Treatment Options for Hemodialysis-related Central Vein Occlusive Disease: Case Series and Review of Literature

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ABSTRACT

Central venous occlusive disease is commonly seen in patients undergoing hemodialysis and can threaten the viability of the arteriovenous access. Majority of cases are related to central venous catheter placement. This paper reports on three patients on chronic hemodialysis who presented with signs and symptoms of upper extremity venous hypertension and underwent three different therapeutic modalities, all with successful relief of symptoms. A review of the existing literature on past and current treatment options is done.

Keywords: central vein occlusion, hemodialysis, venous hypertension

INTRODUCTION

The incidence and prevalence of chronic kidney disease (CKD) among adult Filipinos have been steadily rising in number. In 2003, the Department of Health reported that 2.6 out of 100,000 adult Filipinos were affected with CKD. By 2008, the incidence increased to 9.75 per 100,000 within the same population.[1] The vast majority of these patients are undergoing hemodialysis (97.25% as of 2016).[2] Not surprisingly, trends in the number of vascular access performed for hemodialysis (HD) have also been progressively increasing. Data from the 2021 United States Renal Data System revealed that from a total of 130,400 patients beginning renal replacement therapy in 2019, 85.1% was via hemodialysis.[3] From this number, 81.8% initiated treatment with a catheter (with or without a maturing fistula or graft). More importantly, among patients who initiated HD using a catheter in 2018, over 46% and 23% were still using a catheter six months and one year after HD initiation, respectively.[3]

With frequent use of central catheters for bridging therapy, it is not surprising for central vein occlusive disease (CVOD) to complicate patients on chronic HD. Central vein stenosis (CVS) and/or occlusion (CVO) have been documented to occur in 15-20% of all patients on dialysis, 30% in those with a history of prior catheter placement, and as high as 50% in those presenting with symptoms.[4] It is postulated that the repetitive foreign body trauma from catheterization causes injury to the intima and activation of an inflammatory response within the vessel wall, leading to focal endothelial denudation, increased smooth muscle proliferation, and endothelial hyperplasia.[5] This causes the

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vessel diameter to gradually reduce, leading to increased intraluminal pressure and consequently, venous hypertension. In patients with functioning AV access, the increase in extremity blood flow may result to edema, swelling, pain and erythema of the ipsilateral extremity.

There are now a number of treatment options for CVOD. The objective of this study is to present various treatment modalities performed at our institution using actual representative cases. A review of the literature is likewise undertaken.

CASE SERIES

We present three patients with HD catheter-related CVOD who underwent different forms of treatment. All three patients had the following salient features: (1) End stage renal disease on chronic HD; (2) A history of HD catheter insertion(s), either at the internal jugular and/or subclavian veins; (3) Upper extremity swelling with or without ipsilateral facial edema; (4) And the presence of a functioning ipsilateral arteriovenous fistula (AVF).

Procedure

All procedures were done either at the catheterization laboratory or at the operating room using a mobile C-arm. Initial access was made percutaneously via the ipsilateral AVF and secured with a hemostatic sheath. Once the lesion was identified by venography, wire passage was attempted using a standard 0.035 hydrophilic wire (Zipwire, Boston Scientific) supported by a Berenstein catheter. If unsuccessful, other wires with a different material and tip configuration (i.e., Classic Double Flexible Tip, Cook Medical) were used. If still unsuccessful, then attempts at crossing the lesion were made retrograde via the R femoral vein.

Lesions successfully crossed were treated with balloon angioplasty. The balloons were sized appropriately based on lesion length and luminal diameter of adjacent normal vessel as measured from the angiographic images. This was done in two to three cycles at a minimum of 1 minute inflation each time. Balloon dilatation can be somewhat painful hence additional sedation and pain medications were given. If there was significant recoil after angioplasty or the stenotic 'waist' was not eliminated, then a different high-pressure balloon (i.e., Mustang, Boston Scientific) or a stent sufficiently large in diameter to effect adequate wall apposition was deployed. Technical success was defined by elimination of the stenosis by at least 80%.

If the lesion cannot be crossed from either antegrade or retrograde approach, the procedure is terminated and alternative treatment options such as access ligation or surgical bypass to a patent venous segment (i.e., ipsilateral jugular or femoral vein, contralateral axillary vein) were discussed with the patient. Venography of possible feeder vessels for possible surgical bypass was done to demonstrate patency.

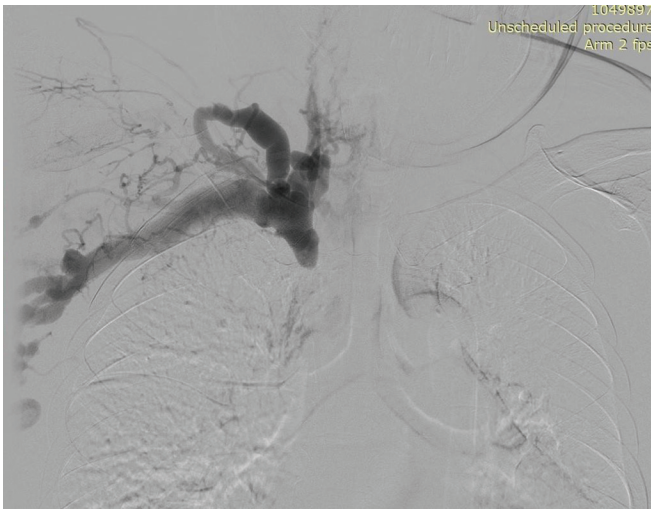

Figure 1. Venography revealed total occlusion of the R mid-innominate vein.

Case 1

D.Y. is a 62-year-old diabetic male on chronic HD via a R radiocephalic AVF. He has a long and complicated history of hemodialysis access, having had catheter insertions of varying durations in his subclavian and internal jugular veins bilaterally, and a L radiocephalic AVF which thrombosed. He presented with severe R upper extremity swelling associated with pain and venous stasis ulcers. He, however, continues to undergo HD via the R forearm AVF.

Venography done via the AVF revealed occlusion of the R innominate vein (Figure 1). Attempts at recanalization, both antegrade and retrograde, were unsuccessful. Surgical options were presented and the patient opted for ligation of the R forearm AVF with subsequent creation of a L upper arm AV access using an early cannulation prosthetic graft. Significant improvement of his R upper extremity swelling was noted post-ligation.

Case 2

L.M. is a 58-year-old hypertensive female on chronic hemodialysis via a L brachiocephalic AVF. The AVF was being used for 2 weeks when she developed L upper extremity and hemifacial edema. She has a history of bilateral internal jugular catheterization for HD.

Venography done through the AVF and the R femoral vein showed total occlusion of the L innominate vein (Figure 2). Repeated attempts at wire passage beyond the occlusion, both via antegrade and retrograde access, were however unsuccessful. As preoperative vein mapping revealed limited access sites for this patient, a decision was made to salvage her existing AVF hence a surgical bypass was contemplated. Venography of the target inflow vessel (R axillary vein) was done which incidentally demonstrated approximately 60% stenosis of the R brachiocephalic vein (Figure 3). This was successfully balloon dilated.

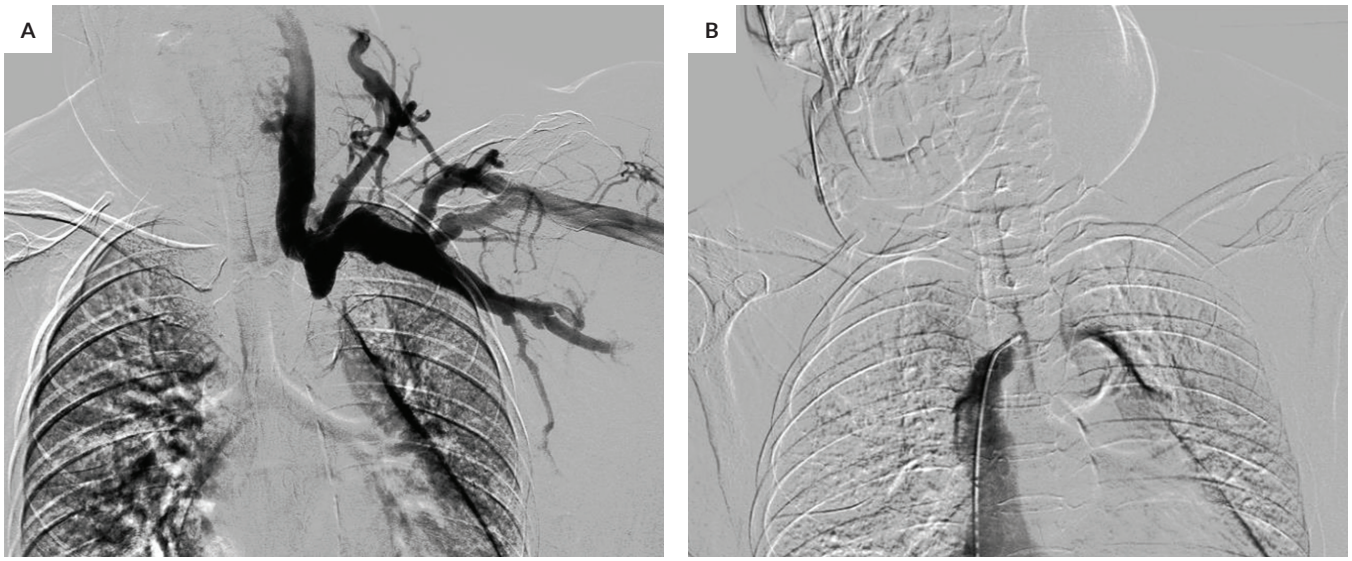

Figure 2. (A) Venography via the L brachiocephalic AVF and **(B)** R femoral vein showing total occlusion of the L innominate vein.

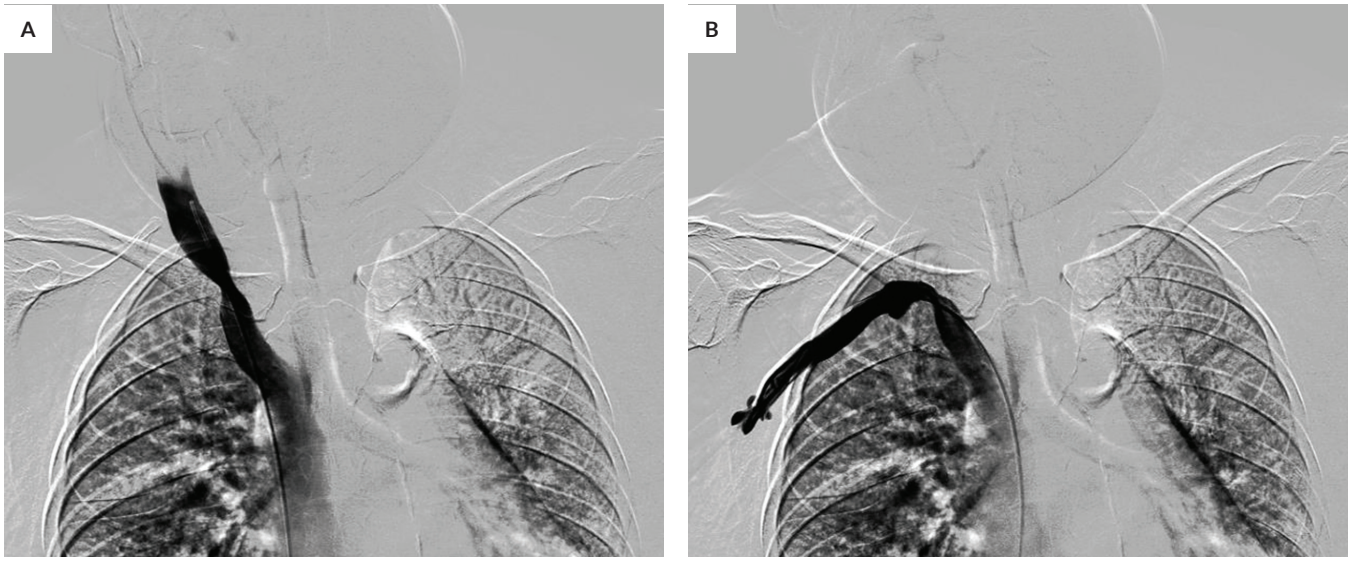

Figure 3. Stenosis of the R innominate vein at its confluence.

The patient subsequently underwent L axillary to R axillary vein bypass using a ringed PTFE graft. Symptomatic relief of the edema was noted almost immediately postoperatively with preservation of the AV access.

Case 3

E.C. is a 61-year-old male with CKD secondary to diabetic nephropathy, on chronic HD via a R proximal radiocephalic AVF. The AVF was being used for HD when four months prior to consult, he developed swelling of the R upper extremity extending to the upper chest (Figure 4A). He has a history of R internal jugular vein cannulation for HD.

The patient underwent venography via the AVF which showed total occlusion of the R innominate vein (Figure 5A). The occlusion was crossed using a 0.035 hydrophilic wire (Zipwire, Boston Scientific) followed by balloon dilatation (XXL, 14 x 40mm, Boston Scientific). Post-angioplasty venography resulted in good flow to the superior vena cava with minimal residual stenosis (Figure 5B). The patient was dialyzed using the R forearm AVF the next day and subsequently sent home post-HD with significant reduction of the upper extremity swelling (Figure 4B).

DISCUSSION

Central venous stenosis and occlusion are common but serious complications for chronic hemodialysis patients. Several studies have cited previous or concomitant placement

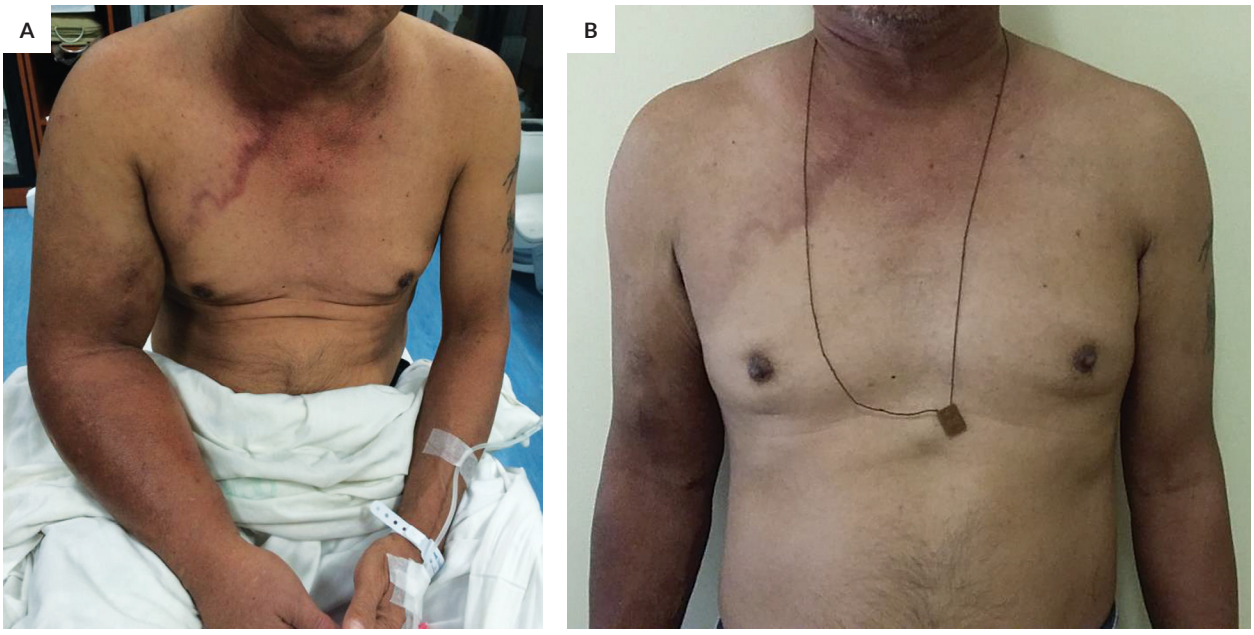

Figure 4. **(A)** Patient presenting with R upper extremity swelling, pre-intervention. **(B)** Post-balloon angioplasty.

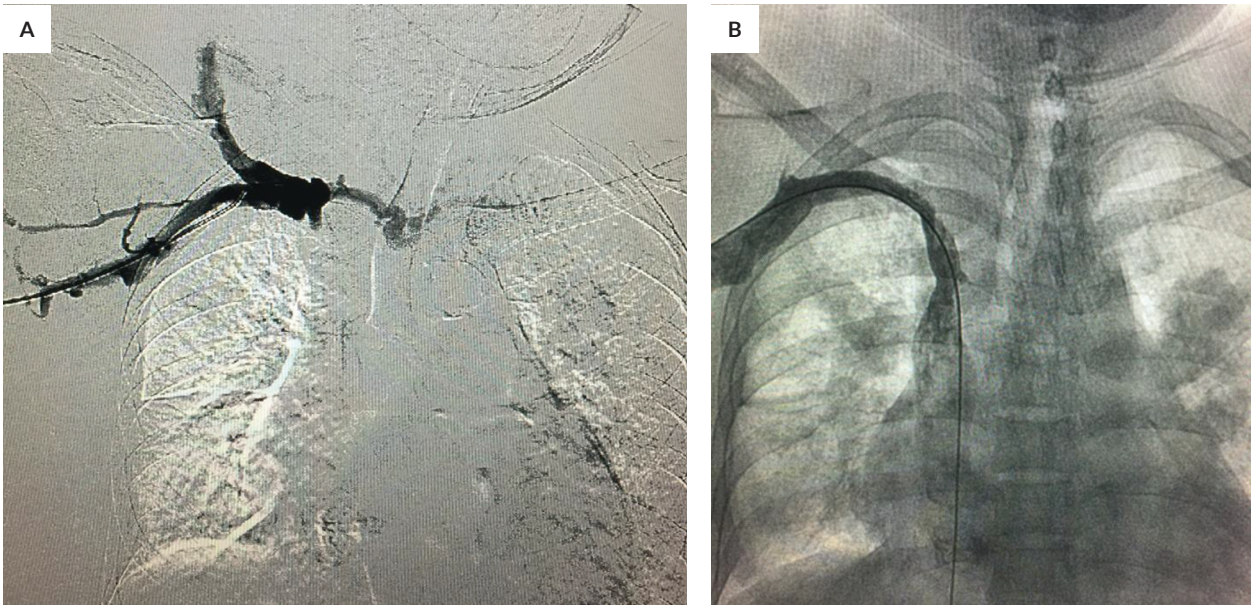

Figure 5. **(A)** Venography via the R forearm cephalic vein revealing total occlusion of the R innominate vein. **(B)** Post-balloon dilatation venography showing good flow to the superior vena cava with minimal residual stenosis.

of central venous catheters as the primary reason for its development, particularly when the subclavian vein is used.[4,5] In these instances, the pathology most likely stems from mechanical injury due to continuous catheter movement inside the vessel, causing endothelial damage, neointimal hyperplasia and fibrosis. However, there have been reports of symptomatic central venous occlusive disease occurring in patients with no prior history of catheterization.[6] In a retrospective review of 26 patients with symptomatic CVS, Kotoda et al.[7] observed that only seven patients had undergone central venous cannulation. It is plausible that vascular access-related changes in the flow dynamics causing altered shear stress and turbulence, in conjunction with oxidative stress, result to venous wall hyperplasia and eventual stenosis. Moreover, they noted that seven of the 19 patients without history of catheterization had extrinsic compression of the L innominate vein between the sternum and the R brachiocephalic artery as demonstrated by MDCT

angiography, suggesting the association of mechanical compression by the surrounding structures to increased susceptibility to CVS.[7] The therapeutic implication of this observation will be discussed later.

There are a number of treatment options for CVOD. The goal is to resolve the symptoms of venous hypertension while maintaining patency of the AVF. Early in our experience, ligation of the ipsilateral AVF with creation of a new access on the contralateral extremity was the principal mode of treatment, as exemplified in Case 1. While ligation alleviates the symptoms in most cases, it deprives the patient with a valuable access resource. We have since abandoned this as a therapeutic option unless the patient's life expectancy is limited and alternative options for access placement exist.

Currently, endovascular intervention with balloon angioplasty (PTA) is the recommended first line treatment for symptomatic CVOD.[8] Technical success rates for endovascular treatment are excellent albeit 6- and 12-month primary patency rates are poor, at 50% and 25%, respectively.[9,10] The poor patency rate is by and large due to the strong elastic recoil of the diseased vein exhibited after balloon dilatation, leading to significant residual stenosis. This lack of durable results with PTA led many to recommend concomitant stent placement. Surprisingly, a number of studies have shown that primary and assisted primary patency of primary stenting (PTS) is modest at best and that PTA may even be superior in terms of assisted primary patency.[11,12] In their experience of 26 patients treated with PTS and 47 patients treated with PTA, Bakken et al.[11] reported that with respect to primary patency, PTS and PTA are equivalent and hence concluded that given its greater cost, PTS should not be added to the management of central vein stenosis. These studies however need to be taken in context, as the type of stent used may be a factor in the variable success and patency rates. In a retrospective study using the nitinol Shape Memory Alloy (SMART) stent for instance, Vogel et al.[13] reported a significantly better primary patency of 14.5 months in 15 patients with CVS. These nickel-titanium alloy stents have the advantage of thermal memory characteristics, are super-elastic and kink resistant, and resist deformation with greater radial resistive force.

The use of covered stents has been proposed as an option for recalcitrant cases of CVOD. Theoretically, these stent grafts have the advantage of providing a relatively inert and stable intravascular matrix for endothelialization, thereby reducing restenosis. In a number of studies, primary patency at 1-year has been promising at 56-67% although frequent re-interventions for either stenosis or thrombosis were noted.[14,15]

It is theorized that the disappointing overall results of endoluminal interventions may be partially due to the results being analyzed as a whole. Killig[16] alluded to the notion that not all venous outflow lesions are the same and that treatment should be individualized. Specifically, that lesions at the costoclavicular junction should be considered dialysis-associated venous thoracic outlet syndrome and optimal treatment therefore entails concomitant surgical decompression of the vein with first rib resection and venolysis. We do observe that indeed, subclavian vein stenoses adjacent to the costoclavicular junction respond poorly to PTA and are in the opinion that surgical decompression should be performed to provide for the best hope for long term success.

From a technical standpoint, application of endovascular modalities is dependent on successful wire passage through the central vein lesion. We usually attempt recanalization antegrade via the AVF access and if unsuccessful, re-attempt with the use of a retrograde approach from the femoral vein. If still unsuccessful, then the patient is condemned to access ligation, surgical bypass, or long-term dependence on tunneled catheters in unconventional locations. A number of novel techniques at facilitating wire passage have been reported although these are not available in our country. Guimaraes et al.[17], recounted their experience with the use of radiofrequency guidewire for recanalization of CVO after failed conventional endovascular techniques. Technical success rate was 100% for 42 patients with 40 of 42 stents patent and asymptomatic at 6 and 9 months after treatment. Other techniques have been reported in the literature with varying degrees of technical success such as laser recanalization[18], sharp (needle) recanalization[19], and the use of novel telescoping catheters (TriForce, Cook Medical) designed to facilitate crossing difficult venous occlusions[20].

In our institution, when endovascular treatment fails, the patient is largely relegated to surgical options, as with Case 2. Our primary goal in surgical management of CVO is finding an effective venous outflow for the functioning AV access. This will encompass extra-anatomic bypasses to an open venous segment (i.e., ipsilateral or contralateral jugular, axillary or femoral veins and direct bypass to the superior vena cava or right atrium) or reconstruction of the occluded segment. Our preference is to bypass to the ipsilateral jugular vein if its outflow is patent. If not, next target is the contralateral axillary vein and finally, to the ipsilateral femoral vein. The choice of bypass site is generally dictated by the extent and location of the occlusion, the status of the superficial and central veins, the relative technical ease of the procedure (i.e., simplest and shortest first) as well as resource availability (i.e., a shorter graft is cheaper and more readily available). A number of retrospective reviews have detailed their experience with the use of surgery for symptomatic upper extremity venous hypertension done after failed endovascular therapy. The Johns Hopkins group reported their experience with axillary-to-femoral vein bypass where sixty percent of their patients had symptomatic relief of the upper extremity swelling along with successful salvage of the dialysis access.[21] Likewise, the study by Anaya-Ayala et al.[22] recounts their institutional experience on creating of complex vascular accesses for hemodialysis-related CVO. In this paper, they proposed an algorithm for surgical planning which can be a good resource for the surgical management of CVO.

Lastly, albeit not available in the Philippines, the Hemodialysis Reliable Outflow (HeRO) graft has provided an innovative means to obtain HD access in patients with severe CVO. In a retrospective review of HeRO graft placement in patients with CVOs, successful graft placement was achieved in 86% of their patients.[23] And when compared to stent placement in patients with CVOD presenting with arm swelling, Cline et al.[24] noted that, while both modalities were comparable in alleviating symptoms, the HeRO graft had more durable results in terms of primary and secondary patencies.

CONCLUSION

Increasing use of indwelling catheters for hemodialysis access will render central venous stenosis and occlusion a continuing problem for HD patients. Endovascular techniques are the first line therapy but should it fail, surgical options exist. This paper describes three patients treated differently, all with successful relief of symptoms.

Statement of Authorship

LLKJ contributed in the review of data, revising, and drafting of final manuscript. AEM contributed in the review of manuscript. PLCM contributed in the conceptualization of work, acquisition of data, and initial drafting of manuscript.

Author Disclosure

All authors declared no conflicts of interest.

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