Case Study 1: Multiple SA Aneurysms

The first case study presented here is of a young, healthy female, 38 years of age. The patient was not pregnant, has three young children, and no prior history of smoking. This patient saw her primary care physician for moderate right thoracic and right flank pain. The patient has a prior history of kidney stones, which was the reason for the clinical visit. The physical examination of the patient’s abdomen was normal with no palpable mass, tenderness, or signs of splenomegaly. A computed tomography (CT) scan, without contrast, of the abdomen was done to look for kidney stones. The scan showed three kidney stones within the right kidney without hydronephrosis. The CT also showed a normal-sized spleen, but also a rounded 1.5-cm vascular structure near the splenic hilum. With this finding, a dedicated CT angiogram (CTA) was ordered of the abdomen and pelvic areas to check for a possible splenic aneurysm.

The CTA, with contrast, was performed 3 weeks later. The scan showed multiple abnormalities in the distal splenic artery (SA). At least four splenic hilar aneurysms were found with the largest measuring at 1.8 × 1.7 cm in diameter. It also showed a small distal aneurysm in the right renal artery measuring 1.1 × 0.8 cm. Normal celiac artery (CA) and superior mesenteric artery (SMA) were visualized with no evidence of fibromuscular dysplasia. The radiologist recommended that a splenectomy be done due to the patient’s age. This patient was then referred to our vascular office for further evaluation. A follow-up CTA of the chest and abdomen/pelvis with runoff was ordered. These results were nearly identical to the previous test with the largest aneurysm measuring 1.9 × 1.8 cm size. The CTA showed a normal ascending aorta, aortic arch, and descending thoracic aorta with normal runoff to the feet. The right renal artery aneurysm was seen measuring at 1.4 × 0.8 cm in the hilum of the kidney.

After these findings, an abdominal ultrasound was ordered to correlate the findings with the CTA and use this as a modality to potentially follow the patient with nonradiation imaging in the future. The ultrasound confirmed the CTA with visualization of four SA aneurysms with the largest measuring 1.84 × 1.8 cm diameter. These aneurysms were seen at the distal end of the SA, at the hilum, and showed elevated peak systolic velocities and turbulent arterial flow within the dilated lumen.

The plan for the patient is to take a conservative approach with follow-up examinations in 3 months. If expansion of the aneurysms is seen, surgical intervention will be recommended.

Prevalence of SA Aneurysms

SA aneurysms were once seen as a very rare disorder with studies highlighting them as present in only 1%
of the population. They were most frequently incidental findings or found during autopsy. In more recent case studies, the prevalence of these aneurysms is found with a reported rate from 0.1% to 10% of people. The increase in prevalence is due to improved and more frequent imaging. With increased imaging these rare, and occasionally, life-threatening disorders are still most frequently found as incidental findings.

SA aneurysms are the third most common intra-abdominal aneurysm (after aortic and iliac) and most common of the splanchnic artery aneurysms, accounting for up to 60% of splanchnic aneurysms. These aneurysms are four times more likely to occur in women than in men, and most dangerous during pregnancy.

**Etiology and Dangers of SA Aneurysms**

SA aneurysms are defined as abnormal dilation of the vessel to more than 1 cm in diameter. The pathogenesis is not fully known for these aneurysms but risk factors include trauma, hormonal and local hemodynamic events in pregnancy, portal hypertension, arterial degeneration, and atherosclerosis. As of 2009, there were only 400 reported cases of SA aneurysms, with 100 during pregnancy. Rupture risk of a SA aneurysm is 3%, with a 25% mortality rate. During pregnancy, the mortality rate jumps to 75% upon rupture. The majority of ruptures will occur in pregnancy, representing 95% of the total ruptures of SA aneurysms. With these high percentages of ruptures in pregnant women, diagnosis and quick intervention become key. It is fair to conclude the population that carries the greatest risk for not only an SA aneurysm, but also a fatal rupture of the aneurysm, is pregnant females and multiparous women having a greater risk of developing SA aneurysms.

**Ultrasound and SA Aneurysms**

There is little information on SA aneurysms and ultrasound found in the literature. This lack of data is probably due to the fact that the SA is not visualized often with ultrasound during an examination and could be due to the limitations of the equipment, sonographer, and imaging protocols. Looking for a SA aneurysm is not a routine test. Performing this type of unique examination requires excellent knowledge of the visceral vascular anatomy. The SA is a naturally tortuous vessel that dives deep into the abdomen, possibly limiting visualization of the test with obese patients, pregnant women, or patients with bowel gas. Even without these limitations, this examination can be challenging due to the size of the vessel and experience of the sonographer.

The examination should be scheduled in the AM with the patient NPO from midnight to help increase the chance to visualize this vessel. The patient should be in the supine position and the test should begin under the xiphoid process at the proximal aorta. With normal vasculature, the CA should be the first branch off the aorta and demonstrate a low-resistance waveform. The celiac will bifurcate into the common hepatic artery (CHA) and SA. This area of bifurcation is commonly called the “seagull sign” and can be used as a landmark to find the SA, as shown in Figure 1.

The SA will then course in a “candy cane” shape as it moves proximally from the bifurcation and then turns distally. Following the vessel from this point becomes a challenge as it dives deep into the abdomen. Color Doppler and waveform analysis will help identify this vessel as it courses to the spleen, as shown in Figure 2. The vessel should show a low-resistance waveform and proper angulation of the Doppler curser is needed for accurate velocities. To see the SA move into the spleen, the patient may need to be moved into the right lateral decubitus position, as was the case with this study, to adequately visualize the distal SA. This is the area where most SA aneurysms will be seen and was found in this case study. On ultrasound, these appeared as round cyst-like structures sitting just outside and on the border of the spleen, as shown in Figure 3.

Knowing the patient’s history was helpful as the aneurysm could have easily been mistaken as cysts without color Doppler to ensure there was arterial flow in the lumen. Flow in the aneurysm vessel appeared in a ying-yang color pattern in the largest aneurysm suggesting a possible pseudoaneurysm, as shown in Figure 4 and once again in Figure 6 accompanied by multidirectional flow inside the aneurysm. Pulsed wave Doppler was used and demonstrated low-resistant waveforms with elevated velocities seen in the largest aneurysm, as shown in Figure 5. After confirming arterial flow inside the aneurysm, I then measured all the dilated areas, with and without color flow, to help delineate the borders, as shown in Figure 6. Next color Doppler was used on the spleen to check for blood flow in this organ. The measurements of all four aneurysms were very close to the measurements taken from the CTA performed earlier, with the largest measuring 1.84 × 1.79 cm, as shown in Figure 7. Ultrasound examinations of the SA can be greatly limited by bowel gas, obesity, and sonographer skill. In patients with clear images, it can be used as a useful tool in
surveillance of these aneurysms. With the knowledge of SA aneurysms and correlation with pregnancy, ultrasound can be a useful tool in identifying these aneurysms instead of using tests that include radiation that can harm the pregnancy.

Size and Treatment for SA Aneurysms

The management of patients with SA aneurysms is variable since the natural history of these aneurysms is poorly delineated. Most patients are asymptomatic when the aneurysms are found as incidental findings. Size and symptoms dictate the treatment. In one case study, between 1996 and 2009, 128 patients with SA aneurysms were evaluated and followed. Of these patients, 62 underwent surgical repair and another 66 were treated conservatively and received serial observation. The mean age of the patients was 61, with 69% of them being female. The mean size of the aneurysm was 2.4 cm. Of the 128 patients with a SA aneurysm, 7 (5.5%) had a ruptured aneurysm resulting in two deaths. Patients requiring surgery were more likely to be female (60%), younger (between 58 and 64), and current smokers (18%). The mean aneurysmal size sent for serial observation was 1.67 cm and showed a growth rate of 0.2 mm/year. The 10-year survival rate was 89.4% for all patients with no aneurysm-related mortality identified later in life.

Although larger SA aneurysms can be lethal, smaller aneurysms can be followed safely carrying a negligible rupture risk. In larger aneurysms, where surgical intervention is required, there are different treatment options that are based on the location of the aneurysm. If the aneurysm is proximal, transcatheter embolization is the preferred method, but with distal aneurysms, a splenectomy may have to be performed. Less invasive methods are being used, but there is no single preferred method of treatment at this time due to the limited prevalence of this disorder.

Discussion

SA aneurysms are a rare disorder, more frequently diagnosed due to increased medical imaging. There
are many different types of tests that can be performed to confirm or follow the growth of the aneurysms over time. Ultrasound remains a useful tool as an alternative option to radiation-based tests. Pregnant patients with SA aneurysms need immediate intervention to repair the vessel as the risk for rupture is great during pregnancy. If smaller aneurysms are found, they can be followed until reaching around 2 cm before intervention will need to be discussed. With the case study presented, a few key factors will favor intervention in her lifetime, as she is young (with ample time for aneurysmal growth), of childbearing age, and is female. Presence of multiple aneurysms in the same vessel could be another risk factor for intervention sooner rather than later.

Case Study 2: Isolated, Spontaneous Hepatic Artery Dissection

This is a case study of a 54-year-old healthy, nonsmoker, male cardiologist. He exercises three to four times a week with a healthy diet.

The patient was experiencing abdominal pain accompanied by moderate-to-severe postprandial pain. Over the course of a week, the pain would fluctuate with intensity, but would intensify with eating. Oral intake was therefore limited to minimal soft foods and mostly liquids. The patient performed an ultrasound on himself. He saw a “string sign” in his, believed to be CA at the time. The artery was enlarged and showcased severe color aliasing, indicating a possible dissection and high-grade stenosis inside the vessel. He was admitted for a CTA and med management with anticoagulation and intravenous antihypertensive medications.

On arrival to the ER, the patient’s blood pressure was 172/112 mmHg. There was no history of hypertension. On physical examination, the patient was experiencing moderate abdominal pain with tenderness in the left upper quadrant. A CTA with contrast was performed and showed a normal aorta with separate origins of the CHA and SA. There was no CA, as both these vessels coursed off the aorta to their respective organs. This is a normal variant of abdominal vasculature, but is rarely reported in medical literature, showing an incidence rate of only 1.3% in one study. The CTA showed mural thrombus with vessel expansion at 14 mm, and a small pseudoaneurysm projecting superiorly to the stenotic vessel lumen. The CHA also showed minimal recanalization and a vascular string sign inside the vessel. The right and left hepatic arteries were stenotic but reconstituted distally. The SA, SMA, renal arteries, and inferior mesenteric artery (IMA) were completely patent and normal in caliber.

The patient was transferred to a tertiary hospital. Follow-up CTAs confirmed the diagnosis, but also showed a mass encasing the proximal CHA. The mass was of unknown etiology and with concern of rupturing the vessel in its fragile state it was left alone for the time being. Early differential diagnosis for this was lymphoma or vasculitis. There was also an 11-mm mass found in the right lobe of the liver. The possibility of metastatic disease was included in the differential; therefore, surgical oncology was also consulted. Follow-up CTAs
showed mild, progressive dilation of the artery. The patient was in moderate constant pain.

An endoscope was performed to better visualize the area and possible mass, but was performed with great care in order not to rupture the artery. The problematic area was located 3 cm distal to the CHA origin from the aorta. The aorta was still normal and showed no signs of aneurysm and/or dissection. The CT showed a small aneurysm with abnormal wall thickening. There was an intimal flap within the aneurysmal dilation and the vessel was now almost completely thrombosed as only trickle flow was seen within the lumen. The mass was seen, but was still unable to be dealt with. Lab work was not remarkable for vasculitis or lymphoma. Care for the patient at the time was conservative as they were trying to reduce his pain and keep him on strict blood pressure control. With this being such a unique case, the doctors were unsure of the best course of action to treat the problem, suggesting only watching the vessel for the time being.

After weeks of an uncomfortable hospital stay, the patient was discharged with strict instructions to monitor his blood pressure and provided with a list of things to watch for in the event of vessel rupture. With the doctors unsure of the next step in his treatment, a recommendation was made to send him to the Mayo Clinic. A doctor, who is currently practicing there, treated a patient with isolated CA dissection and thrombosis and did well after 2 years of treatment. Before making the trip to the Mayo Clinic, the patient came back to my lab to document it on ultrasound and to monitor blood flow to his liver.

This is currently an ongoing case as the patient’s care has been taken over by the Mayo Clinic. After spending 2 weeks at Mayo, the patient returned home feeling much better about his prognosis. The patient is scheduled for surgery in early September for a duodenal adenoma that was found during a second endoscopic ultrasound procedure.

Ultrasound Interrogation

I had attempted to perform several ultrasounds on this patient in the past, but was never able to visualize his anatomy due to extreme bowel gas. The patient was a juicer and was always extremely gassy, so his anatomical variants were never seen even though he had been practiced on many times.

When the patient arrived, he was NPO for over 16 hours and had taken Gas-X tablets. I began the examination in the proximal aorta and went straight to his aortic branches to visualize the dissected area. The first thing noticed was that the CHA looked like the CA. The CHA, splenic, and SMA were extremely close in proximity, which made it difficult to differentiate three separate vessels, as shown in Figure 8.

In viewing the CHA I could immediately see the thickened walls of the vessel, with a small echo free space in the middle of the lumen, as shown in Figure 9.

The dissection was difficult to see at this point as the vessel was almost completely thrombosed. The size of the vessel measured 14 mm and was mildly dilated.

The aneurysm appeared completely thrombosed at the time of the ultrasound.

Color Doppler showed aliasing up to this area and then complete dropout, as shown in Figure 10. Turbulent flow could be seen following the area, and Doppler showed poststenotic turbulence and tardus-parvus waveforms, as shown in Figure 11.

What you could also see in this area were collateral vessels coming from the CHA and moving toward the right lobe of the liver. With the right hepatic artery showing low velocity waveforms, the collaterals were minimally supplying the liver with blood. No flow could be seen supplying the left lobe with blood flow as the vessel was occluded, as seen with color angio in Figure 12. At this point, I followed the SA and could see collateral vessels moving toward the left lobe of the liver.

Flow inside the liver showed strong waveforms in multiple intrahepatic arteries in the left lobe and weak flow in the vessels in the right lobe. The liver was normal in size and did not show any signs of infarct.
The SMA, renal arteries, and IMA showed normal velocities and waveforms. This ultrasound highlighted the importance of collateral vessels in helping supply organs when catastrophic events occur. Without the collaterals from the CHA, SA, and SMA, the liver would not receive arterial blood flow. Even though the liver receives about 75% of its blood flow from the portal veins, the lack of arterial flow would put the liver at risk. The fear of thrombus extension from the dissected area was of concern with the fear of a hepatic infarct. In addition, and of major concern was the fear of rupture of the aneurysm, which could be fatal.

Prevalence of CHA Aneurysm and Dissections

There are not many documented cases of isolated hepatic artery aneurysms and dissections. I found a few cases of celiac dissection with progression into the hepatic artery. I also found cases of SMA dissections, but isolated hepatic artery dissections appear rare. The estimated incidence rate of HA aneurysms is less than 0.25%. There have been only approximately 500 cases reported in the medical literature of HA aneurysms with most being found during autopsy. Findings of HA aneurysms show that up to 50% of these are pseudoaneurysm, which can increase the rate of rupture, and 17% of HA aneurysms were reported after liver transplantations with a correlation to anastomotic complications. It accounts for 20% of the splanchnic artery aneurysms, with a rupture rate of 44–85%. There has been no reported correlation for rupture of HA aneurysms with respect to vessel size at this time and most patients have shown to be asymptomatic before rupture occurs. Without data to link rupture with aneurysm size, surgery should be offered to patients without medical contraindications. This approach has not been universally accepted, and some authorities would recommend surveillance for asymptomatic atherosclerotic HA aneurysms that measure less than 2 cm in diameter.

Only 12 cases of HA aneurysms associated with dissection have been reported on in the literature at the time this article was written. Dissecting HA without aneurysm was associated in 8 of the 12 cases with only 30% of these patients having classic clinical triad symptoms of epigastric pain, upper gastrointestinal hemorrhage, and jaundice. Because of the high morbidity and mortality associated with HA aneurysms, a conservative approach solely aimed at reducing hypertension is rarely indicated and elective surgery has been recommended for both symptomatic and asymptomatic patients.

In one case study, 19 patients were reviewed to survey dissections in the splanchnic arteries. Of these patients, 11 had SMA dissections, 3 in the CA, 2 in both CA and SMA, 1 common hepatic dissection, 1 celiac to SA dissection, and 1 from the celiac to proper HA. Twelve of the patients were asymptomatic with all cases diagnosed by CT. Surgical treatment was performed in one patient with a large aneurysm of the CHA, and the remaining patients were followed conservatively. No expansion or progression of the false lumen was observed in the follow-up patients in this study. Of these 19 patients, 17 were male with a mean age of 58 and in 6 of these,
Treatment Options

The problem with treatment options for this condition is that there is a lack of outcome studies to show what works best. One study identified isolated spontaneous celiac trunk dissection (ISCTD), which also included HA and SA dissections. This study aimed to evaluate initial clinical and diagnostic aspects, treatment modalities, and outcomes. A total of 60 publications were identified between 1987 and 2015, with 11 case series and case reports, achieving a total of 169 patients identified with ISCTD. Again, this study heavily favored males (99–17), with an average age of 53. Diagnosis was once again done via CT and the most common associated conditions were hypertension and smoking in 31% and 23% of the cases, respectively. In 79% of the cases, conservative management was recommended. Several treatment options were used in this study including a conservative approach, anticoagulation, endovascular interventions, and open surgery. Most of these patients were asymptomatic (80.1%) and most of the common symptoms reported were abdominal pains (99%) and nausea or vomiting (14.8%). Two of the patients in the group died of vessel rupture and were diagnosed at autopsy; one with a HA dissection and the other with a SA dissection. Of the 20.1% of patients who underwent surgical repair, 11.8% of them were done via an endovascular approach with the other 8.9% done with open surgery.

This study concluded that initial conservative treatment seems adequate for most cases, but a few patients will require interventional treatment for this condition. If intervention is required, open surgery or an endovascular approach is recommended in patients who show failure with conventional medical therapy, in patients who are hemodynamically unstable, have visceral ischemia, show progression of the dissection on follow-up examination, and aneurysmal degeneration.

Discussion

This was a very unique and complex case that is still ongoing. After reviewing the literature and examining case studies, I have managed to piece together a few interesting thoughts. The patient fits in the demographics of the few reported cases perfectly in respect to his age, gender, and hypertension. Not one of the case studies I found was exactly like this one. I did not find a CHA dissection, in the literature, associated with anomalous origin of the CHA from the aorta. Every case study I saw with splanchic artery dissections were diagnosed via CT and this patient managed to self-diagnose via ultrasound. I was able to reproduce what he saw via ultrasound a month and a half after initial diagnosis. This case demonstrates a very rare CHA variant that is present in only 1.3% of people and with a dissection in the CHA that has an incidence rate of less than 0.25%, with initial diagnosis on ultrasound.

References