Ruby Coil and POD System: Tools for Dense and Durable Embolisation

BY DR. MED. ALEXANDER MASSMANN

Penumbra, Inc.'s embolisation system continues to provide tools for interventionalists to conduct durable and efficient embolisations. The embolisation system is composed of three unique coil technologies: the Ruby Coil, POD (Penumbra Occlusion Device), and POD Packing Coil—all of which are large-volume coils that are similar in caliber to a 035 coil and are deliverable through LANTERN, a high-flow microcatheter (Figure 1).

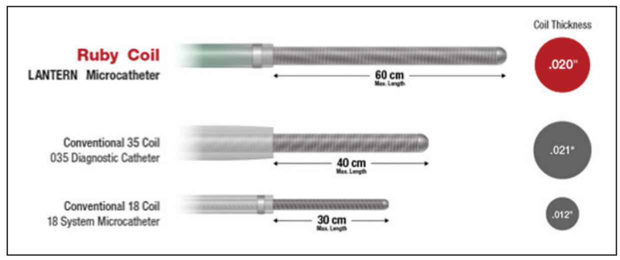


Figure 1. Volume advantage size comparison of the Ruby Coil versus a conventional 035 coil and a conventional 018 coil. Image provided by Penumbra, Inc.

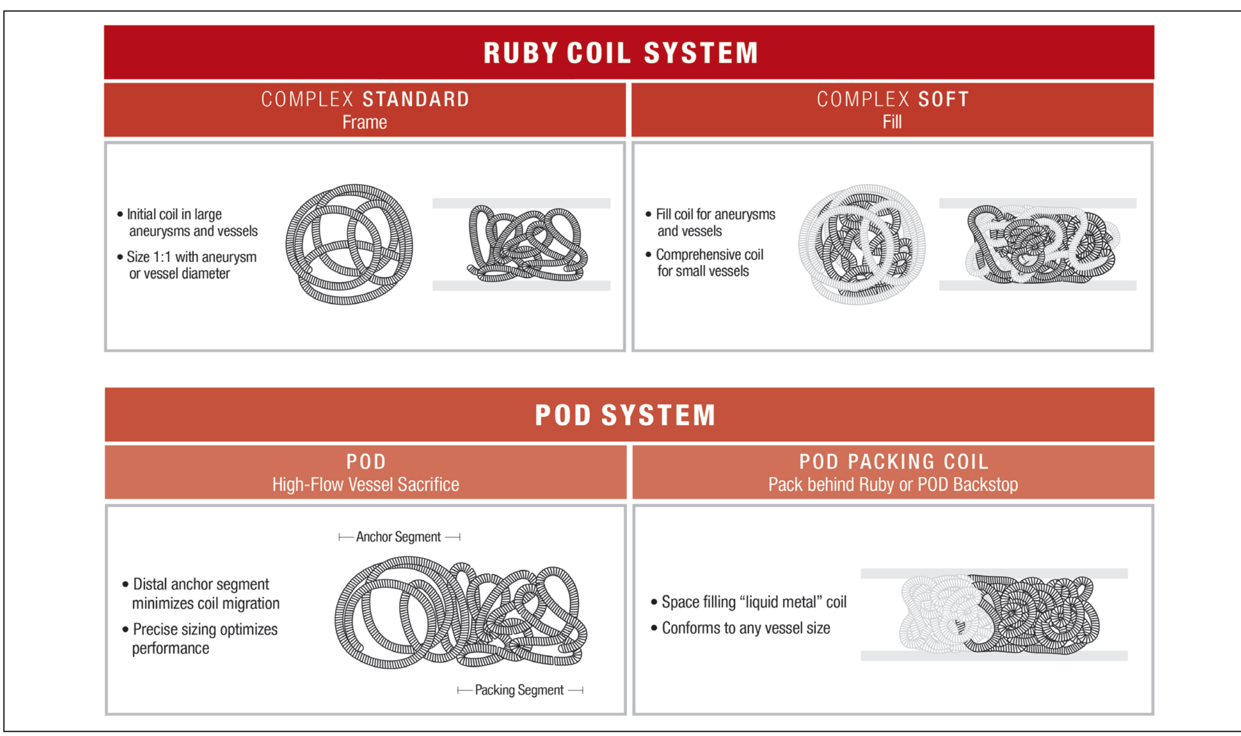
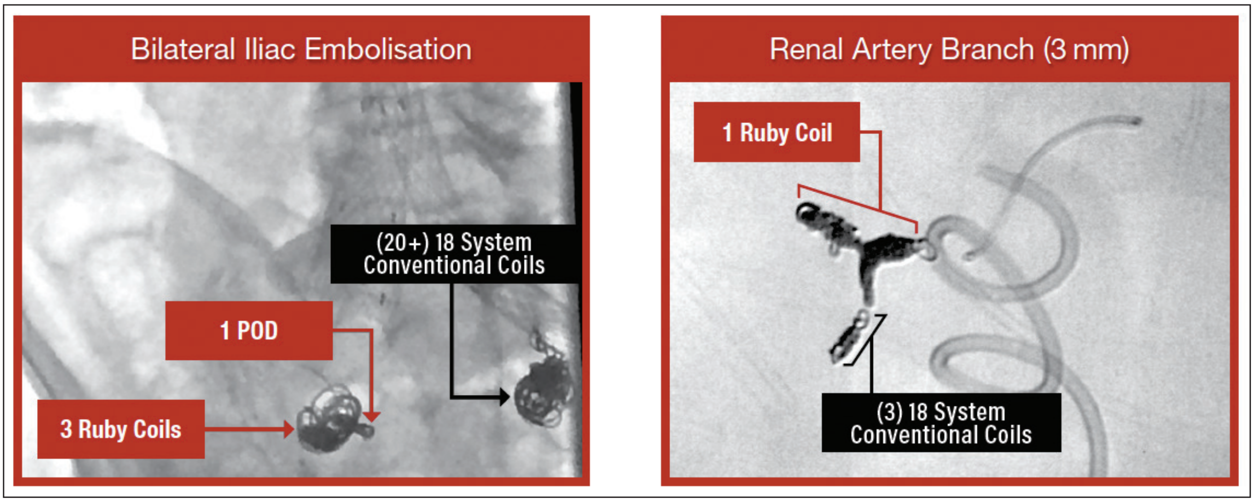


Figure 2. A complete coil embolisation platform. Ruby Coil features a three-dimensional shape and is available in standard and soft configurations. Standard coils frame aneurysms or vessels, and soft coils pack densely within or behind a standard coil. POD is a progressively soft coil with a built-in anchor, helping to simplify vessel sacrifice. POD Packing Coil is like liquid metal. The device has no stated diameter and is designed to pack behind a POD or Ruby backstop. The softness of the coil allows it to conform to any vessel that accommodates a microcatheter. Image provided by Penumbra, Inc.



Courtesy of Dr. Herbert Cordero, St. Rose Dominican Siena Campus, NV.

Courtesy of Dr. Christopher DeMaioribus, Essentia Health, MN.

Figure 3. Dense and efficient packing in large lesions and in small vessels.

Coil shape and softness differentiates each technology. Ruby Coil is a versatile coil that features 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 is designed to make high-flow vessel sacrifice easier. The distal tip of the device is stiffer, helping the coil to anchor in the vessel. Proximally, the coil becomes softer, allowing the operator to pack densely behind the anchor segment.

POD Packing Coil is like liquid metal. The device has no stated diameter and is designed to pack behind or within a POD or Ruby backstop. The extreme softness of the coil allows the device to conform to various vessel size, reducing the necessity to measure and giving operator the ability to deliver coils up to 60 cm in small vessels (Figure 2).

PRODUCT ADVANTAGES

Ruby and POD offer longer lengths, larger volume, and softer coils compared to conventional coil technologies. The volume and softness of these coils offer important advantages over conventional technologies. Not only can embolisation be performed with fewer devices per case, but more embolic material can be delivered 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).

DATA

Ruby, POD, and POD Packing Coil are designed to achieve high packing density. In cerebral aneurysms, packing density is known to be a leading factor in stable embolic occlusions.[1,2] Studies have supported that dense volumetric filling > 24% of the aneurysm volume promotes occlusion stability in the neurovasculature.[3,4] In the peripheral vasculature, Yasumoto et al found that in aneurysms with packing density of at least 24%, no compaction or recanalization occurred.[5]

The ACE registry was a single-arm, multicenter registry that was designed to further validate the concept of packing density in peripheral aneurysms and apply the concept of packing density to vessel sacrifice.[6] The initial analysis showed a decrease in recanalization rates compared to conventional fibered coil technology that has been shown to recanalize in approximately 20.4% of patients.[6]

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2. Slob MJ, Sluzewski M, van Rooij WJ. The relation between packing and reopening in coiled intracranial aneurysms: a prospective study. Neuroradiology. 2005;47:942-945.
3. Kawanabe Y, Sadato A, Taki W, Hashimoto N. Endovascular occlusion of intracranial aneurysms with Guglielmi detachable coils: correlation between coil packing density and coil compaction. Acta Neurochir (Wien). 2001;143:451-455.
4. Piotin M, Spelle L, Mounayer C, et al. Intracranial aneurysms: treatment with bare platinum coils—aneurysm packing, complex coils, and angiographic recurrence. Radiology. 2007;243:500-508.
5. Yasumoto T, Osuga K, Yamamoto H, et al. Long-term outcomes of coil packing for visceral aneurysms: correlation between packing density and incidence of coil compaction or recanalization. J Vasc Interv Radiol. 2013;24:1798-1807.
6. Enriquez J, Javadi S, Murthy R, et al. Gastroduodenal artery recanalization after transcatheter fibered coil embolisation for prevention of hepaticoenteric flow: incidence and predisposing technical factors in 142 patients. Acta Radiol. 2013;54:790-794.

CASE REPORTS

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GASTROINTESTINAL BLEEDING

WHY I CHOSE PENUMBRA LARGE-VOLUME COILS

- The coil softness allows precise delivery that reduces the risk of microcatheter "kick out" and nontargeted vessel embolisation and enables complete and rapid occlusion of the artery

A woman in her 60s was admitted to the emergency department after failed endoscopic treatment for active bleeding of a duodenal ulcer. CTA confirmed the location of the bleed and showed occlusion of the celiac trunk with hypertrophy of the pancreaticoduodenal anastomoses and the dorsal pancreatic artery. The patient's hemodynamics worsened despite fluid and blood replacement. The patient was sent to the angiography suite for selective transcatheter arterial embolisation.

Right femoral artery access was achieved with a 6-F sheath. Selective arteriography of the superior mesenteric artery (SMA) was performed via a 6-F guiding catheter that confirmed the presence of contrast extravasation sustained by a pseudoaneurysm of the anterior pancreaticoduodenal arcade with inverted blood flow (Figures 1 and 2). Superselective catheterization of the bleeding vessel was performed with a coaxial system using a 4-F diagnostic vertebral catheter, a high-flow microcatheter, and a 0.014-inch guidewire. Superselective embolisation was performed with a sandwich technique, and inflow and outflow vessels were both embolised using standard and soft coils. Standard Ruby Coils were deployed first, forming a backstop for soft coils to pack densely behind. The sandwich technique is performed for pseudoaneurysms that are likely to have collateral inflow vessels. The occlusion is performed distal, across, and proximal to the neck of the pseudoaneurysm, embolising the efferent (back door) and afferent artery. Final angiography confirmed complete exclusion of the bleeding vessel, absence of further active bleeding, and patent posterior pancreaticoduodenal arcade (Figure 3).

Figure 1. A selective SMA arteriogram confirmed active bleeding (arrow) from the reversed pancreaticoduodenal arch.

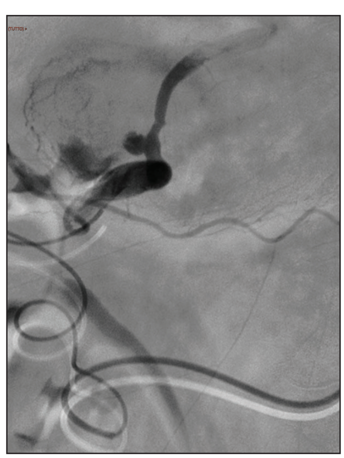

Figure 2. Superselective catheterization of a small-caliber tortuous artery using a coaxial system.

Figure 3. Final angiogram after coil embolisation with standard and soft coils shows complete occlusion of the bleeding lesion.

Images courtesy of Nicola Cionfoli, MD.

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TYPE I ENDOLEAK

WHY I CHOSE RUBY COIL AND LANTERN

- Ruby Coil: 60-cm soft coils and sizes up to 32 mm allow efficient embolisations of large endoleak cavities
- LANTERN: Dual marker band system and radiopaque distal shaft that enables safe coil deployment and is easily visualized in front of or behind endografts

A man in his 70s underwent endovascular aneurysm repair in 2014. A CT scan 4 weeks later showed a proximal type I endoleak along the right side of the upper end of the endograft (Figure 1). At the time, it was decided that the endoleak was not suitable for conventional management options and the patient underwent a successful embolisation procedure with three detachable Ruby Coils and 3 mL of Onyx liquid embolic agent (Medtronic) (Figure 2). Large-volume Ruby Coils served as a scaffold and limited the quantity of Onyx to achieve a complete embolisation.

Three years later, surveillance imaging showed a recurrent endoleak due to inferior migration of the endografts (Figure 3). To address the migration, two additional endografts were placed superiorly. Despite superior extension of endograft coverage, the endoleak persisted and required embolisation.

The endoleak was catheterized through femoral artery access with a reverse hook–shaped diagnostic catheter followed by advancement of a LANTERN microcatheter into the endoleak cavity (Figure 4). Angiography confirmed good location of the catheter in the endoleak and a moderately large endoleak cavity. The endoleak cavity was embolised with multiple large-diameter Ruby Coils with lengths up to 60 cm through the LANTERN microcatheter.

After embolising the endoleak cavity, the LANTERN microcatheter was retracted to the entrance of the endoleak for further embolisation. The endoleak entrance was closed by deployment of soft Ruby Coils (Figure 5). Because of the tightness of packing, use of a liquid embolic agent was not considered necessary. Completion angiography showed complete occlusion of the endoleak cavity with the coils (Figure 6).

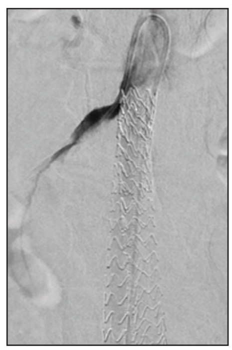

Figure 1. An angiogram of the endoleak cavity in 2014 performed with a Simmons catheter in the endoleak.

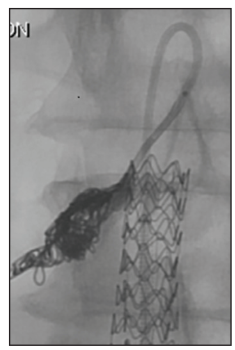

Figure 2. Initial embolisation completion angiogram showing complete exclusion of the endoleak.

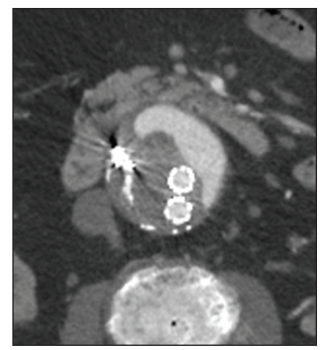

Figure 3. Three-year follow-up CT scan showing a recurrent type I endoleak.

Figure 4. High-flow angiography performed through a LANTERN microcatheter defined the extent of the recurrent endoleak cavity.

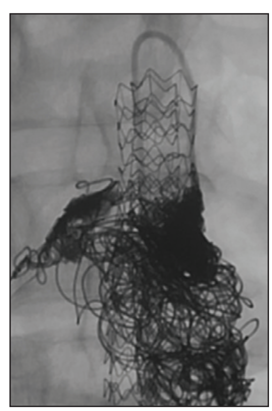

Figure 5. The endoleak cavity and entrance were filled with multiple Ruby Coils.

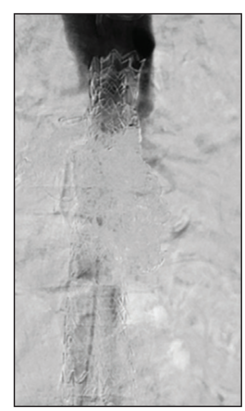

Figure 6. Angiogram after coil embolisation showed complete occlusion of the endoleak cavity.

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IMA SACRIFICE—TYPE II ENDOLEAK

WHY I CHOSE POD PACKING COIL AND LANTERN

- POD Packing Coil: Densely packs without the need to size the vessel diameter
- LANTERN: Dual marker band system enables precise coil deployment

A 65-year-old patient presented with a slightly progressing infrarenal aneurysm 12 months after endovascular aneurysm repair. Contrast-enhanced ultrasound and CT confirmed a type II endoleak via retrograde perfusion of a large inferior mesenteric artery (IMA). Based on the curved vessel course of the SMA supporting the Riolan's anastomosis, cranial cannulation was favored.

Accordingly, left transradial access was achieved using a 4/5-F slender sheath (Figure 1). After accessing the SMA using a double-curved 5-F catheter, coaxial cannulation of the IMA was performed using a 2.6-F LANTERN microcatheter (Figure 2). A POD coil was first placed within the vessel, forming a backstop for POD Packing Coil. POD Packing Coil was then selected to densely pack behind the POD. This resulted in a complete cross-

Figure 1. Digital subtraction angiogram showing the SMA, Riolan's anastomosis, and feeding of a type II endoleak via the IMA.

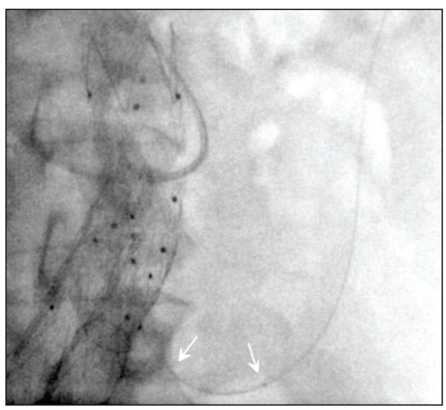


Figure 2. IMA cannulation with LANTERN microcatheter via SMA. Arrows mark LANTERN microcatheter dual markers.

Figure 3. Dense packing of initial backstop coil within the IMA.

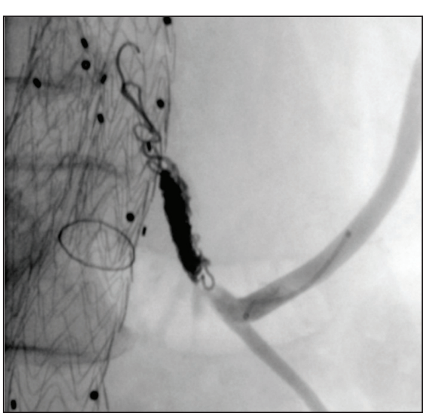


Figure 4. Final angiogram showing dense packing with POD and POD Packing Coil with no flow beyond coil mass and no obstruction of the rectal arteries.

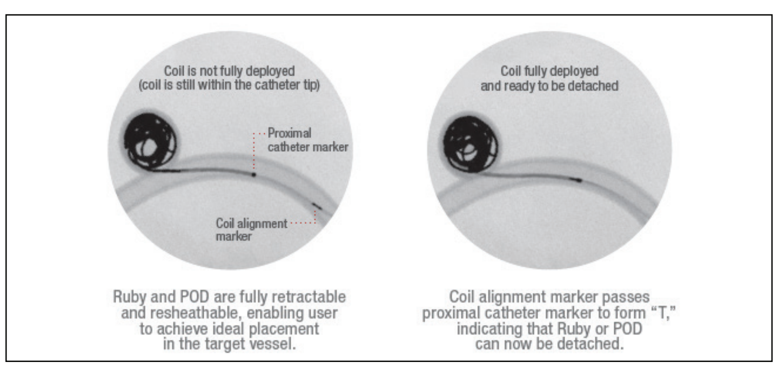
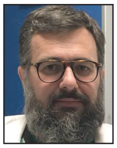


Figure 5. The LANTERN radiopaque distal shaft and proximal marker are easily visualized when the catheter tip is buried within a coil mass. The coil alignment marker enters the visual field and approaches the LANTERN proximal marker as the coil exits the catheter. When the coil alignment marker crosses LANTERN's proximal marker band (forming a "T"), this signifies that the coil is fully outside the distal tip of the microcatheter and can be detached. Photograph taken by and on file at Penumbra, Inc.

sectional metal occlusion. (Figure 3). Final angiography confirmed successful sacrifice of the IMA (Figure 4), and 3-month follow-up demonstrated aneurysm shrinkage after closure of the type II endoleak.

Precise coil deployment was aided by LANTERN's radiopaque distal 3-cm tip and dual marker band system. With traditional single marker band microcatheters, it can be challenging to know when the coil has exited the microcatheter when the tip is buried in a dense coil mass.

Ruby, POD, and POD Packing Coil work in conjunction with LANTERN microcatheter. When the recessed marker on the coil pusher crosses the LANTERN proximal marker, the coil can be confidently detached, even when the tip of the catheter cannot be visualized (Figure 5).



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VARICOCELE

WHY I CHOSE **POD**

- The distal anchor segment allows for precise vessel anchoring

An infertile man in his late 20s presented with a left-sided varicocele that we categorized as grade 3 during clinical examination. On Doppler ultrasound, the reflux during the Valsalva maneuvers confirmed a severe degree of varicocele. After induction of local anesthesia, the right femoral vein was percutaneously accessed, and a 5-F sheath was inserted with a catheter that had a curve specifically shaped for the spermatic vein. Subsequently, the spermatic vein was catheterized using a 0.035-inch hydrophilic wire and a 5-F diagnostic catheter.

Selective phlebography was performed during the Valsalva maneuver with the aim of demonstrating venous incontinence and dilatation of the veins of the pampiniform plexus (Figure 1). A straight 150-cm LANTERN microcatheter was then advanced into the internal spermatic vein and placed at the level of the hip joint. Subsequently, a POD8 was positioned to achieve distal occlusion (Figure 2). Venography performed at the end of the procedure with a Valsalva maneuver showed complete embolisation of the spermatic vein feeders with a single POD (Figure 3).

Total procedure time was 13 minutes. The patient was discharged after 6 hours of observation.

Figure 1. Selective phlebogram confirming venous incontinence and dilatation of the veins of the pampiniform plexus.

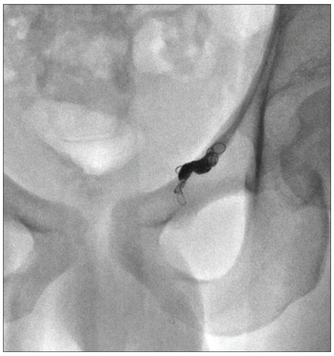

Figure 2. POD8 precisely placed within spermatic vein proximal to multiple feeding veins.

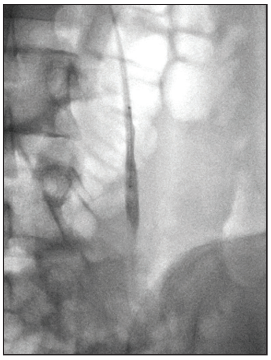

Figure 3. Final phlebogram after coil embolisation showing complete embolisation of the spermatic vein.


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BRONCHIAL ARTERY ANEURYSM

WHY I CHOSE RUBY, POD, AND POD PACKING COIL

- It's a complete embolisation platform of soft coils for dense and precise vessel packing and aneurysm exclusion

A man in his late 30s with cystic fibrosis was admitted to the emergency department after a major hemoptysis of 250 mL in the past 24 hours. His medical history included previous episodes of hemoptysis in earlier years that required embolisation, including coil embolisation at another center. A pre-embolisation CT scan showed hypertrophic bronchial arteries with 5-mm diameter and an aneurysm in a bronchial artery with abnormal origin (cranial wall of the aortic arch between the left subclavian and carotid arteries) (Figure 1).

Using right femoral access, a bibronchial trunk, aberrant right bronchial artery, and right intercostal-bronchial artery were embolised with 500–700-µm beads to control the bleed. Later, the case was presented in a multidisciplinary meeting where elective aneurysm embolisation was indicated. Under general anesthesia and aseptic conditions through left humeral access, aortography was performed (Figure 2). A 4-F Simmons 1 catheter was advanced until the tip was placed in the origin of the aneurysmal bronchial artery. A LANTERN microcatheter was advanced distally, and again, 500–700-µm beads were used for distal embolisation.

With the microcatheter still in the vessel outflow, a POD6 was placed as a backstop within the 6-mm vessel. Proximally, 60- and 45-cm POD Packing Coils packed densely behind the POD6 backstop. The shapeless coils conformed to the vessel diameter without need to size. To embolise the aneurysm sac, standard Ruby Coils sized 1:1 first framed the aneurysm. Soft Ruby Coils were then selected to pack densely within the previously placed frame. The final control imaging demonstrated occlusion of the vessel (Figure 3). The patient remains asymptomatic 12 months after the procedure.

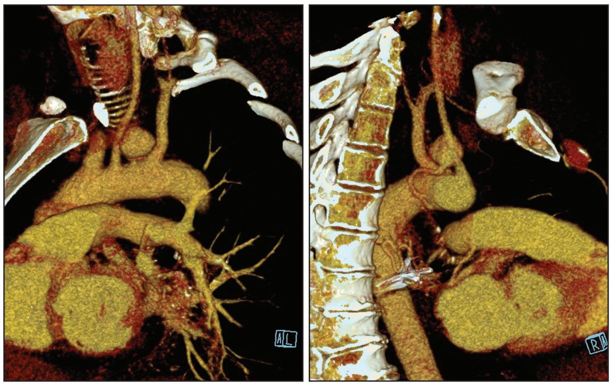

Figure 1. A three-dimensional reconstruction of a CTA showing the aneurysmatic origin of an aberrant bronchial artery.

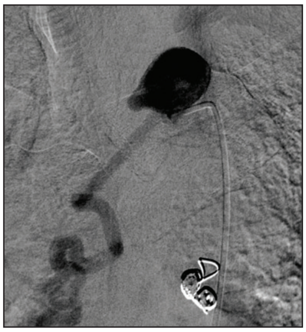

Figure 2. Selective angiogram showing a hypertrophic bronchial artery with a 20- X 19-mm aneurysm at its origin.

Figure 3. Control angiogram showing dense packing of the coils and occlusion of the embolised vessel.

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INFERIOR PANCREATICODUODENAL ARTERY ANEURYSM

WHY I CHOSE RUBY COIL

- Detachable coils help to make the endovascular treatment of visceral aneurysms safer and easier
- They are available in a wide range of diameters (3–32 mm) and lengths (up to 60 cm)
- The large volume allows for a decrease in the number of coils to obtain the proper coil packing density and reduce the rate of recanalization

A woman in her 60s presented with abdominal pain and was referred to the interventional radiology suite by the vascular surgery department. A previous Doppler ultrasound examination and CTA scan revealed a large aneurysm of the inferior pancreaticoduodenal artery (42 X 21 X 23 mm) in association with celiac trunk occlusion due to median arcuate ligament compression (Dunbar syndrome). To treat the wide-necked aneurysm, we planned to first lay a stent across the aneurysm neck, then densely pack the aneurysm with soft, large-volume Ruby Coils.

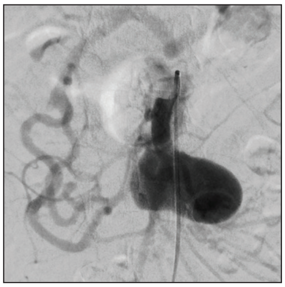

Figure 1. Using arteriography, a large, saccular, wide-neck aneurysm of the inferior pancreaticoduodenal artery could be visualized.

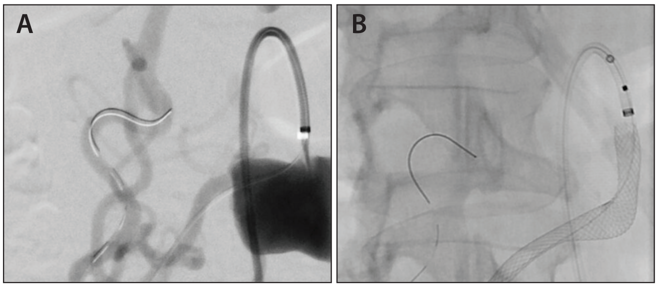

Figure 2. A LANTERN microcatheter with a 0.014-inch soft guidewire was advanced beyond the aneurysm into the outflow vessel close to the connection with the hepatic artery (A). To deliver the stent, the guidewire was exchanged for a supporting 0.014-inch guidewire. After removing the LANTERN microcatheter, a low-profile, self-expanding stent was implanted across the neck of the aneurysm (B).

The right common femoral artery was accessed, and a short 6-F sheath was introduced. A 5-F diagnostic C1 catheter was placed in the ostium of the SMA. Using arteriography, a large, saccular, wide-neck aneurysm of the inferior pancreaticoduodenal artery could be visualized (Figure 1).

To access the lesion, a triaxial system was used. After placement of a 6-F, 45-cm angled vascular sheath in the proximal part of the SMA, a 4-F hydrophilic diagnostic catheter was inserted more distally in the SMA trunk. A Penumbra microcatheter with a 0.014-inch soft guidewire was then advanced beyond the aneurysm into the outflow vessel close to the connection with the hepatic artery.

To deliver the stent, the soft 0.014-inch guidewire was exchanged for a supporting 0.014-inch guidewire. After removing the LANTERN microcatheter, a low-profile, self-expanding stent was implanted across the neck of the aneurysm (Figure 2).

To coil embolise the aneurysm sac, the dual marker microcatheter was reinserted over the 0.014-inch wire and tracked between the stent struts and into the aneurysm sac. The aneurysm was first framed, starting with 32-mm X 60-cm Standard Ruby Coils. The complex, three-dimensional shape distributed across the aneurysm dome. Smaller-diameter soft coils were then selected to densely pack. Twenty coils, all 50 cm or longer, were deployed, reaching a packing density of 22.17%. Arteriography performed at the end of the procedure showed total exclusion of the aneurysm with good patency of the parent vessel and no symptoms of impaired hepatic circulation (Figure 3).

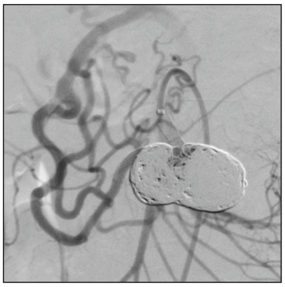

Figure 3. Arteriography performed at the end of the procedure showed total exclusion of the aneurysm with good patency of the parent vessel and no symptoms of impaired hepatic circulation.

At 18-month follow-up, color Doppler ultrasound and contrast-enhanced MRA confirmed a durable result. No recanalization of the aneurysm and no liver ischemia were observed. Clinical symptoms, including abdominal pain, were resolved. ■

Dr. Corti, Dr. Morgan, Dr. Massmann, Dr. Spinazzola, Dr. Gómez Muñoz, and Dr. Maciag are consultants to Penumbra, Inc. and 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.