Ruby, POD, and POD Packing Coil: Dedicated Devices for Different Applications

BY GIUSEPPE GUZZARDI, MD

Penumbra's unique peripheral embolisation system provides game-changing tools for durable and efficient occlusions in all kinds of applications. The three coil technologies that make up the embolisation system are Ruby Coil, POD, and POD Packing Coil. All three technologies are large-volume coils that are similar in caliber to 035 coils and are deliverable through LANTERN, a high-flow microcatheter (Figure 1).

PRODUCT ADVANTAGES

Each of Penumbra's coil technologies is differentiated by means of the coil shape and softness. Ruby Coil is a versatile coil with a three-dimensional shape and is available in Standard and Soft configurations. Standard coils frame aneurysms or vessels, and Soft coils pack densely within or behind a Standard coil. POD has been designed for high-flow vessel sacrifice. The leading distal segment of the device is more robust, allowing it to anchor in the vessel, and the softer packing segment allows for it to tightly pack proximally. POD Packing Coil is like liquid metal—the 15- to 60-cm–long coil has no stated diameter and is made to densely pack in any size vessel behind a Ruby or POD backstop. Although each of these products was designed for dedicated purposes, they can be used to complement each other (Figure 1).

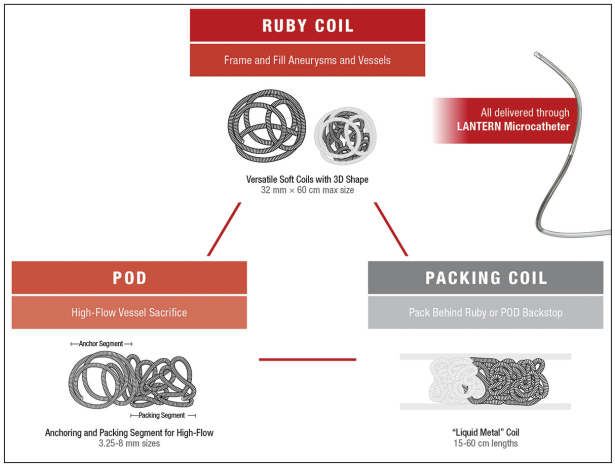

Figure 1. Dedicated devices for different applications.

Penumbra's peripheral embolisation system offers softer coils, longer lengths, and larger volume compared to conventional coil technologies (Figure 2). The volume advantage enables interventionalists to perform emboli-

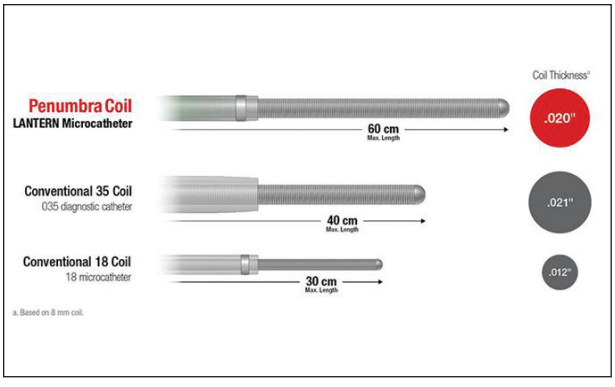

Figure 2. Ruby, POD, and POD Packing Coil are all similar to a 035 coil, but are still microcatheter compatible.

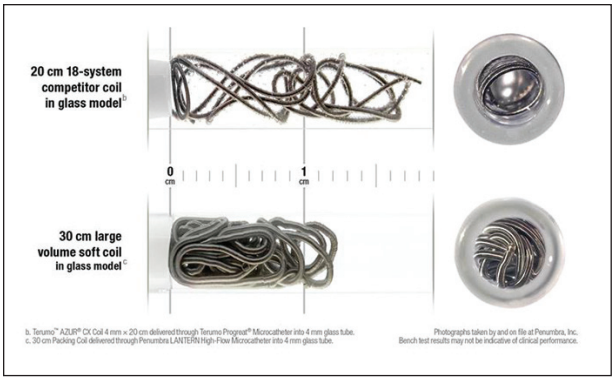

Figure 3. Softer coils enable a dense coil pack within a certain landing zone.

sations with fewer devices per case, and the extraordinary softness of the coils allows for the delivery of more embolic material to a given landing zone. With more embolic material, there is less reliance on the clotting cascade to generate thrombus within the empty spaces between coil loops (Figure 3).

CASE REPORTS

TYPE I ENDOLEAK

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A 78-year-old man underwent endovascular aneurysm repair in 2006 at another center. Eleven years later, he presented to our endovascular department with abdominal pain related to a type Ib endoleak from the left side of the endograft and a volumetric increase (from 5.2 cm to 6.7 cm) of the aneurysmal sac. The patient was treated emergently with an iliac branch extension with coverage of the left internal iliac artery. The following year, CTA showed a persistent distal type Ib endoleak fed by the left internal iliac artery and an unsealed right branch with an aneurysmal sac diameter of 7 cm (Figure 1).

The patient underwent a new endovascular treatment. The sac was catheterized through right common femoral artery access with a transsealing technique (Figure 2). The 32-mm X 60-cm coils were delivered first. The large coils adequately framed the aneurysmal sac. Three additional 60-cm coils were then deployed, efficiently filling the space (Figure 3). Then, the left common iliac artery was catheterized, and the origin of the internal iliac artery was embolised with POD8 and a 60-cm POD Packing Coil (Figure 4). The final step consisted of embolisation of the right iliac axis between the artery wall and the branch with glue (Glubran 2, GEM srl).

The final angiographic control showed the regular patency of the aortic endograft in absence of high-flow endoleak (Figure 5). At 3-month follow-up, the patient underwent a CTA control that showed no significant endoleak and stability of the aneurysmal sac dimensions (Figure 6).

WHY I CHOSE PENUMBRA LARGE-VOLUME COILS

- Ruby Coil: Large-diameter coils allow efficient embolisation of the aneurysmal sac
- POD: Permits precise anchoring in high-flow vessels
- POD Packing Coil: Enables a highly dense pack for durable vessel occlusion

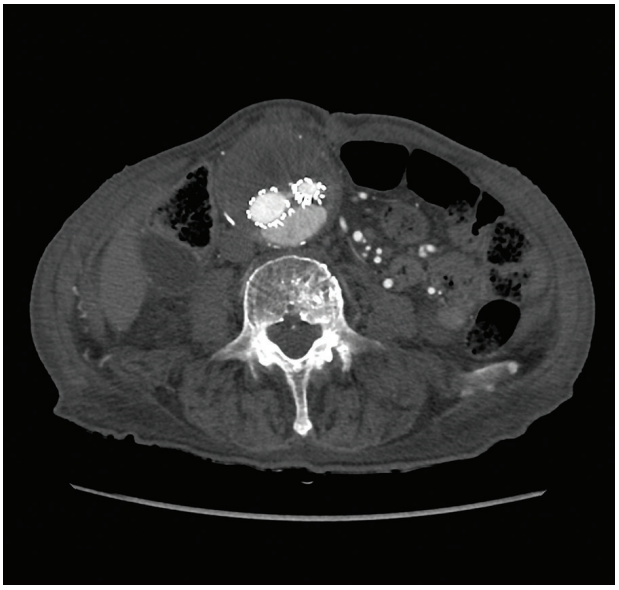

Figure 1. CTA showed a recurrent type Ib endoleak.

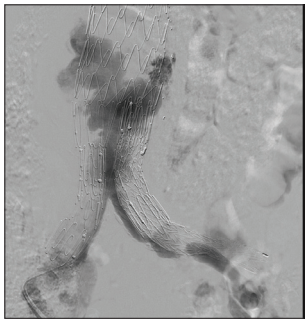

Figure 2. Angiogram showing transsealing catheterization of the sac.

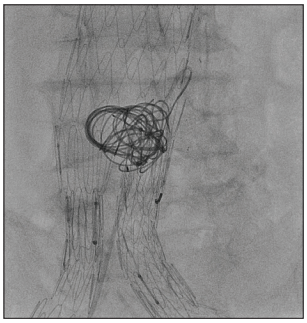

Figure 3. Embolisation of the sac with Ruby Coils.

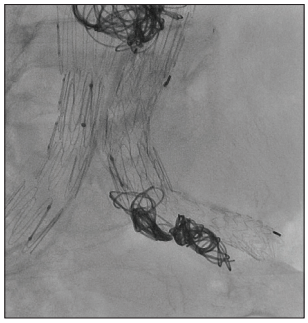

Figure 4. Embolisation of the left internal iliac artery with POD and POD Packing Coils.

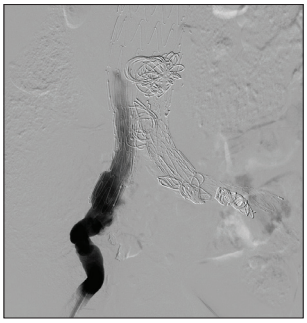

Figure 5. A control angiogram demonstrated the regular patency of the endoprosthesis in the absence of endoleak.

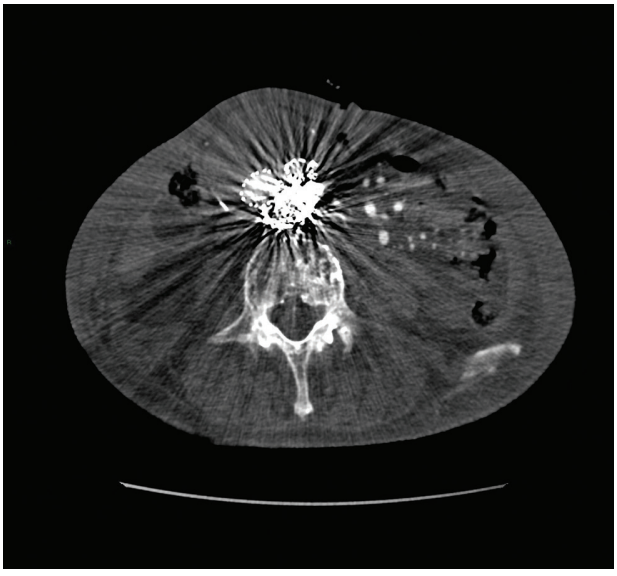

Figure 6. A CTA at 3-month follow-up showed no endoleak and a stable aneurysmal sac.

PULMONARY ARTERIOVENOUS MALFORMATION

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All coil embolisation procedures require the first coil to be accurately and securely placed, and this is particularly important in high-risk procedures such as closure of pulmonary arteriovenous malformations (PAVMs), where nontarget embolisation leading to stroke can be catastrophic. In these high-flow environments, POD provides a reliable anchor at the beginning of the embolisation procedure, as well as a high volume of coil material to facilitate and initiate an effective occlusion. Subsequent large-volume coils provide further high-density packing to eliminate the high-flow AV shunt effectively and safely, especially in hard-to-reach territories such as the peripheral pulmonary arterial branches.

WHY I CHOSE POD AND RUBY COIL

- POD provides a reliable anchor to facilitate and initiate an effective occlusion
- Penumbra large-volume Soft coils provide high-density packing to eliminate the high-flow AV shunt effectively and safely

CASE STUDY

A 39-year-old man with hereditary hemorrhagic telangiectasia was referred for embolisation of bilateral PAVM. He had recently been treated for a brain abscess secondary to the PAVMs and had respiratory symptoms with difficulty breathing and oxygen saturation as low as 88% on room air. A CT pulmonary angiogram demonstrated large, single, bilateral PAVM in the lower pulmonary lobes (Figure 1). The nidus of the PAVMs was sizable bilaterally with dilated draining pulmonary

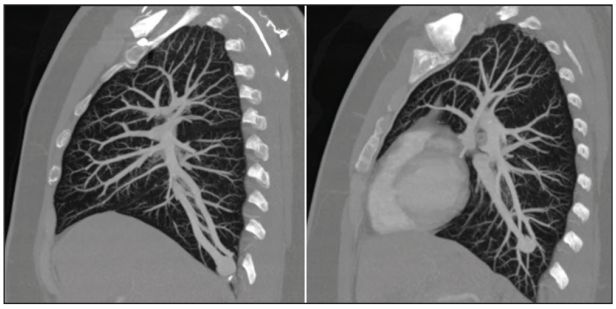

Figure 1. Oblique sagittal CT thick-slice reconstructions demonstrating right and left lower lobe PAVM.

veins (PVs). The right lung PAVM had a simple 1:1 pulmonary artery (PA)-to-PV connection, and the left lung PAVM had two feeding PAs and a single draining PV. After discussion at the PAVM multidisciplinary meeting, the patient was consulted in the interventional radiology clinic in the weeks before the procedure and consented appropriately for the embolisation. The procedure was subsequently carried out under general anesthesia as a day-case procedure without complication.

Right femoral vein access was achieved, and a 6-F, 90-cm hydrophilic vascular sheath was advanced to the main PA. A 5-F, 100-cm diagnostic catheter was then used to selectively catheterize the feeding vessel of the right lower lobe PAVM. Several oblique projection angiograms were obtained to select the most appropriate and safe view for embolisation. A coaxial microcatheter was then used to deliver a POD8 into the distal feeding vessel followed by Ruby Coils (Figure 2). Attention was then turned to the left lung, and the vascular sheath was advanced into the left PA. The coaxial catheter combination was then advanced toward the PAVM after appropriate oblique projection. A POD6 was deployed in the distal dominant feeding vessel, and both feeding arteries were subsequently embolised with Ruby Coils (Figure 3). Retraction and repositioning of the POD were possible to achieve accurate placement and deployment. Rapid and satisfactory embolisation was achieved bilaterally without sacrificing normal adjacent vessels or lung. A total of 440 cm of coil was delivered in just 13 devices. The patient was discharged later the same day, and a follow-up CT pulmonary angiogram 6 months later demonstrated satisfactory total occlusion of both PAVMs. The patient had a marked clinical response, and saturation was maintained at 99% on room air at follow-up.

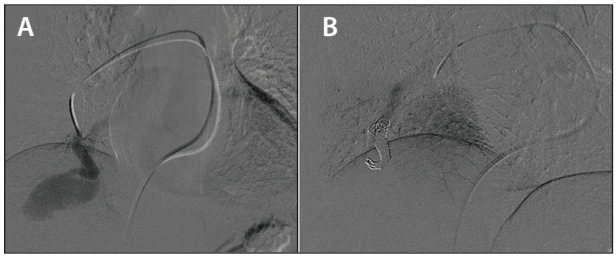

Figure 2. Digital subtraction angiogram of the right lower lobe PAVM pre- (A) and postembolisation (B) with POD and Ruby Coils.

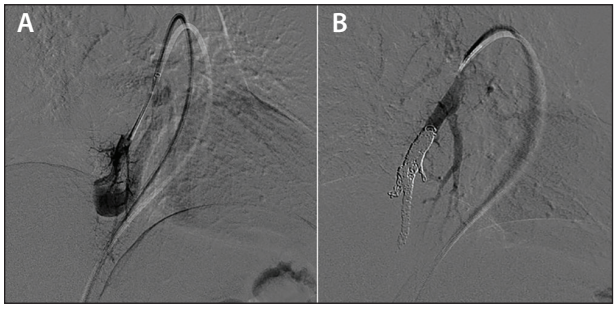

Figure 3. Digital subtraction angiogram of the left lower lobe PAVM pre- (A) and postembolisation (B) with POD and Ruby Coils.

DISCUSSION

PAVMs can be sporadic or associated with hereditary hemorrhagic telangiectasia. They can lead to stroke, cerebral abscess, and respiratory symptoms related to hypoxia. Total occlusion of the malformations is required to prevent these clinical scenarios. The consequences of nontarget embolisation in treating PAVMs can be catastrophic, and in my opinion, POD provides a threefold solution: (1) a robust distal anchor segment helps prevent migration of the coil mass; (2) the softness of the packing segment of the coil allows for dense packing for effective occlusion, which thereby reduces the chance of subsequent recanalization; and (3) added confidence with a reliable mechanical detachment.

PELVIC CONGESTION SYNDROME

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WHY I CHOSE RUBY COIL

- The coil is really soft, so it can be easily placed in the optimal position
- Vein occlusion is fast and efficient due to long coil length—up to 60 cm

A 40-year-old woman presented with abdominal pain that aggravated around the time of her period. The pain worsened during the day while standing for a long time and after exercise. The patient was a mother of three (all children delivered vaginally). The history of pain started after the third delivery.

Transvaginal ultrasonography was performed, which revealed multiple tortuous vessels with a slow blood flow in the parametrium. MRI was performed, which confirmed widening of the left ovarian vein (LOV) to 12 mm and right ovarian vein (ROV) to 8 mm and a widened venous parametrial plexus bilaterally. Both ovarian veins presented with evident reflux in dynamic MRI sequences (Figure 1). The pain was assessed with the use of the pain score scale.

Figure 1. Dynamic MRI sequence showing reflux in the LOV and ROV and widening of the parametrial plexus.

Figure 2. The connection between the left LOV and the left IIV.

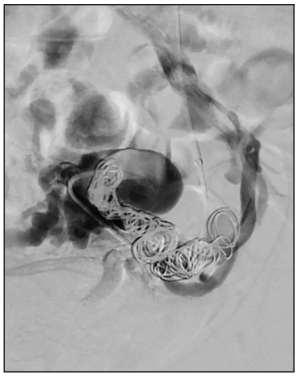

Figure 3. The biggest vein connecting the parametrial plexus and the left IIV occluded with three Ruby Coils.

The right internal carotid vein was punctured, and a 5-F, 70-cm-long, angled sheath was introduced. The LOV was catheterized with 4-F Berenstein catheter (Merit Medical Systems, Inc.), and a high-flow microcatheter was guided into the left parametrial plexus. Both the 4-F catheter and the 5-F sheath were then pushed forward to reach the inferior part of the LOV. Initial angiography confirmed large dilatation of the parametrial plexus with slow contrast outflow to both ovarian veins and the left internal iliac vein (IIV) (Figure 2).

The high-flow microcatheter was subsequently guided into the left IIV through three outflow veins, which were occluded with one Standard Ruby Coil (12 mm X 60 cm) and two Soft Ruby Coils (8 mm X 60 cm) in the largest vein (Figure 3) as well as one Soft Ruby Coil (8 mm X 60 cm) in the smaller veins.

After the connection to the left IIV was occluded, a foam of 3% aetoxisclerol and CO_2 (mixture 1:4) was injected (2 X 5 mL foam) during a Valsalva maneuver.

While withdrawing the microcatheter, the LOV with all branches were closed using six pushable coils in the lower part of the LOV and two Soft Ruby Coils in the mid and upper part of the LOV (Figure 4). The need for a higher number of pushable coils in the lower LOV highlights the volume advantage of Ruby Coils, which provide denser packing with a lower quantity of coils overall.

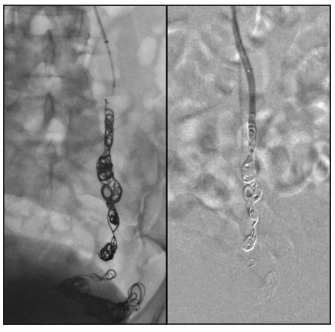

Figure 4. Successful occlusion of the LOV with the use of six pushable coils (12 mm X 14 cm) in the lower part of the LOV and two Ruby Coils (12 mm X 40 cm and 8 mm X 60 cm) in the mid and upper part of the LOV.

The same approach was used on the right side, occluding connection between the parametrial plexus and right IIV and then occluding the ROV.

During follow-up, the patient experienced mild pain in her lower abdomen for a week, which was successfully treated with over-the-counter pain medication. During 6-month follow-up, the patient had no pain in her daily life or after exercise. The mean pain score diminished from 6 to 0.

RENAL ARTERY ANEURYSM

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A 79-year-old man presented with an incidental finding of a partially thrombosed aneurysm of a hilar renal artery branch diagnosed 1 year ago. The aneurysm measured 27 mm on initial imaging and had increased to 32 mm on 1-year follow-up imaging. Additionally, there was a significant decrease of the thrombosed lumen from approximately 80% to an almost complete reperfusion under treatment with rivaroxaban. Both the increase in size and reperfusion resulted in the decision to embolise the aneurysm.

The procedure was performed under fluoroscopy in the angiography suite. Access was achieved via a 5-F left femoral sheath, as the patient had a history of right iliac occlusion. The right renal artery was catheterized with a 5-F guiding catheter under guidance of a hydrophilic 0.035-inch guidewire. Selective angiography of the renal vascular system was performed, confirming an aneurysm deriving from the middle hilar renal branch (Figure 1A). Selective catheterization of the lumen of the aneurysm was achieved using a 2.6-F LANTERN high-flow microcatheter with a 45° angled tip under guidance of a 0.016-inch hydrophilic guidewire.

After confirming the correct position of the microcatheter inside of the aneurysm, the perfused part was measured at 32 X 24 mm (Figure 1B). The embolisation was started by placing two 24-mm X 57-cm Standard Ruby Coils, creating a frame. After that, four 20-mm X 60-cm Soft Ruby Coils were deployed to fill the sacculus. No kickback or dislocation of the microcatheter was observed at any time throughout coil placement. Only six coils were needed to achieve total occlusion of the aneurysm, resulting in a very quick and safe embolisation. During and after embolisation, the originating renal artery branch was patent at all times and the associated renal parenchyma remained perfused, resulting in no parenchymal loss (Figure 2). Additionally, no stent was used.

WHY I CHOSE RUBY COIL

- Ruby Coil's large diameter and three-dimensional shape provide a precise solution for framing and filling large aneurysms while maintaining patency of the parent vessel
- Large-volume coils reduce the number of coils needed per case, resulting in faster procedures

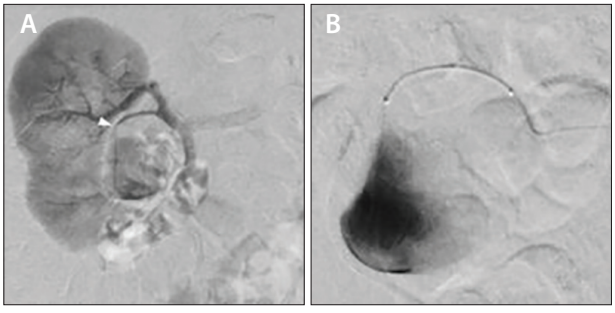

Figure 1. Selective angiogram of the right renal artery showing an aneurysm of the middle hilar renal branch with a small neck (arrowhead) (A). Superselective angiogram of the aneurysm for planning the embolisation. The perfused lumen measured 32 X 24 mm (B).

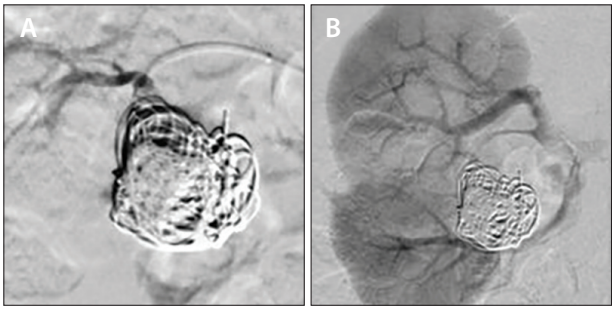

Figure 2. During embolisation (five coils placed), the renal branch from which the aneurysm originated was perfused distally of the aneurysm at all times (A). Final angiogram after embolisation with a total occlusion of the aneurysm using only six large-volume coils (B).

ESOPHAGEAL VARICES

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A 52-year-old man with a history of type 2 diabetes mellitus with microvascular complications (diabetic retinopathy and diabetic nephropathy) and cirrhosis of enolic origin diagnosed in early 2018, digestive endoscopy performed in the past year with esophageal varices and hypertensive gastropathy, and multiple admissions due to edematoascitic decompensation presented to the emergency department for a progressive increase of the abdomen and swelling of the lower limbs. His last paracentesis was 4 days prior to this presentation. Evacuated paracentesis was performed with an output of 15 L of ascitic fluid without signs of spontaneous bacterial peritonitis. The analysis of the ascitic fluid showed worsening of his renal function and signs of urinary tract infection.

During hospitalization, he required two red blood cell concentrates for suspected multifactorial anemia. Due to the frequent need for evacuated paracentesis, at least three in the last 2 weeks, transjugular intrahepatic portosystemic shunt (TIPS) was performed with a right jugular approach, and a GORE VIATORR TIPS Endoprosthesis (Gore & Associates) was placed, which obtained a gradient of 9 mm Hg. Angiography post-TIPS showed persistence of two gastroesophageal varices (Figure 1) .

Given this situation, it was decided to proceed with the embolisation of varicose veins. After placement of a 4-F Cobra diagnostic catheter through the TIPS, a microcatheterization of the two highest-caliber varicose veins was performed with a LANTERN high-flow microcatheter. In the first varicose vein, a 6-mm X 30-cm Ruby Coil was placed, followed by a 60-cm POD Packing Coil. In the second varicose vein, a 6-mm X 30-cm Soft Ruby Coil was placed, followed by a 60-cm POD Packing Coil (Figure 2). We achieved the complete occlusion of both varices in < 10 minutes from the start of embolisation (Figure 3).

The patient was discharged from the hospital 24 hours after embolisation.

WHY I CHOSE POD PACKING COIL

- POD Packing Coil's "liquid-metal" design seeks out collateral vessels without the need for catheterization

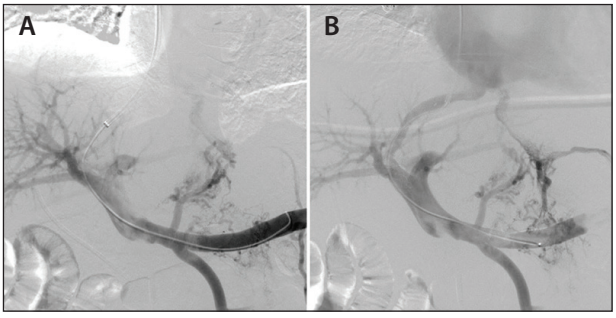

Figure 1. Direct portography prior to TIPS showing gastroesophageal varices (A). Portography post-TIPS with persistent varices (B).

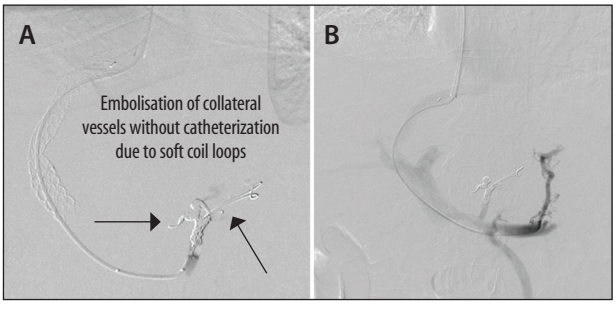

Figure 2. Occlusion of the first embolised varicose vein (6-mm X 30-cm Ruby Coil and 60-cm POD Packing Coil) (A). Microcatheterization of the second varicose vein (B).

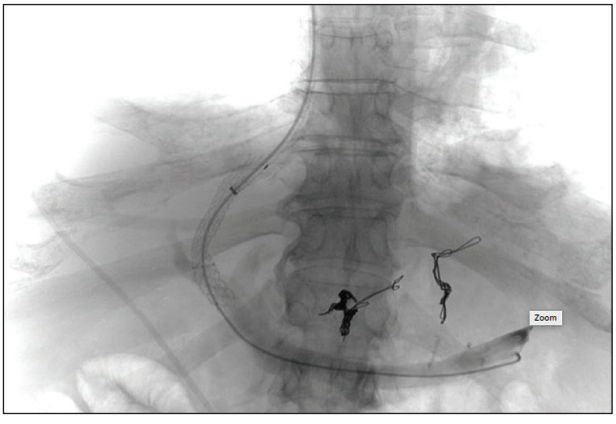

Figure 3. Final result showing permeable TIPS with varicose occlusion.

VISCERAL ARTERY ANEURYSM

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A 78-year-old woman underwent an abdominal ultrasound for recurrent pain in the right upper quadrant. The examination revealed an aneurysm near the pancreas head. CTA showed a saccular aneurysm of the anterior duodenopancreatic arcade fed by the gastroduodenal artery, which reached 16 mm at its great axis with a large circulating lumen and thin wall thrombosis. The aneurysm was not complicated (Figure 1). No celiac trunk stenosis was found. We concluded that the aneurysm was of fibrodysplastic origin and needed to be embolised to avoid rupture.

From femoral artery access, a long introducer sheath was easily positioned in the celiac trunk to provide stability for microcatheterization and embolisation (Figure 2). The aneurysm was catheterized with a Cobra-shaped catheter, and a LANTERN high-flow microcatheter was advanced and crossed over the aneurysm until it reached the efferent vessel (the right gastro-omental artery), which was then embolised with 5-mm X 20-cm and 5-mm X 30-cm Ruby Coils. Then, the microcatheter was positioned into the aneurysm cavity. Angiography confirmed good location of the microcatheter (Figure 3). The aneurysm lumen was embolised with multiple Standard and Soft Ruby Coils. Care was taken to gradually withdraw the microcatheter until the tip of the microcatheter was located in the very short afferent feeding artery, and it was closed safely by deploying another Ruby Coil.

The final control angiogram showed complete occlusion of the aneurysm and the preservation of hepatic and pancreatic vasculature through the hepatic artery and the other duodenopancreatic arcades (Figure 4).

DISCUSSION

The prevalence of splanchnic arcade aneurysms is 0.01% to 0.2%, and 60% of them are true aneurysms. Duodenopancreatic arcade aneurysms represent 2% to 10%, and rupture may reveal the disease in 62% of patients regardless of the aneurysm size.[1,2] Mortality may reach 21% in case of rupture,[3] which leads to preventive embolisation or surgery. ■

1. Horton KM, Smith C, Fishman EK. MDCT and 3D CT angiography of splanchnic artery aneurysms. AJR Am J Roentgenol. 2007;189:641-647.
2. Tétreau R, Beji H, Henry L, et al. Arterial splanchnic aneurysms: presentation, treatment and outcome in 112 patients. Diagn Interv Imaging. 2016;97:81-90.
3. Moore E, Matthews MR, Minion DJ, et al. Surgical management of peripancreatic arterial aneurysms. J Vasc Surg. 2004;40:247-253.

WHY I CHOSE RUBY COIL

- Ruby Coils provide a solution for compact embolisation and are similar to 035 coils in volume, yet are microcatheter deliverable

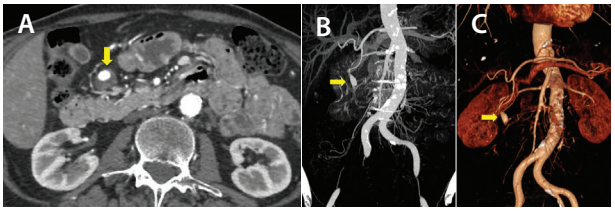

Figure 1. Axial CT scan showing a true aneurysm near the duodenopancreatic rim (arrow). Note the large circulating lumen and crescentic wall thrombosis (A). Maximum-intensity projection (B) and volume-rendering technique (C) CT reconstructions clearly show the aneurysm originating at the end of the gastroduodenal artery.

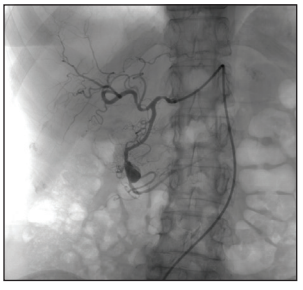

Figure 2. Hepatic artery angiography.

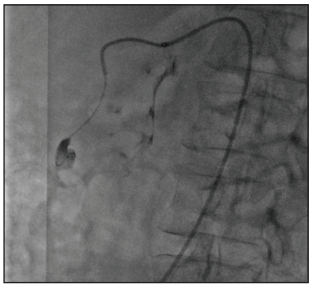

Figure 3. The LANTERN high-flow microcatheter positioned within the aneurysm sac.

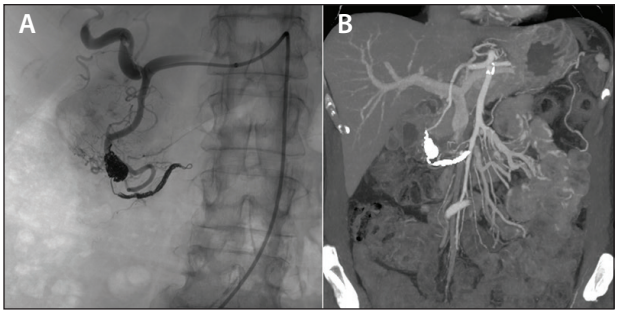

Figure 4. Angiography after embolisation (A) and 3-month follow-up CT scan (B) showing complete occlusion of the aneurysm. Ruby Coils were placed in outflow and in the aneurysm sac.

Drs. Guzzardi, Jones, Pietura, Zeile, and Pardo Moreno were compensated in association with this article.

Disclaimer: The opinions and clinical experiences presented herein are for informational purposes only. The results may not be predictive of all patients. Individual results may vary depending on a variety of patient-specific attributes.