

Visceral Artery Aneurysms: Review of Current Management Options

Ulka Sachdev-Ost, MD

University of Pittsburgh Medical Center, Pittsburgh, PA

OUTLINE

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ABSTRACT

Visceral artery aneurysms are relatively rare clinical entities, although their detection is rising due to an increased use of cross-sectional imaging. Rupture is the most devastating complication, and is associated with a high morbidity and mortality. For this reason, elective repair is preferable in the appropriately chosen patient. In general, splenic artery aneurysms measuring 2 cm or larger and those found in women of childbearing age and in persons undergoing liver transplantation should be treated. Hepatic artery aneurysms 2 cm or larger and those that are multiple or nonatherosclerotic in nature should be repaired in the appropriate patient due to a higher risk of rupture. Endovascular coil embolization has excellent success rates and is the first-line treatment for anatomically suitable splenic artery aneurysms and intrahepatic hepatic artery aneurysms. However, reperfusion is an important complication of endovascular management. Aneurysms involving the celiac, superior mesenteric, pancreaticoduodenal, gastroduodenal, and inferior mesenteric arteries, as well as

visceral artery pseudoaneurysms, are unpredictable and should be repaired in the appropriate medical patient. These aneurysms are often amenable to ligation due to the presence of collateral circulation. Endovascular management is particularly useful in the treatment of pseudoaneurysms where comorbidities and previous surgery make open surgical repair less desirable. ***Mt Sinai J Med 77:296–303, 2010. © 2010 Mount Sinai School of Medicine***

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Visceral artery aneurysms (VAA) are uncommon entities that affect the splenic, hepatic, celiac, and superior mesenteric arteries. Increased imaging of the abdomen with ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) to evaluate nonvascular pathology has led to a concomitant increase in their diagnosis in asymptomatic patients. Elective repair is recommended in certain situations to prevent the high morbidity and mortality that is associated with aneurysm rupture.

Conventional repair of VAA has included excision, bypass, ligation, and end-organ resection. Endovascular techniques have gained popularity and have become the first-line treatment for certain types of aneurysms, such as those that affect the mid- to proximal splenic artery. Finally, laparoscopic techniques have been used with excellent results, and

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have allowed for the treatment of patients who would otherwise be unfit for open surgery due to comorbidities. This article will systematically review the natural history (when known), management

Address Correspondence to:

Ulka Sachdev-Ost

Department of Surgery
University of Pittsburgh Medical
Center

Pittsburgh, PA

Email: sachdevu2@upmc.edu

recommendations, and current treatment options for aneurysms involving branches of the celiac and superior mesenteric arteries, with particular emphasis on endovascular therapies. Management of visceral artery pseudoaneurysms also will be discussed.

SPLENIC ARTERY ANEURYSMS

Splenic artery aneurysms (SAA) account for about 50% to 75% of all VAA,^{1–6} are estimated to have a prevalence of <0.1%, and may be associated with other intra-abdominal aneurysms involving visceral (3%) and renal (14%) arteries.⁴ They have a female to male predominance of 3–4:1^{3,4,7} and are associated with multiparity.³ In a review of 217 patients with SAA, mean age was 61 years, 79% were women, 95% of the aneurysms were solitary, and the majority were asymptomatic.³ However, rupture was the presenting symptom in close to 5% of patients, with a mean diameter of 3.5 cm (3.2 cm for males, 2.3 cm for females).³ In contrast, the mean diameter of the nonruptured SAAs was 2.2 cm. Interestingly, calcification, which is often thought to offer evidence of chronicity and stability, was seen in 90% of the ruptured aneurysms,³ and should therefore not be used to guide management decisions.

True SAAs are associated with multiparity as well as portal hypertension.^{4,5,7} Hormonal changes and increased portal congestion associated with pregnancy are thought to lead to loss of structural integrity within the splenic artery, leading to aneurysm formation.⁴ SAA has a prevalence as high as 10% in patients with portal hypertension,⁴ and aneurysm rupture after liver transplantation is not an uncommon outcome. In a series of 30 patients who underwent repair of SAA at a busy liver transplant center, 20 patients had a previous orthotopic liver transplant (OLT) and 12 patients had a history of portal hypertension. Rupture was an indication for repair in almost half the patients in this study, and occurred within 2 weeks of liver transplantation in 7 patients.⁷ Other etiologies of SAA include systemic hypertension, as well as less-common conditions such as medial fibrodysplasia and α – 1 antitrypsin deficiency.⁴ Although calcification is commonly seen within them, atherosclerosis does not appear to be a major factor in the development of SAA.⁴

The natural history of untreated SAA is poorly defined, but may be best described in the Mayo Clinic experience by Abbas *et al.* in which the decision was made to observe 168 patients at the initial presentation of SAA.³ Sixty-five percent of these patients had aneurysm size documented on presentation, and 47% had size information available at

follow-up. Mean aneurysm size at presentation in the nonoperative group was 2.1 cm, with approximately one-third of those patients having aneurysms between 2 and 3 cm. Of the 79 patients in whom follow-up measurements were obtained, 11 (14%) had evidence of aneurysm growth; of these, 3 underwent elective repair. None of the patients who were observed ruptured their aneurysms during a mean follow-up period of 75 months (range, 1–371 months).³ To summarize natural history information as well as indications of repair, SAA can have an appreciable growth rate, and increased aneurysm size is associated with rupture. Current available data would indicate that repair should be offered for symptomatic aneurysms, aneurysms ≥ 2 cm aneurysms found in women of childbearing age (because rupture in pregnant women is associated with high maternal and fetal mortality),⁸ and in patients with SAA who are undergoing OLT. In the latter case, repair of the aneurysm at the time of transplant has been reported.⁷

Treatment options for SAA include open surgical repair, endovascular management with either coils or covered stents, and, more recently, laparoscopic excision. The location of the aneurysm as well as its presentation dictates the type of open procedure that is performed. Resection with end-end repair can be performed in many cases, owing to the predominantly proximal location of SAA and to the redundancy and tortuosity of the artery.⁵ This allows for splenic preservation, which has important implications for the immune system. However, splenectomy may become necessary in aneurysms involving the splenic hilum,⁹ and is performed more commonly in the setting of aneurysm rupture.^{3,5,7}

Endovascular management of SAA has gained popularity over the last decade, owing to its acceptable technical success rate and low morbidity.^{1,2,6,10,11} Percutaneous embolization with either coils or glue (N-butyl cyanoacrylate) is particularly appropriate for saccular aneurysms, fusiform aneurysms with good collateral flow to the end organ, and aneurysms of vessels in which other sources of arterial flow to the end organ are present.^{2,10} Thus, SAA are often ideal candidates for coil embolization (Figure 1). Triaxial systems that utilize microcatheters allow for super-selective catheterization of branches to optimize aneurysm exclusion.^{2,10} Procedures can be performed under local anesthesia with sedation and are generally ambulatory in the elective setting.¹ Percutaneous access is most commonly achieved through cannulation of the femoral artery.^{2,10} When there is no evidence of rupture, systemic heparin is administered to prevent thrombosis of the sheath and access vessels. Rates of successful exclusion of SAA range

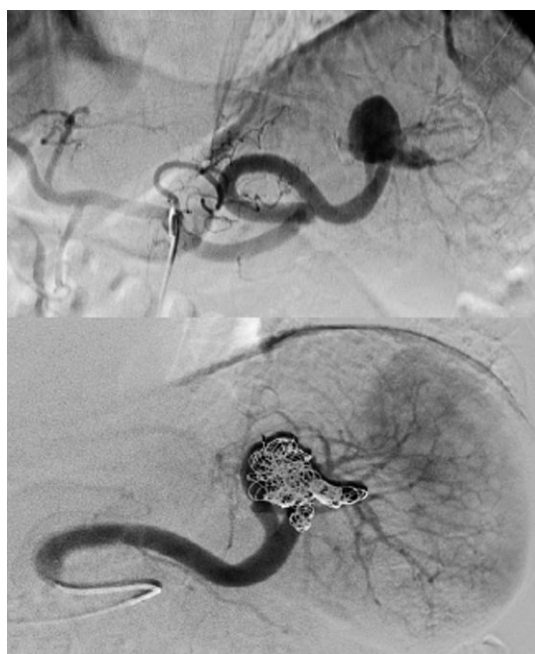


Fig 1. Angiogram demonstrating splenic artery aneurysm (A) before and (B) after successful coil embolization.

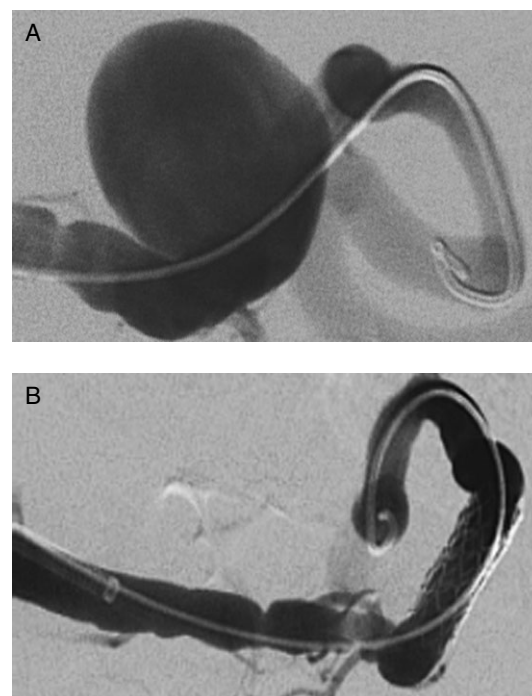


Fig 2. Angiogram showing (A) splenic artery aneurysm and (B) successful stent graft exclusion.

from 90% to 100%.^{1,2,11,12} Placement of stent grafts to maintain perfusion in the main artery has also been described with success in the splenic artery^{1,13} (Figure 2); however, tortuosity of the artery can complicate stent graft placement and deployment.

Complications of SAA coil embolization include splenic infarct (Figure 3) and reperfusion of the aneurysm, which can occur in 5% to 20% of patients.^{1,12} Thus, yearly follow-up with CT or MRI is necessary to evaluate for leak and subsequent growth.¹² In our previously reported experience at Mount Sinai Medical Center, 3 out of 15 patients treated with endovascular coil embolization developed evidence of reperfusion. However, all were able to be treated by repeat embolization through endoluminal access, avoiding the need for laparotomy.¹ Splenic infarcts have been seen more commonly in patients with portal hypertension and hilar location of aneurysms, but usually are successfully treated with pain control.^{1,2,6,14} In reported series, splenic infarcts occurred in 25% to 40% of the patients treated, yet no patient developed sequelae requiring further management.^{1,2,12,14}

Laparoscopic management of SAA was first reported in 1993,¹⁵ and though it is not a commonly performed procedure, it does offer an alternative to endovascular and open surgical management. Although the literature describes only small series, outcomes appear to be acceptable, and the

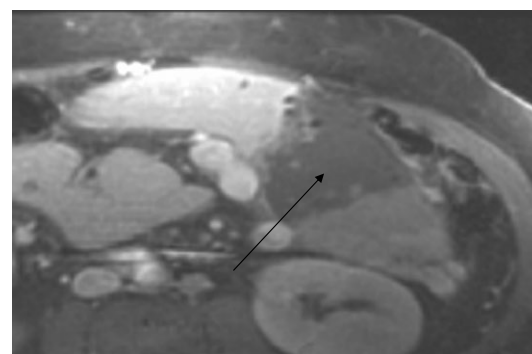


Fig 3. Arrow demonstrates splenic infarct after successful splenic artery embolization. This patient had splenomegaly associated with portal hypertension.

procedure offers certain advantages over other treatment options. Patients are spared the need for yearly CT follow-up to evaluate for aneurysm reperfusion, which is required for endovascular management and may be problematic in young patients. Furthermore, splenectomy can be performed at the time of the procedure, which obviously prevents the syndrome associated with postembolization infarction, pain, and potential for infection. In 1 small series, splenectomy was performed when laparoscopic-assisted Doppler sonography demonstrated markedly diminished flow to the spleen after aneurysm exclusion.¹⁶ This occurred most commonly in hilar aneurysms.

Although, theoretically, end-to-end arterial anastomoses can be performed laparoscopically to maintain arterial perfusion, in the aforementioned small series a robotically assisted anastomosis was performed in the 1 case in which reconstruction was performed, adding to the complexity and cost of the procedure.¹⁶

HEPATIC ARTERY ANEURYSMS

Hepatic artery aneurysms (HAA) are the second most common true VAA (Figure 4). However, increased performance of percutaneous biliary procedures, nonoperative management of trauma, and liver transplantations has led to an increase in hepatic artery pseudoaneurysms,^{1,2,9,10,17,18} making them the most commonly reported VAA in the period from 1985 to 1995.^{17,19} In contrast to SAA, HAA are more

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commonly identified in men (male/female [M/F] ratio 3:2),^{4,20} although the mean age of presentation is similar (sixth to seventh decade).^{3,4,20} In a series of 36 true HAA reported by the Mayo Clinic, hypertension was the most commonly associated comorbidity, occurring in 72% of patients.²⁰ Nonhepatic VAA were identified with HAA in 31% of patients

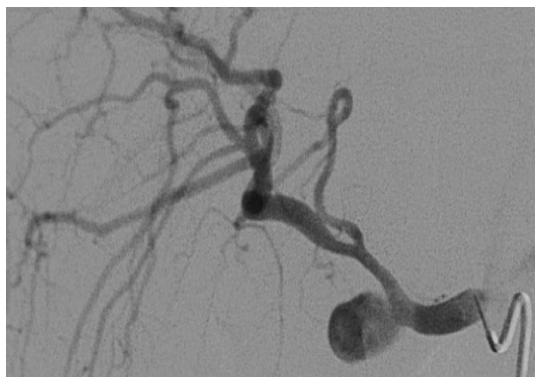


Fig 4. Angiogram demonstrating hepatic artery aneurysm.

and were identified in the splenic artery in 20% of patients.²⁰ The majority of aneurysms were solitary and atherosclerotic in nature, and aneurysm rupture was seen only in patients with multiple aneurysms or with aneurysms of nonatherosclerotic etiology (eg, fibromuscular dysplasia, polyarteritis nodosa, or mycotic).²⁰ Most aneurysms were located in the extrahepatic circulation, and fewer were seen in both the extrahepatic and intrahepatic arterial system. Pure intrahepatic aneurysms were an uncommon finding.²⁰

Most HAA are identified as incidental findings on cross-sectional imaging or abdominal ultrasound.⁴ However, abdominal or back pain can be present in rapidly expanding aneurysms.⁴ Importantly, rupture into the biliary tree is more common than free, intraperitoneal rupture, and can present with jaundice, biliary colic, and gastrointestinal hemorrhage as is described in Quincke's triad.^{4,19} In the Mayo Clinic experience, 22 patients (61%) were managed nonoperatively for aneurysms <2.0 cm (n = 14) and >3.0 cm (n = 4).²⁰ Two of these patients presented ruptured, and 1 died. The other had contained hematoma, was observed, and was alive at 3 months follow-up. In 3 patients managed nonoperatively, aneurysm growth was noted, but repair was precluded due to either poor medical condition or aneurysm size <2.5 cm.²⁰ None of the observed patients, including those with aneurysm diameter >3 cm, proceeded to rupture.²⁰

Based on the Mayo Clinic experience, which represents one of the largest series of true HAA in the literature, indications for treatment include symptomatic aneurysms, nonatherosclerotic aneurysms, multiple aneurysms, and aneurysms >2 cm in good-risk patients with a life expectancy of at least 2 years. In their series, patients with significant comorbidities who presented with aneurysms >3 cm were observed, and none proceeded to rupture.²⁰ Alternatives to open surgical management, including endovascular treatment, may allow for treatment of large aneurysms in the medically compromised patient.¹⁸

Traditional surgical management of HAA depends on the location of the aneurysm, presence of collateral flow, and medical state of the patient. Procedures can include ligation, ligation with bypass using autologous vein or prosthetic graft, hepatectomy, and, in rare instances, OLT.^{1,19,20} In either the open or endovascular strategy, ligation or coil embolization of the hepatic artery should be performed only if the portal vein is patent.¹⁸ Aneurysms involving the proper hepatic artery require vascular reconstruction as a component of repair, whereas

common HAA may be managed without reconstruction if collateral flow through the gastroduodenal artery is adequate.^{4,5,17,18} Complications of open surgical repair include graft thrombosis, bile leak, and intra-abdominal abscess or sepsis.^{1,20} Open surgical repair for rupture is associated with a high morbidity and mortality (100% and 33%, respectively²⁰); thus, elective repair, when appropriate, is preferred.

Literature describing the use of endovascular techniques to manage HAA is limited to small series. Percutaneous embolization is considered first-line treatment for intrahepatic aneurysms owing to the complicated nature of open repair.²¹ Percutaneous approaches appear to have particular use in

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the treatment of hepatic artery pseudoaneurysms, in which previous abdominal surgery and medical comorbidity are prominent features.^{1,10,17} In our series describing the experience at Mount Sinai, an endovascular approach predominated in the treatment of hepatic artery pseudoaneurysms, whereas true aneurysms involving the extrahepatic circulation were more likely to be treated by surgical resection ($n = 10:1$, pseudo:true treated endoluminally versus 4:7, pseudo:true treated by open surgery; $P = 0.002$).¹ In another series from the Cleveland Clinic, technical success at coil-embolizing 10 HAA was 80%, and failures were attributed to an inability to cannulate the aneurysm neck.¹⁰ Although follow-up imaging was not available for all patients, no reperfusion was seen in patients in whom imaging was available.¹⁰ In another small series of 12 hepatic artery embolizations, no evidence of hepatic ischemia occurred after aneurysm ablation with either coils or glue.²

Stent graft repair may be desirable in patients with baseline hepatic insufficiency, or in aneurysms involving the proper hepatic artery in order to maintain antegrade perfusion. However, anatomic suitability for stent graft repair must be determined preoperatively to evaluate the adequacy of the seal zones, the potential for kinking of the artery, and the accessibility of proximal vessels for delivery sheaths. Reported complications of endovascular therapy include access-related problems such as groin hematomas, pseudoaneurysms, and arterial thrombosis, which can occur during any

percutaneous intervention. Procedure-specific complications can also include arterial dissection²¹ and aneurysm rupture.

SUPERIOR MESENTERIC ARTERY ANEURYSMS

Superior mesenteric artery (SMA) aneurysms are the third most common type of VAA, and are a rare entity. Most commonly they involve the proximal 5 cm of the SMA.²² Extension of aneurysm-related thrombus or dissection beyond the collateral circulation of the celiac and inferior mesenteric arteries may result in ischemic symptoms.²³ Historically, the etiology of SMA aneurysms was infectious.²² However, in a series of 21 patients, etiologies varied from atherosclerosis and cystic medial dysplasia to collagen vascular disorders and polyarteritis nodosa.²⁴ Medial dysplasia may be a secondary finding.²³ Only 1 patient had evidence of infection. In that same series, 8 patients presented ruptured, and nearly half of the patients with rupture subsequently died.²⁴ In contrast to SAA aneurysms, patients with calcified SMA aneurysms did not have rupture either at presentation or follow-up.²⁴ There was no accurate description of aneurysm size in patients who ruptured, but the mean size in patients who did not rupture was 2.2 cm. Furthermore, male patients were more prone to rupture. Of the 13 patients who did not rupture, 10 were asymptomatic.²⁴ Patients were repaired unless comorbidities precluded operative intervention. Although elective repair did not require bowel resection, repair for rupture was associated with small-bowel resection in 3 out of the 8 patients for bowel ischemia.²⁴ Thus, elective repair may be beneficial in terms of bowel preservation. Based on limited literature, indications for repair other than rupture include size ≥ 2 cm in a good-risk patient, growth, and symptoms.

Ligation of the vessels that enter and exit the aneurysm is one of the more common surgical approaches to treat SMA aneurysms.^{23,24} Collaterals from the celiac and inferior mesenteric arteries are usually sufficient to prevent ischemia, although test occlusion with an intraoperative assessment of bowel viability can be performed.²³ Other open surgical approaches include endoaneurysmorrhaphy and arterial reconstruction with bypass after ligation using either vein or prosthetic graft. Vein is the preferred conduit in the setting of an infected aneurysm. Operative exposure is transmesenteric in more distal aneurysms, whereas those in the proximal SMA may require exposure through medial visceral rotation.²³

Reports of endovascular management of SMA aneurysms describe the use of coil embolization and stent grafts.^{6,24} Percutaneous management is particularly useful in patients with a hostile abdomen and medical comorbidities. In our previously published experience, 3 patients with SMA pseudoaneurysms

Reports of endovascular management of superior mesenteric artery (SMA) aneurysms describe the use of coil embolization and stent grafts. Percutaneous management is particularly useful in patients with a hostile abdomen and medical comorbidities.

were successfully managed by endovascular means without procedure-related complications. Two of these patients had hostile abdomens, and 1 had medical comorbidity.¹⁰ In general, literature on these techniques is limited to very small series or case reports, thus long-term outcomes are difficult to assess.

CELIAC ARTERY ANEURYSMS

Celiac artery aneurysms (CAA) are quite rare, accounting for 4% of VAA.²² The etiology of these aneurysms is usually atherosclerosis, and infectious causes are rare. Most are asymptomatic, but symptoms can mimic pancreatitis due to the location of the arteries.²³ Of note, association with other aneurysms is common, occurring in 66% of patients in 1 series.²⁵ Concomitant aneurysms included aortic, renal, popliteal, and femoral in that report.²⁵ In 1 series, CAA were the most common VAA encountered (9 of 23 patients), most likely because SAA were seen and treated by interventional radiologists.²⁶

Because these aneurysms are so rare, reports of their natural history are limited. Again, the Mayo Clinic experience represents the largest compilation of patients with CAA (n = 18), some of whom were treated and some of whom were observed.²⁵ The patients who were observed were considered too high-risk for repair, and were thus followed with serial imaging.²⁵ Mean aneurysmal size was 2.1 cm (range, 1.5–3.5 cm) in this group of 8 patients who were observed. One patient with a 2.5-cm aneurysm who declined repair ruptured 5 years after presentation, whereas the others did not demonstrate any sign

of growth over a 91-month mean follow-up period (range: 1–371 months).²⁵ Thus, observation in medically compromised patients is a reasonable option.

Traditional open repair can be performed through a transabdominal route, and may require medial visceral rotation of left colon, spleen, and pancreas to gain access to the proximal celiac artery.²³ A thoracoabdominal approach may be required in some instances when the aneurysm is large.²³ Ligation can be performed in the absence of liver pathology.²⁵ Aneurysmectomy with arterial reconstruction using vein or prosthetic graft is another approach, using the supraceliac aorta as an inflow source.²³ In the Mayo Clinic experience, vein bypasses occluded within 6 months follow-up. Kinking of the graft and thrombosis in the setting of competitive flow were proposed explanations for this finding.²⁵ Thus, prosthetic grafts may offer some advantage in this setting.

Endovascular management of CAA has been described and may be appropriate in high-risk patients without liver dysfunction and without disease of the collateral circulation, including the SMA and gastroduodenal arteries.^{2,11,27} Endovascular treatment of CAA may also be performed during endoluminal repair of other VAA,¹ or before treatment of aortic aneurysms.²⁷

Endovascular management of celiac artery aneurysms (CAA) has been described and may be appropriate in high-risk patients without liver dysfunction and without disease of the collateral circulation, including the SMA and gastroduodenal arteries.

The nature of the collateral circulation theoretically allows for embolization of the inflow, outflow, and branches of the aneurysm without arterial reconstruction. Though reports of this technique are limited in regard to CAA repair, celiac artery coverage and occlusion is sometimes utilized in endovascular repair of thoracic artery aneurysms (TEVAR). The safety of celiac artery coverage in that setting is a matter of current investigation. Most authors recommend preoperative angiography to evaluate collateral circulation,^{28,29} and some have advocated selective arteriography through the SMA with concomitant celiac artery test occlusion to evaluate the adequacy of mesenteric collaterals.^{28,30} However, in 1 study, test occlusion of the celiac and mesenteric

angiography did not prevent foregut ischemia in the setting of celiac artery coverage. Furthermore, in the same study, coverage of the celiac artery during TEVAR led to foregut ischemic complications in 25% of patients who did not have preoperative celiac artery revascularization.²⁸ Complications included an ischemic gastric ulcer, gangrenous cholecystitis, liver abscess, and exacerbation of cirrhosis.²⁸ Whether the ischemic complications were due to inadequate flow or procedural embolization was an unresolved issue in that report. Complications specifically related to endovascular aneurysm exclusion do not appear to commonly involve organ ischemia,^{2,11} although reports are limited. Late coil migration leading to fatal gastrointestinal hemorrhage has been described.³¹

GASTRODUODENAL, PANCREATODUODENAL, AND INFERIOR MESENTERIC ARTERY ANEURYSMS

True aneurysms involving the gastroduodenal, pancreaticoduodenal, and inferior mesenteric arteries are rare. However, their behavior is unpredictable. In 1 series of VAA in 34 patients, all 6 patients with pancreaticoduodenal artery aneurysms presented ruptured, and 2 died.³² Thus, aneurysms in these locations should be treated. Management with ligation or coil embolization is appropriate, as reconstruction is not only technically difficult, but is likely not required due to adequate collateralization.^{11,32} However, adequate collateral flow should be documented with preoperative imaging if permitted. Imaging with CT and magnetic resonance angiography demonstrate excellent resolution for preoperative planning.²² However, angiography may allow for better evaluation of real-time flow dynamics.

VISCERAL ARTERY PSEUDOANEURYSMS

Visceral artery pseudoaneurysms (VAPA) occur in the setting of infection, chronic inflammation, and trauma. The literature suggests that VAPA are more prone to symptoms or rupture.^{2,11} In 1 series, 7 out of 25 patients who presented with rupture had VAPA secondary to chronic pancreatitis.¹¹ Endovascular treatment of VAPA has certain advantages in anatomically difficult locations, and in the postoperative abdomen. In our series from Mount Sinai, ruptured VAPAs were significantly more likely to be treated by

endovascular techniques. Hemodynamic instability did not preclude endovascular repair, which has also been seen in other studies.^{1,33} Indeed, endovascular approaches may have some advantage in the hemodynamically unstable patient with VAPA in difficult locations—angiography not only confirms the pathology, but, in addition, endovascular access may allow for rapid control with intraluminal balloon occlusion.

CONCLUSION

In summary, although VAA and VAPA are relatively rare, the mortality associated with rupture is significant. Thus, a rigorous plan should be adopted when they are recognized in the elective setting. In general, SAA measuring ≥ 2 cm and those found in women of childbearing age and in persons undergoing OLT should be treated. Hepatic artery aneurysms > 2 cm and that are multiple or nonatherosclerotic in nature should be fixed in the appropriate patient due to a higher risk of rupture. Endovascular coil embolization has become the treatment of choice for anatomically suitable SAA and intrahepatic HAA. Success rates range from 85% to 100%, but reperfusion is a reported complication. Aneurysms involving the celiac and superior mesenteric arteries are much less common, but should be repaired in the appropriate medical patient. Ligation without reconstruction is feasible in the management of these aneurysms, provided that collateral circulation, often determined on preoperative imaging, is adequate. Otherwise, bypass with vein (in the setting of infection) and prosthetic graft is recommended. Finally, aneurysms involving the pancreaticoduodenal, gastroduodenal, and inferior mesenteric arteries, as well as VAPA, should be repaired, as rupture risks are high and behavior is unpredictable. Endovascular coil embolization is particularly useful in these settings, in which open operative exposure may be difficult and arterial reconstruction is not necessarily required.

DISCLOSURES

Potential conflict of interest: Nothing to report.

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