Ruby, POD, Packing Coil, and LANTERN: A Complete Embolization Platform for Both Aneurysms and Vessels

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Penumbra, Inc. has introduced a complete embolization platform that facilitates durable and efficient embolization in more lesions. The embolization system is made up of three unique detachable coil technologies: the Ruby® Coil, POD® (Penumbra Occlusion Device), and Packing Coil—all of which are large-volume coils, similar in caliber to a 035 coil, and deliverable through the company's LANTERN® high-flow microcatheter.

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 anchor within vessels, which simplifies vessel sacrifice, even in high flow. The distal tip of the device is robust, helping the coil to engage the vessel wall. Proximally, the coil becomes softer, allowing the operator to pack densely behind the

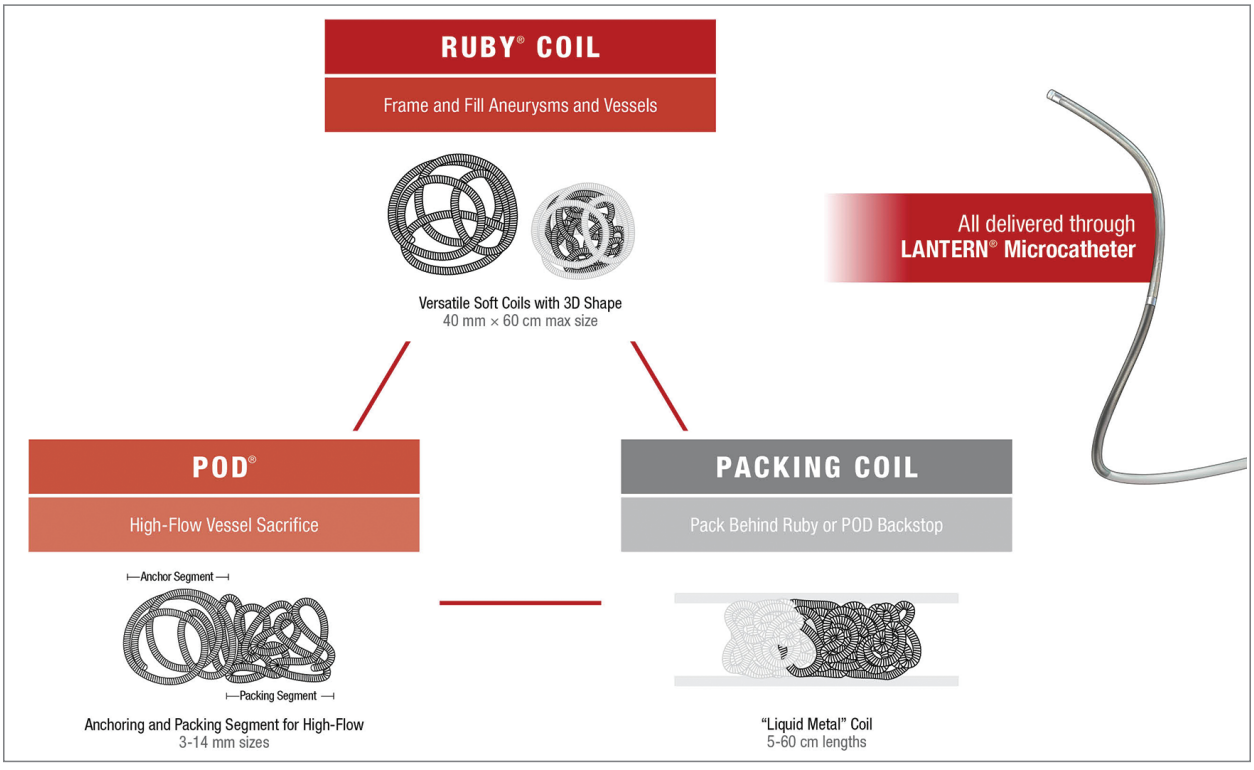
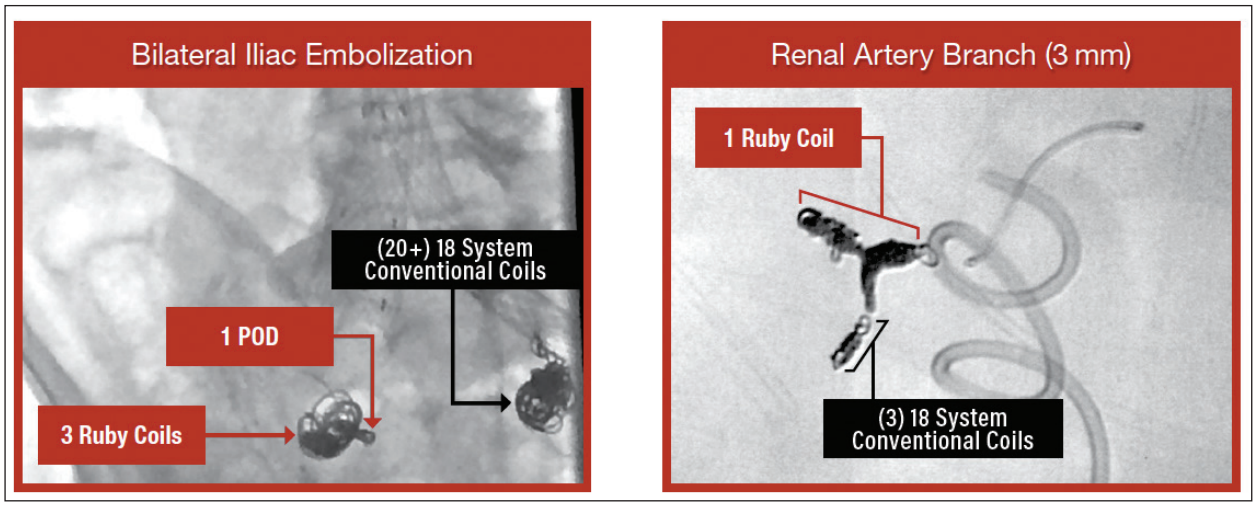


Figure 1. The Penumbra embolization system.



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

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

Figure 2. Dense and efficient packing in large lesions and in small vessels.

anchor segment. Finally, Packing Coil has no stated diameter and is designed to densely pack in any size vessel. Like "liquid metal," the 5- to 60-cm Packing Coils pack densely behind a Ruby or POD backstop (Figure 1).

VOLUME ADVANTAGE AND COST SAVINGS

Ruby, POD, and Packing Coil offer longer lengths, larger volume, and softer coils compared to conventional coil technologies. Not only can we perform embolization with fewer devices per case, but we can deliver 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.

In both small vessels and large lesions, the increased volume of Ruby, POD, and Packing Coil have proven to be cost-effective compared to other detachable coils. The larger coil volumes and longer available lengths have helped dramatically reduce the number of coils per case, limiting case cost and reducing procedure time and radiation exposure (Figure 2).

ENDOLEAK CASE EXPERIENCE WITH RUBY, POD, AND PACKING COIL

The versatility and low-profile delivery of Ruby, POD, and Packing Coil have increased efficiency and simplified treatment in my endoleak practice. Through transarterial, translumbar, and transcaval approaches, Ruby Coils up to 40 mm in diameter and 60 cm in length frame aneurysm sacs; POD anchors within outflow vessels and Packing Coils densely pack within a nest of Ruby Coils or behind a POD backstop (Figure 3).

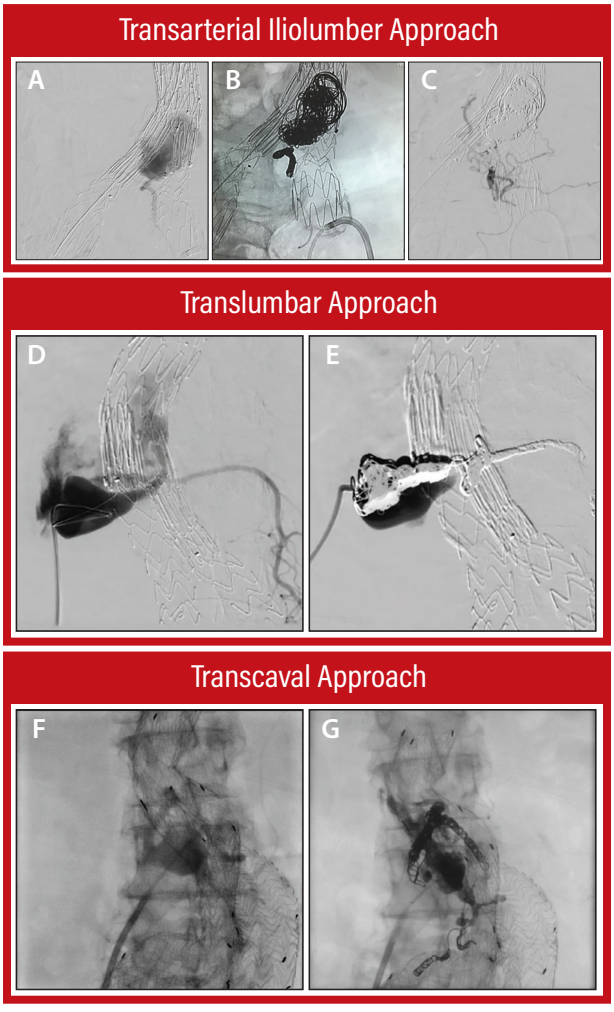


Figure 3. Multiple case images demonstrating the utility of Ruby coils. Case 1: transarterial iliolumber approach (A, B, C). Case 2: translumbar approach (D, E). Case 3: Transcaval approach (F, G).

CASE REPORTS

HYPOGASTRIC ARTERY EMBOLIZATION

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WHY I CHOSE RUBY AND PACKING COIL

- These large-volume embolization devices are deliverable through low-profile access, allowing increased efficiency and simplified access in otherwise challenging cases

This patient presented with a 6-cm infrarenal aortic aneurysm and a 3.4-cm left common iliac artery (CIA) aneurysm that extended to the iliac bifurcation. The aneurysm was technically challenging due to severe right iliac artery tortuosity and the long length of the left CIA aneurysm (Figure 1). Because of this anatomy, I elected to embolize the left hypogastric artery using an ipsilateral approach. We initially planned to use a plug; however, maintaining stable access while trying to cannulate the hypogastric artery with a large sheath for plug delivery proved to be very challenging. I was also concerned about significant sheath kickback during plug delivery. Therefore, to simplify the procedure, we elected to use an embolization technique that could be performed through a lower-profile embolization system, and we transitioned to Ruby and Packing Coils.

To achieve stable access within the hypogastric artery, a diagnostic catheter was inserted through the sheath, which was now "parked" within the CIA. The diagnostic catheter allowed for easier selection of the hypogastric artery. With access to the hypogastric artery, a LANTERN high-flow microcatheter was inserted and tracked distally into the main trunk of the hypogastric artery. A 10-mm Ruby Coil was deployed first (Figure 2). The softness of the coil allowed for easy delivery without catheter kickback. Two Packing Coils (60 and 30 cm) were deployed, packing densely within the vessel (Figure 3). The procedure was completed with stenting of the iliac artery (Figure 4).

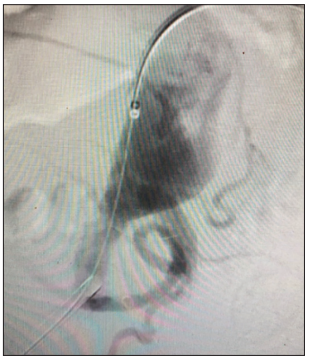

Figure 1. A CIA aneurysm located at the bifurcation of the internal and external iliac arteries.

Figure 2. A 10-mm Ruby Coil was delivered into the main hypogastric artery.

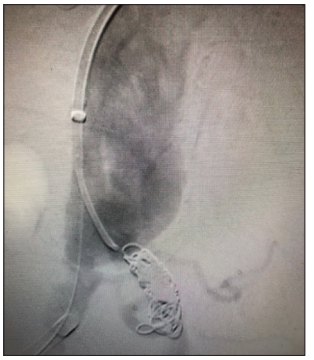

Figure 3. Next, 60-cm and 30-cm Packing Coils were deployed.

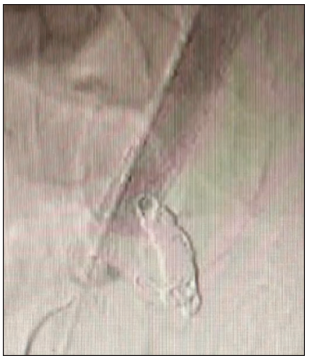

Figure 4. The left common iliac orifice was covered with an iliac stent graft extending into the external iliac artery.

TEVAR WITH LEFT SUBCLAVIAN ARTERY SACRIFICE

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WHY I CHOSE RUBY COIL

- Large-volume embolization device deliverable through a low-profile delivery system
- Helps to facilitate faster and easier embolization, even in tortuosity

The patient presented with a thoracic aortic aneurysm. Due to its location, excluding the aneurysm with a thoracic endograft required covering the right subclavian artery with the endograft. To maintain perfusion to the left arm, a carotid-subclavian bypass was performed, and the left subclavian artery (Figure 1) was embolized in order to prevent reflux blood flow from causing an endoleak behind the endograft.

To embolize the subclavian artery, a 5-F sheath was placed in the brachial artery. A 115-cm LANTERN microcatheter was introduced through the 5-F sheath and tracked distally. In order to embolize the tortuous 16-mm origin of the subclavian artery, two 20-mm X 60-cm standard Ruby Coils were first delivered through LANTERN, creating a frame for the soft Ruby Coils to densely pack within. The softness and the conformability of the Ruby Coils enabled them to conform and lock into the tortuous ostium of the left subclavian artery (Figure 2). Completion angiography was performed, confirming dense packing and complete embolization of the left subclavian artery, with no flow through the coil mass (Figure 3).

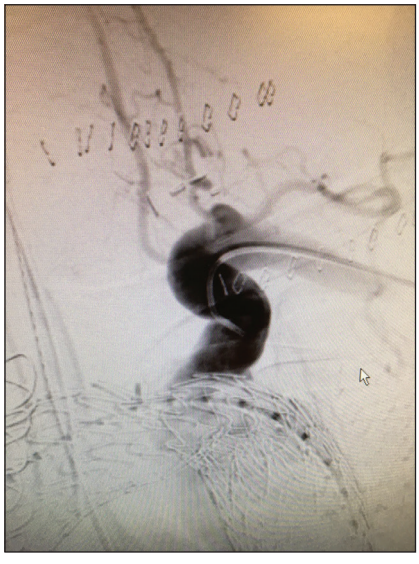

Figure 1. Pre-embolization angiogram showing substantial tortuosity in the left subclavian artery.

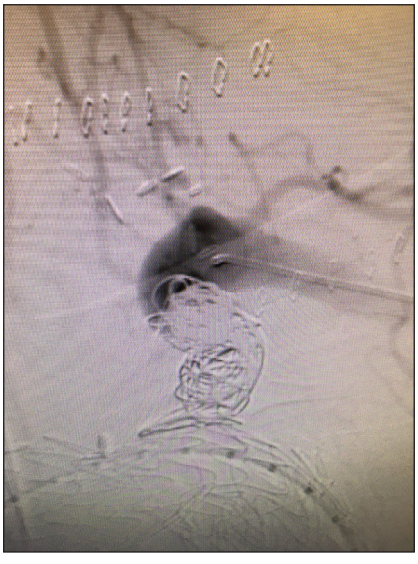

Figure 2. Completion angiogram showing complete occlusion of the left subclavian artery and conformability of the coils in tortuous anatomy.

Figure 3. Completion angiogram.

PULMONARY ARTERIOVENOUS MALFORMATION

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The patient presented with a pulmonary arteriovenous malformation (AVM, Figure 1). Access was first gained to the right common femoral vein. A 6-F Destination sheath (Terumo Interventional Systems) was then advanced to the main pulmonary artery. Through the sheath, a 5-F Glidecath (Terumo Interventional Systems) was delivered, allowing selection of the feeding artery (Figure 2).

The LANTERN microcatheter was then tracked distally to the AVM sac. To embolize the sac, a 14-mm X 60-cm standard Ruby Coil was deployed first, framing the sac (Figure 3). Two additional coils, a 12-mm X 60-cm standard Ruby Coil followed by an 8-mm X 60-cm soft Ruby Coil, were then deployed and packed densely within the nidus (Figure 4). To complete the embolization, a 60-cm Packing Coil was deployed within the feeding artery (Figure 5). A completion angiogram was then performed showing complete occlusion of the feeding vessel (Figure 6).

WHY I CHOSE RUBY AND PACKING COIL

- Confidence in tortuous anatomy: Unlike plugs, coils can occlude both straight and curved vessels
- Packing Coil: Densely packs without the need to size the vessel diameter

Figure 1. Preoperative angiogram showing an AVM in the left lower lobe.

Figure 2. Subselective angiogram confirming catheterization of the feeding vessel.

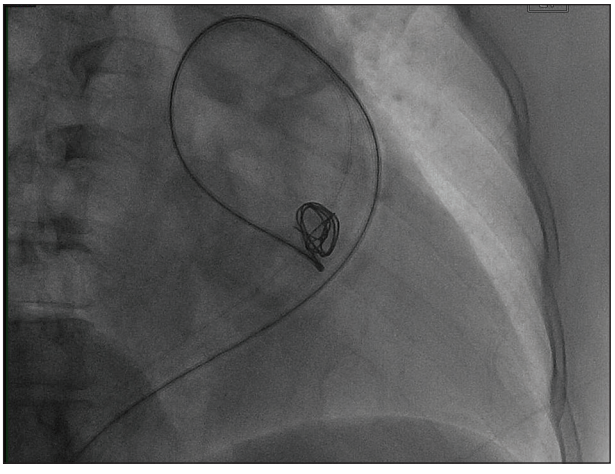

Figure 3. The 3D complex shape of Ruby Coil frames the AVM nidus.

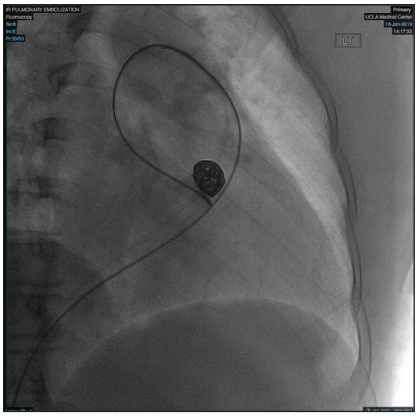

Figure 4. Three 60-cm Ruby Coils efficiently embolize the AVM nidus.

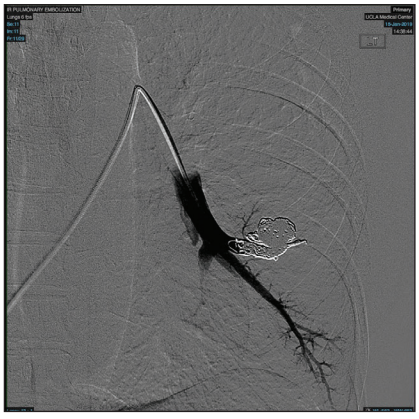

Figure 5. Angiogram after deployment of a single 60-cm Packing Coil in the AVM inflow.

Figure 6. Completion angiogram showing complete occlusion with no flow distal to the coil mass.

CARTO

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Ruby Coil is available in larger-diameter sizes and longer lengths than other available coils. While most other coils have a maximum diameter of 20 mm, Ruby is available in up to 40 mm in diameter and 60 cm in length. This has proven to be very useful in my practice, reducing procedure time and the total quantity of coils used.

The following case is an example of how I utilize Ruby for coil-assisted retrograde transvenous occlusion (CARTO). Although the standard procedure requires a balloon to be inflated for hours after the procedure, there have been experiences published in the literature demonstrating the use of coils after injecting sclerosant to enable balloon removal postprocedure.[1]

In this case, a 58-year-old woman presented with cirrhosis, portal hypertension, myocardial infarction, and upper gastrointestinal bleeding. A 12-F long sheath was placed in the left renal vein via access to the right groin. Coaxially, an 8-F balloon guide was placed through the long sheath and tracked distally into the splenorenal shunt outflow (Figures 1 and 2). Through the balloon guide, a LANTERN high-flow microcatheter was then advanced. The radiopaque distal shaft was easily visualized and helpful when tracking the catheter through the tortuosity of the varix.

Initially, 32-mm X 60-cm Ruby Coils were deployed. The larger diameter and long lengths help the coils to act

WHY I CHOSE RUBY COIL AND LANTERN

- Ruby Coil: Larger diameters and longer available lengths
- LANTERN: Enhanced visibility in tortuous varices

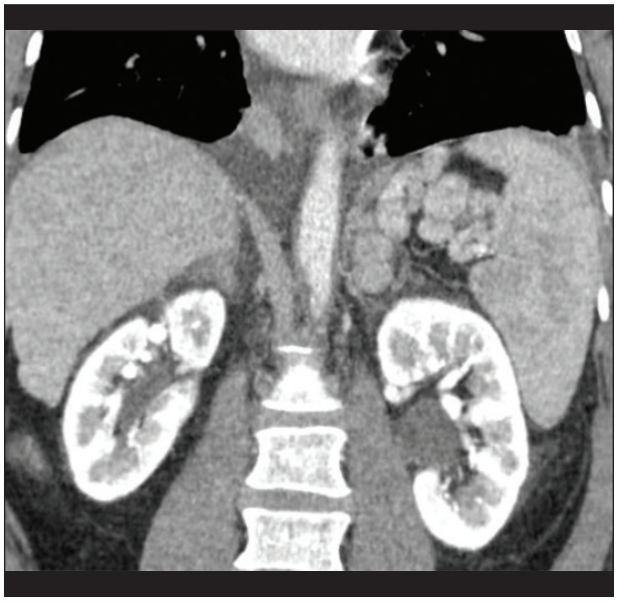

Figure 1. Preprocedural CT scan showing large splenorenal shunt.

Figure 2. Preprocedural angiogram visualizing outflow of the splenorenal shunt.

Figure 3. Postembolization angiogram showing efficient and dense packing, allowing a single-session treatment.

as a scaffold for the foamed sclerosant. The balloon was then inflated, and the sclerosant was injected. Following injection, soft Ruby Coils were then deployed, packing densely and preventing distal migration of the sclerosing agent. After embolization, angiography was performed, which showed no contrast penetrating the coil mass, allowing us to deflate the balloon and treat the patient in a single setting (Figure 3).

1. Sabri SS, Saad WE. Balloon-occluded retrograde transvenous obliteration (BRTO): technique and intraprocedural imaging. Semin Intervent Radiol. 2011;28:303-313.

NEW FRONTIERS IN EMBOLIZATION: FONTAN EMBOLIZATION WITH PACKING COIL

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Single-ventricle patients routinely develop aortopulmonary collaterals (APCs), which can influence hemodynamics. The mechanisms leading to APC development are not completely understood, but potentially occur due to angiogenic factors that are induced from hypoxemia.

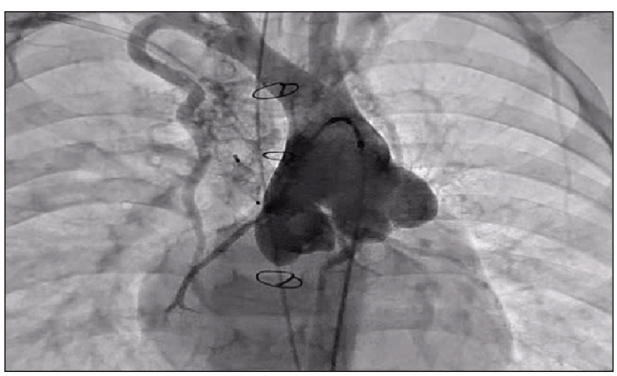

Figure 1. Angiography performed in the neoaorta shows multiple APCs.

Figure 2. Packing Coil deployed in right internal mammary artery.

Figure 3. Packing Coil was used to embolize the left internal mammary artery (one 60-cm coil and one 45-cm coil) and the branch of the left thyrocervical artery (one 15-cm coil).

The presence of APCs in patients who undergo the Fontan procedure has been associated with longer duration of inotropic support, pleural drainage, ventilation, and hospital stay.

Packing Coil has been able to reduce procedure time and radiation exposure in my practice while providing better clinical results for my patients. The softness of the coil allows it to seek collateral vessels without catheterization, and the lengths (60 cm maximum length) and volume of the devices allows me to embolize these long vessel segments with just a few devices, whereas I would have traditionally used many more.

CASE REPORT

A 3-year-old with single-ventricle physiology underwent cardiac catheterization prior to his Fontan completion. Evaluation of APCs was performed using angiography (Figure 1), visualizing the aortic root injection with opacification of multiple collateral vessels. Selective cannulation and angiography were also performed in the internal mammary, thyrocervical, and lateral thoracic arteries. Once the arterial source was identified, the vessel was cannulated with a 4-F guide catheter through which a high-flow microcatheter and wire were introduced. Once stable positioning was achieved in the right internal mammary artery, embolization was performed with two 60-cm Packing Coils (Figure 2). The Packing Coil tracks into the distal vessel without support from the microcatheter. The soft coil also easily tracks into the branching vessels without selective cannulation by the microcatheter and conforms to the irregular vessel, thus packing it densely. The left internal mammary artery and collateral off the left thyrocervical artery were embolized using Packing Coils with no residual collateral flow (Figure 3).

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The embolization toolbox has changed dramatically over the past few years. Since the early 1970s, when pushable technology was the only option for vessels and aneurysms, the field has progressed significantly. The addition of detachable coils has given operators more control compared to their pushable predecessors. Longer and larger detachable coils have increased efficiency by reducing the number of coils per case. Enhanced coil softness has allowed operators to more easily achieve high packing densities, helping to reduce recanalization rates over the long term. Most recently, Penumbra has introduced an embolization platform with dedicated devices for aneurysm exclusion and vessel embolization capable of efficiently achieving higher packing densities. Their addition of this complete embolization platform has simplified embolization for interventionalists and has improved outcomes for patients. ■