Vascular access of last resort

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Exhausted vasculature is not uncommon in patients receiving long-term hemodialysis treatment. Certain patients exhaust their peripheral veins and do not retain the venous capital necessary for fistula creation. Others suffer from severe peripheral arterial disease and despite the presence of adequate venous capital are not able to receive an arteriovenous access successfully. Most importantly, in the case of occluded central veins, the creation of an arteriovenous access in the arms or thighs would be futile, even if peripheral veins and/or arteries were available. Because renal transplant is not readily available, such patients virtually face death in the absence of dialysis therapy. Hence, it is critically important that vascular access options be available to successfully receive renal replacement therapy. This article describes accesses of last resort and provides information vital to nephrologists for discussion with their patients and to surgeons in choosing an optimal option.

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Increases in the prevalence of patients with chronic kidney disease progressing to end-stage renal disease (ESRD) requiring hemodialysis and longer survival of patients on hemodialysis have led to higher recognition of vascular access–related complications. In this context, the development of central venous stenosis is of particular concern. At the same time, access-related complications have led to innovative approaches to create accesses of last resort. These approaches are available for patients who have central venous stenosis and/or have exhausted their peripheral venous capital.

The superficial and deep veins in the upper and lower extremities along with transient and/or long-term use of central venous catheters are primarily utilized to create vascular access for hemodialysis. The survival of patients with ESRD has improved over time due to advances in dialysis technology and a better process of care in the dialysis centers.[1] The resulting challenge faced by the dialysis community is preserving functioning vascular access. ESRD patients often go through a cycle of dialysis, successful transplantation, transplant allograft failure, and restarting dialysis—resulting in depletion of all conventional and nonconventional vascular sites used for permanent vascular access creation.

Central vein occlusion (CVO) poses a special challenge in patients with already compromised vascular access and no remaining available sites.[2] Because dialysis patients do not have unlimited availability of venous capital, diagnosis and intervention to maintain patency of central veins are critically important.

Imaging modalities are extremely important for diagnosing and planning intervention for CVO. Venous computerized tomographic (CT) angiography and magnetic resonance angiography are helpful tools to localize the site of occlusion or stenosis in these circumstances. However, using the minimum amount of radiocontrast and avoiding gadolinium-based radiocontrast agents is important. A specific CT venography protocol for imaging of central veins has been developed to plan intervention in these difficult cases (personal communication from Hooman Khabiri, MD). Contrast can be injected into any available vein in the arm. With arms up, 100 ml of nonionic contrast is injected i.v. at the rate of 4 ml/s. We believe that raising the arm achieves 2 results. First, it helps by keeping the arm out of the beam and removes any possibility of artifact. Second, arm raising helps the viscous contrast rush toward the central veins. Scans are taken from the angle of the mandible through the adrenals with a 40-second delay. Another set of scans is taken from the angle of the mandible to the mid-sternum at 60-second delay to accurately identify the location and severity of stenosis in central veins. In patients with advanced venous disease in whom obtaining peripheral i.v. access to inject iodinated contrast is not feasible, the protocol is modified to allow use of the patient's tunneled dialysis catheter (if present) for injecting contrast when performing a CT venogram. However, visualization of the stenosis can be challenging if it is present just above the tip of the catheter. It is important to mention that there is no difference in our current CT venography protocol and the traditional CT venogram in terms of clarity of images, cost, amount of contrast, or the need for special equipment. We believe that our protocol allows for better visualization of the neck veins.

It is true that endovascular interventions of CVO result in aggravation and recurrence of stenosis or occlusion. However, the importance of maintaining the patency of central veins to continue life-saving dialysis therapy renders endovascular intervention the mainstay of therapy despite serious limitations. Managing CVO requires the presence of relevant local expertise as well as consideration of the life expectancy and transplant eligibility of the patient. In patients with CVO, there are special techniques that can still provide functional vascular access to avoid a life-threatening situation.

Depending upon the anatomy and chronicity of occlusion, conventional endovascular techniques utilizing hydrophilic coated wires, directional catheters, sheaths, and angioplasty balloons may be sufficient to recanalize an occlusion. In a majority of patients with acute CVO, successful recanalization can be performed with relatively simple techniques. An antegrade approach from the ipsilateral arm is often successful in acute CVO.

Chronic occlusions may make it challenging to cross the lesion antegradely, especially if it involves superior vena cava. A combined retrograde-antegrade approach is required and usually involves obtaining access in an upper extremity or neck vein as well as femoral vein access. To provide enough stiffness and direction, a support catheter or sheath is utilized in addition to the primary selective catheter. With probing from both directions under fluoroscopy at different angles, the lesion can often be crossed. Once the lesion is crossed, angioplasty is performed. It is important to carefully measure the diameter of the reference vessel (the adjacent normal segment in the same anatomical territory or the contralateral side). Due to chronicity and the fibrous nature of lesions, it is advisable to consider serial dilatations with progressive increase in balloon sizes until the reference diameter is reached. A stent can be placed in elastic lesions after the occlusion is recanalized to maintain patency.[3] It is worth mentioning that the stent must be carefully sized to be slightly larger than the diameter of the stenotic area to avoid its migration.

In recalcitrant lesions that cannot be crossed with conventional techniques despite retrograde-antegrade attempts, advanced techniques can be used. Radiofrequency (RF) wire recanalization of the occluded segment is a valuable technique in expert hands. Application of RF should be limited to recanalization of only short segments of occlusion where access both proximal and distal to the lesion has been established. It is important to use fluoroscopy at a different angle to ensure correct positioning of the RF wire and avoid complications. A useful recanalization technique for CVO involves the use of the inside-out technique,[4] which can create a pathway to provide external access to central circulation. A tunneled catheter or hybrid graft-catheter access can be placed once a tract has been created. The Surfacer Inside-Out access catheter system (Merit Medical Systems, South Jordan, UT) recently received European CE mark approval for use in obtaining central venous access via an inside-out approach and is available in the UK, Germany, Austria, Belgium, Netherlands, and Luxembourg.

Various options for access placement are available in dialysis patients as accesses of last resort.[5–17] These include trans-lumbar, trans-hepatic, trans-renal, azygous, and hemiazygous vein dialysis catheters. In addition, the HeRO (hemodialysis reliable outflow, Merit Medical Systems) device is also available for dialysis patients as an access of last resort. Finally, various surgical options are available as accesses of last resort.[18–33]

Dialysis catheters as a last resort

Trans-lumbar catheters represent one of the final attempts to maintain functioning vascular access when access to the superior or inferior vena cava (IVC) is limited. The 3-, 6-, and 12-month patency rates in 146 access sites including trans-lumbar catheters, tunneled femoral catheters, native long saphenous vein loops, prosthetic mid-thigh loop grafts, peritoneal dialysis, and expedited donation after cardiac death cadaveric renal transplants via local allocation policies in 62 patients with central vein stenosis were compared.[5] Over a median follow-up of 876 $\pm$ 57 days, 3-, 6-, and 12-month primary-assisted patency rates for each modality were reported (Table 1). Similar to primary patency rates, the secondary patency rates for long saphenous vein loops at 3 (87% patency), 6 (80% patency) and 12 (77.8% patency) months were better than those for thigh loop graft (72% at 3 months, 52.4% at 6 months, and 41.7% at 12 months) or tunneled femoral catheters (75.4% at 3 months, 60% at 6 months, and 28% at 12 months) ($P < 0.01$).[5] There were no deaths due to loss of access.

A trans-hepatic catheter offers another such measure in desperate cases of CVO. The tip can be placed in IVC or right

Table 1 | Comparative primary patency of different modalities of intervention in patients with central venous stenosis[5]

Intervention	3-month patency, %	6-month patency, %	12-month patency, %
Trans-lumbar catheter	75.4	60	28
Tunneled femoral catheter	88	65	50
Saphenous vein loop	87.5	60	56.5
Mid-thigh loop grafts	64	38	23.5
Peritoneal dialysis	62.5	62.5	50
Expedited donation	72.7	72.7	72.7