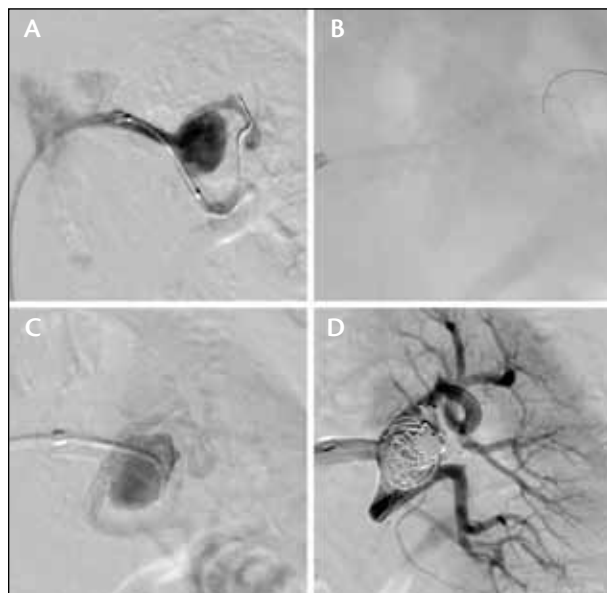


Figure 1. A Y-configured double-stent-assisted coil embolization for a renal artery aneurysm. Implantation of the first self-expandable stent (Xpert) into the lower lobe of the renal artery (A). The bifurcation of the renal artery is supported by both stents implanted in a Y-configuration (B). Cannulation of the bifurcation aneurysm (C). The aneurysm is coiled with both major branches preserved and a normal nephrogram (D).

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 specifically designed to reduce flow velocities in the aneurysm sac, promote thrombosis, and maintain flow

in the main artery and branch vessels. 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.

SPLenic ARTERY ANEURYSMS

True splenic artery aneurysms (SAAs) are the most common type of VAA, comprising approximately 60% of all VAAs. They occur more often in women than in men (male/female ratio of 1:4) and are strongly associated with multiparity. It is suggested that the combined effect of hormonal changes and a splanchnic high-flow state, which is seen during pregnancy, is responsible for alteration of arterial wall elasticity that in turn causes aneurysmal dilatation. Rupture of an SAA during pregnancy, most often seen in the third trimester, is a catastrophic event, with reported maternal and fetal mortality rates of 70% and 90%, respectively.⁸ Apart from pregnancy, SAAs also have a strong association with portal hypertension, with a prevalence of up to

10%.⁹ It is important to identify from these patients those who will undergo liver transplantation because of the high likelihood of rupture in the posttransplant period.¹⁰ On the other hand, pancreatitis and pancreatic pseudocysts are frequent causes of splenic artery pseudoaneurysms.

Current indications for treatment include symptomatic aneurysms, aneurysms > 2 cm in diameter, smaller aneurysms in women of childbearing age, and patients undergoing liver transplantation. EVT is well described, with a high technical success rate and low mortality. The choice of approach predominantly depends on the aneurysm location. The splenic artery, for this purpose, is divided between the main splenic artery, the splenic hilum, and smaller intrasplenic arteries. Generally, coil embolization (packing) of the aneurysm alone, or with stent assistance, can be used to exclude most aneurysms developing in the main artery or close to the hilar region of the spleen (Figure 2).^{11,12} At the same time, aneurysms of the proximal main splenic artery, if unsuitable for packing, can be treated by coiling the afferent and efferent segments of the splenic artery, as the short gastric and gastroepiploic arteries provide sufficient collateral flow to the spleen.¹³ There are several reports of covered stents used to treat splenic aneurysms, but this method should be reserved for proximally located aneurysms in an easily accessible, nontortuous splenic artery.¹⁴

Intrasplenic aneurysms should be embolized with coils, particulate embolics, glue, or Onyx (Covidien), with care taken not to embolize other intrasplenic arteries. Surgical treatment of SAAs, which always remains a viable option, also depends on the location of the aneurysm. Ligation, without the need for surgical bypass is preferred for aneurysms located in the proximal or middle splenic artery, and splenectomy is most often performed for hilar or intrasplenic lesions.

HEPATIC ARTERY ANEURYSMS

Hepatic artery aneurysms (HAAs) are the second most common type of VAA (20%), with nearly half of all HAAs resulting from percutaneous biliary interventions. True HAAs are more common in men than in women (male/female ratio of 3:2). Intrahepatic aneurysms are most frequently a result of iatrogenic injury or trauma, whereas extrahepatic aneurysms are usually the result of degenerative or dysplastic diseases. False anastomotic aneurysms may form after liver transplantation.

The chosen treatment strategy depends on HAA localization. Intrahepatic branch aneurysms are generally treated with coils, particular embolics, glue, or Onyx without serious regard to parenchymal ischemia because

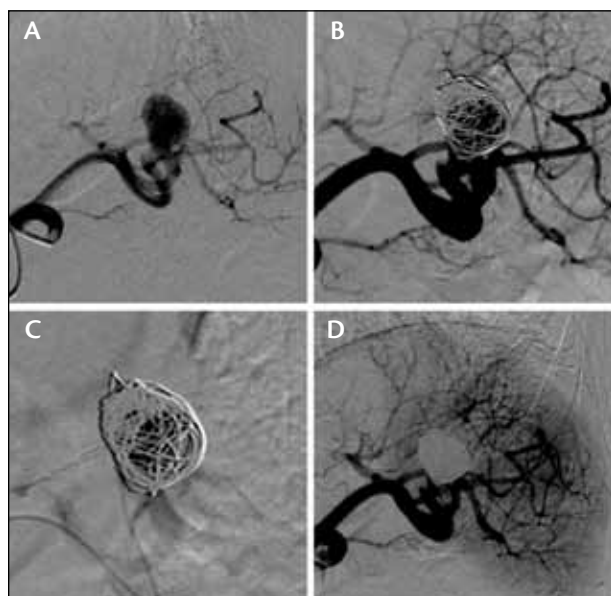


Figure 2. An SAA embolized with detachable coils and Onyx 34. An angiogram showing the location of the narrow-necked aneurysm close to the spleen hilum (A). Progressive coiling of the aneurysm with detachable coils (B). The remainder of the space between the coils is filled with Onyx to achieve a better packing density (C). A control angiogram showing complete exclusion of the aneurysm with patent intrasplenic arterial branches (D).

of the dual blood supply of the liver. Aneurysms of the common hepatic artery can usually be treated by excluding the aneurysm with proximal and distal embolization (isolation with coils), as the gastroduodenal artery will provide the hepatic artery with ample blood flow into the liver. Care should be taken to assess the patency of the SMA and the gastroduodenal artery, especially in patients who have undergone abdominal surgery. On the other hand, aneurysms of the hepatic artery or in the bifurcation of the common hepatic artery should be excluded with the aim to retain patency of the parent artery. In cases of wide-neck aneurysms, a covered stent or stent-assisted coiling may be used as deemed appropriate. The successful use of flow-diverting stents in the treatment of HAAs has been reported by Ferreo et al with preservation of all branch vessels and aneurysm exclusion; however, one stent thrombosed on follow-up, fortunately without clinical sequelae.¹⁵

GASTRODUODENAL AND PANCREATICODUODENAL ARTERY ANEURYSMS

True aneurysms of the gastroduodenal artery and pancreaticoduodenal artery are relatively uncommon (6%). They are often the result of hyperkinetic blood flow through the pancreaticoduodenal arcades in the presence of hemodynamically significant stenosis of the celiac axis. Celiac axis stenosis may be secondary to atherosclerosis or due to compression by the median arcuate ligament. Other causes of gastroduodenal artery or pancreaticoduodenal artery aneurysms include atherosclerosis, fibromuscular dysplasia, or congenital diseases. False aneurysms of the pancreaticoduodenal arcades¹⁶ are more common and are usually associated with complications of pancreatitis or previous abdominal surgery. They often rupture into the gastrointestinal tract and carry a > 50% mortality rate.¹⁷

EVT is therefore recommended, as the detection rate of pancreaticoduodenal artery aneurysms during open surgery is estimated at only 30% because of their localization behind or within the parenchyma of the pancreas, making partial pancreatectomy necessary in the majority of ruptured cases.

The best EVT technique is thought to be isolation with coils or liquid embolics such as glue or Onyx. Care should be taken to assess both the afferent and efferent arteries of the aneurysm from both the celiac axis and the SMA, as isolation from just the afferent artery may be impossible in many cases. An alternative technique, especially in the cases with pseudoaneurysms, may be embolization of the afferent artery after packing of the aneurysm.

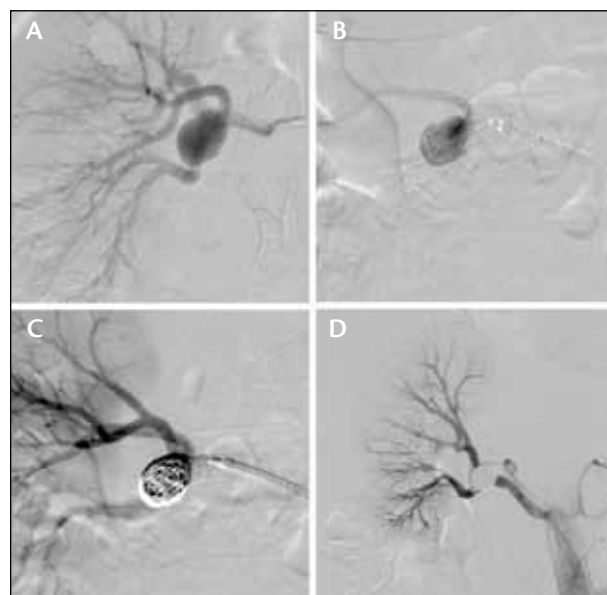


Figure 3. Stent-assisted coiling of a renal artery bifurcation aneurysm. An angiogram showing a renal artery bifurcation aneurysm (A). Implantation of a self-expandable stent to support the renal artery bifurcation (B). Progressive coiling of the renal artery aneurysm with detachable coils (C). A post-procedural angiogram showing exclusion of the renal artery aneurysm and normal nephrogram (D).

RENAL ARTERY ANEURYSMS

Renal artery aneurysms may be more common than previously thought, with a prevalence of 0.1% of the general population and a particular predilection in women (male/female ratio of 1:1.75). The main causes of true renal artery aneurysms are fibromuscular dysplasia (34%) and atherosclerosis (25%), whereas iatrogenic injuries after percutaneous treatments are responsible for most intraparenchymal false renal artery aneurysms. Symptomatic renal artery aneurysms are associated with hypertension, hematuria, and renal infarction.⁴

Women, especially those with anticipated pregnancy, are considered to be at a high risk of rupture, with mortality rates in this setting reported at 80%.¹⁸

The type of EVT treatment should depend on the location of the aneurysm. Aneurysms involving the main renal artery are fairly straightforward to treat and can be excluded by means of a covered stent (self-expanding or balloon-expandable). Aneurysms of the renal hilum are more challenging and were traditionally referred for surgical treatment. Currently, the use of modern EVT allows for the treatment of most hilar aneurysms. Aneurysm exclusion can be achieved by packing the aneurysm with coils, in cases of aneurysms

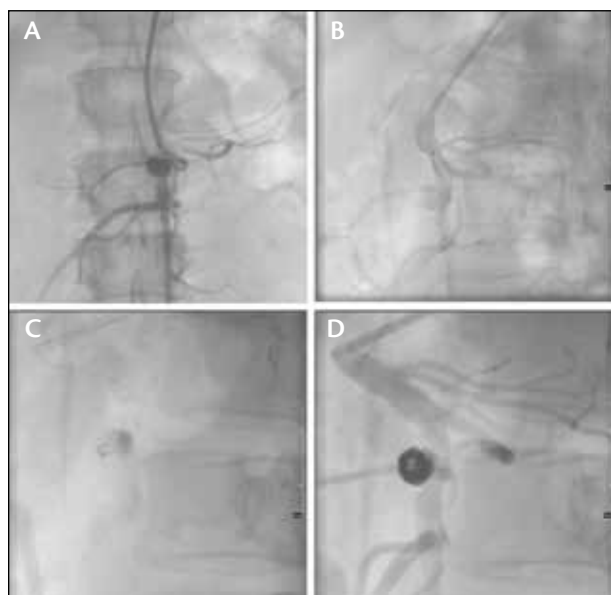


Figure 4. Stent-assisted coiling of a posttraumatic SMA aneurysm. An angiogram showing a saccular aneurysm adjacent to major branches of the SMA (A). Implantation of a self-expandable stent across the neck of the aneurysm (B). Cannulation of the aneurysm sac with a microcatheter in preparation for coiling (C). The coiled aneurysm with a completion angiogram showing preservation of all branches of the SMA and an excluded aneurysm (D).

with a narrow neck, or with the use of stent-assisted coiling, either with a single self-expandable stent or with two stents in a Y-stent configuration (Figure 3). Flow diverters can also be used, especially in cases when stent-assisted coiling is anatomically impossible.¹⁹

CELIAC ARTERY AND SMA ANEURYSMS

Celiac artery and SMA aneurysms are rare and usually atherosclerotic in nature. They present a relatively high risk of rupture, which is coupled with a nearly 100% mortality rate. Most aneurysms of the SMA involve the proximal 5-cm segment of the SMA.

EVT is difficult, and the approach has to be individually tailored to each patient. In some cases, patency of the celiac artery can be preserved by excluding the aneurysm with a covered stent placed through the celiac artery into the hepatic artery. This approach intentionally sacrifices the splenic artery, leaving blood flow to the spleen to be supplied by collateral circulation. Other endovascular methods rely on proximal embolization of the celiac axis with blood flow to the liver supplied from the SMA via the pancreaticoduodenal arcade. In these cases, it is essential to preprocedurally

demonstrate a well-formed collateral circulation from the SMA into the celiac artery vascular bed.

Treatment of SMA aneurysms is usually attempted by stent-assisted coiling of flow-directional stents (Figure 4). The choice of technique depends on the proximity of important side branches requiring continued patency. Rarely, covered stents can be used.

CONCLUSION

With VAAs being generally uncommon, there is a lack of clinical evidence to determine the best choice for therapy, both in terms of technique and timing. Still, with the development of modern endovascular technologies, these techniques seem to be the best first-line option, although close cooperation should exist between the interventionist and surgeon. ■

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