Chronic central venous occlusions are a common complication of patients undergoing chronic dialysis catheterization, developing in 25% to 40% of cases. A central venous occlusion often prevents arteriovenous (AV) access in the affected arm or causes symptomatic swelling related to fistula placement. The presence of an ipsilateral vascular access increases blood flow in an upper extremity, leading to the development of a central venous occlusion in a large majority of dialysis patients. Ipsilateral upper extremity AV access is also more likely to result in edema in patients with central venous occlusions, and using the access site for dialysis typically exacerbates edema in these individuals.

Successful recanalization or reconstruction of a chronically occluded vein requires access across the damaged area. However, traversal of the occluded segment with guidewires and catheters is technically challenging because the vein lumen is often destroyed by chronic thrombosis after placement of peripherally inserted central venous catheters and venous ports.

Many techniques are available for central venous recanalization. Sharp needle recanalization has been shown to improve hemodialysis access in chronic outflow occlusion, and other techniques include the use of hydrophilic catheters and wires, blunt dissection catheters, and subintimal reentry catheters. Radiofrequency guidewires have also been shown to be a useful treatment option when conventional techniques fail. All of these approaches are better suited for linear anatomy, because in the presence of tortuous anatomy, the devices cannot be easily guided in the direction of the occlusion. Alternative approaches to traverse complex anatomy are therefore needed to improve the treatment of occlusions. This case report describes the use of the PowerWire RF guidewire (Baylis Medical Company, Inc.) and a Morph AccessPro Steerable Introducer Sheath (BioCardia) for traversing the anterior mediastinum to reconstruct a chronically occluded innominate vein.
CASE REPORT

A 41-year-old man presented with recurrent swelling and pain in the left arm. The patient had a history of a well-developed fistula and a known chronic central venous occlusion, which had been previously subjected to three recanalization attempts (Figure 1). The patient was subsequently referred for banding of the arterial inflow, resulting in near-complete thrombosis of the fistula, which was treated with lytic therapy and angioplasty of the arterial inflow.

The patient returned several months later with recurrent swelling and pain. At that time, he was scheduled for another attempt at recanalization using a combination of the PowerWire RF, Morph AccessPro, and rotational CT.

Before initiation of the procedure, the patient was placed under general endotracheal anesthesia. Initially, a 10-F sheath (Cook Medical) was placed into the left groin. Access to the occlusion from the superior vena cava was obtained. The 6-F Morph Steerable Introducer was first advanced into the nub of the innominate vein (Figure 2). A 4-F CXI catheter (Cook Medical) and a 50KRF straight-tip PowerWire were then inserted through the Morph catheter. The radiofrequency tip of the PowerWire was used to traverse the nub of the innominate vein into the anterior mediastinum (Figure 3), and the CXI catheter was advanced over the PowerWire. An 0.035-inch, 180-cm Stiff Shaft Glidewire (Terumo Interventional Systems) was subsequently used to further dissect across the anterior mediastinum toward the nubbin of the innominate vein at the left subclavian/jugular vein junction. Complete traversal of the occlusion could not be achieved from the retrograde approach.

Antegrade access to the occlusion was achieved via the left arm fistula. An 8-F sheath (Cordis Corporation) was placed into the body of fistula. A second Morph catheter was inserted through the 8-F sheath and advanced to the point of the occlusion at the subclavian/jugular vein junction. A third 4-F access was then placed into the fistula with orientation toward the arterial inflow. Through the third access, a 4-F catheter was positioned into the subclavian artery origin (Figure 4).

Before dissecting into the mediastinum with the PowerWire RF, angiography and cone-beam CT were performed to delineate the location of the aortic arch and subclavian artery. Using the antegrade access, a PowerWire RF, CXI catheter, and Morph catheter were then used to navigate across the remaining segment of obstruction. A loop snare was deployed from the retrograde access so that it could be used as a target for the PowerWire RF (Figure 5).

After successful traversal of the segment, an 0.035-inch, 260-cm Stiff Shaft Glidewire (Terumo Interventional Systems) was deployed from the antegrade access into the loop snare (Figure 6). Cone-beam CT of the chest was performed to confirm the course of the wire to be extravascular to any arterial structures.
Reconstruction of the occlusion was started from the retrograde approach. Balloon dilatation of the newly created tract was performed before deployment of each stent graft (Figure 7). The left groin sheath was upsized to 12 F. Two overlapping 13-mm X 5-cm Viabahn endoprostheses (Gore & Associates) were used to recreate the innominate vein.

A follow-up fistulagram was obtained 1 month after the procedure to document continued stability and patency of the reconstruction (Figure 8). At 5 months, a CT of the chest was performed for other medical reasons, and as shown in Figure 9, the stent grafts remained adequately positioned within the anterior mediastinum. At the time this article was written, the patient continues to have resolution of left arm pain and swelling.

DISCUSSION

Fistula salvage in chronic dialysis patients represents an emerging frontier for endovascular specialists. The growing use of central venous catheterization procedures has resulted in an increased number of patients presenting with central occlusions/stenosis needing fistula access. Untreated occlusions can lead to the loss of 50% to 100% of upper extremity access. Further, chronic occlusions present unique technical challenges because the occluded lumen may no longer exist. In situ recreation of the lumen with stent grafts such as the Viabahn...
Endoprosthesis allows reestablishment of normal venous drainage from the AV fistula.

In our experience with more than 200 stent graft deployments in patients with dialysis fistulas over the last decade, we have not observed any postdeployment stent graft migrations. We also have experienced very few cases of recurrent thrombosis or device failure.

Before device placement, the newly created tract must be predilated. Given the extravascular position of this patient’s tract, underdilation with a 10-mm balloon was sufficient for adequate dilatation before deployment. However, in chronic occlusions, immediate recoil can occur. In these cases, a larger balloon may be used to create a larger tract. Also, obtaining through-and-through (ie, arm and groin) access across the obstruction increases the pushability of the device through the tract. In extreme cases of recoil, a balloon can be placed from the opposite end of the stent graft deployment. The stent graft is then advanced into the tract as the balloon is being deflated and withdrawn from the opposite end.

In all reconstructions, care is taken to reconstruct the occlusion with minimal or no sacrificing of collaterals. It is worth noting that access into the extravascular space is obtained with only minimal force when using the PowerWire RF guidewire. Because of the absence of tactile feedback as the guidewire is advanced with the RF tip activated, care must be taken to avoid unintended entry into the arteries. The PowerWire comes in varying degrees of stiffness, making it easy to use with deflecting/steerable catheters such as the Morph.

By pairing these two technologies, it is possible to perform directed/steerable dissection through the extravascular space. Unlike sharp recanalization or other catheter/guidewire-based recanalization techniques, nonlinear anatomy may be more easily traversed using a steerable dissection technique.

**CONCLUSION**

Novel techniques using a combination of steerable catheters, RF wires, and cone-beam CT may offer effective strategies for traversing extravascular spaces, such as the anterior mediastinum, for venous reconstruction. Directional dissection may also be useful in the reconstruction of pelvic and caval vessels that may not be candidates for surgical bypass.

Nick Yee, MD, is with Radiology Imaging Associates in Denver, Colorado. He has disclosed that he received consulting fees and speaking honoraria from Gore & Associates. Dr. Yee may be reached at (303) 765-3843; dominic.yee@riaco.com.

Johanna K. DiStefano, PhD, is Professor and Director, Division of Diabetes, Metabolic and Cardiovascular Diseases, Translational Genomics Research Institute in Phoenix, Arizona. She stated that she has no financial interests related to this article. Dr. DiStefano may be reached at (602) 343-8812; jdistefano@tgen.org.