Surgical Fistula Creation: Techniques for Ensuring Maturation and Long-Term Utility

A guide to patient selection and a step-by-step approach to AVF creation.

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Maintenance of vascular access has long been the Achilles' heel of patients undergoing hemodialysis (HD). Evolving from the direct cannulation of native vessels to highly morbid Teflon shunts, it wasn't until the development of autogenous arteriovenous fistulas (AVFs) for HD by Cimino and colleagues that permanent access became attainable.[1] Many of the surgical techniques described in the seminal paper by Cimino et al are still used today—namely, adequate mobilization of conduits to prevent sharp angulation, use of atraumatic vascular clamps, an arteriotomy up to 5 mm in length, and surgery performed with the use of magnifying loupes. Proper technique can improve the likelihood of maturation and the long-term utility of a vascular access.

PATIENT SELECTION

Patient survival on HD is directly linked to the reliability and longevity of vascular access. Regrettably, the risk of primary failure of AVFs (a failure to mature or failure within the first 3 months of use) averages approximately 50% in randomized trials.[2,3] These access failures are the most common reason for hospitalization of dialysis patients and lead to mean costs of roughly $18,000 to $31,000 per patient per year.[4]

Today, the need for HD vascular access depends on a collaborative assessment of a patient's individualized end-stage kidney disease (ESKD) life-plan.[5] Patients already on kidney replacement therapy, those with progressive chronic kidney disease with anticipated need for HD within 6 months, or an estimated glomerular filtration rate of 15 to 20 mL/min/1.73 m^2 should be evaluated for HD access creation.

AVFs are preferred to arteriovenous grafts (AVGs) due to lower infection risk and fewer long-term vascular access events (thrombosis, loss of primary patency, interventions). Venous conduits should be ≥ 2.5 mm and free of sclerotic segments to ensure a 92% likelihood of maturation.[6] Optimal inflow is supplied by an artery ≥ 2 mm (Sidebar).

The most distal acceptable site on the nondominant upper extremity is chosen to preserve proximal sites for future access, reduce infection rates, and limit disability of the arm and hand.[7] In patients with an ESKD life-plan unlikely to require HD for > 1 year (ie, those with decreased predicted survival), brachiocephalic or more proximal AVF creation is preferred due to higher likelihood of unassisted maturation.[5]

HOW WE DO IT: SIX STEPS

Step 1: Preoperative Evaluation

In addition to a routine history and physical examination, there are a few specific areas that deserve closer attention when deciding on HD access. Bilateral upper extremity blood pressures should be within 20 mm Hg to identify inflow issues that can reduce maturation rates and potentially lead to steal phenomena. One should specifically ask about prior central venous access and pacemaker or defibrillator placements, as well as look for prominent venous collaterals or edema that can indicate the possibility of

PRINCIPLES OF SURGICAL DIALYSIS ACCESS

- Timing
  - AVF 6 months/AVG 3 to 6 weeks prior to dialysis
- Autogenous AVF before prosthetic AVG
- Upper extremity before lower extremity
- Distal on the extremity as possible
- Nondominant upper extremity before dominant
- Direct anastomosis → transposition → translocation
- Duplex venous mapping preoperatively
  - AVF venous diameter > 2.5 mm (artery > 2 mm)
- Venogram if central venous anatomy in doubt or pacemaker/defibrillator wires in place

central venous stenosis. Venous mapping is performed in our adjacent vascular lab the same day to improve access to care for our patients who often have transportation challenges. Patients with suspected central venous stenosis or occlusion are referred for venography. Counseling patients on the variable rates of AVF maturation and the potential need for multiple procedures to achieve a functioning fistula is essential for setting realistic expectations.

Step 2: Anesthesia and Intraoperative Positioning

On the day of surgery, patients undergo regional anesthesia via nerve block in the preoperative care area by our supervising anesthesiologist. Performing access creation under regional anesthesia versus general anesthesia lowers the risk of major adverse cardiac events and has a vasodilatory effect that aids in identifying venous conduits that preoperatively were deemed inadequate.[8] When operating on the upper extremity, the patient is positioned supine with a broad arm table at chair height. The bed is rotated away from the anesthetist to provide sufficient room for both the primary surgeon and an assistant. A transverse bar is placed over the patient's head to suspend the sterile drapes and reduce disorientation if sedation is needed. Intraoperative ultrasound is then performed to confirm venous and arterial anatomy.

Step 3: Exposure and Dissection

Each AVF access creation is unique, but several tenets can be broadly applied. The creation of large flaps is avoided to minimize postoperative seroma formation. The vein is sharply dissected beyond the extent of the incision to allow sufficient length for mobilization without tension (3-5 cm). Prominent branches at the terminus of the intended conduit are utilized to create an anastomotic hood. A short segment of artery (2-3 cm) is exposed. The right self-retaining retractor at this point can reduce the need for an assistant. A Heiss skin retractor is typically used for the distal forearm and blunt Weitlaner retractors for the upper arm. In patients with significant adiposity, a modified Henly retractor allows for interchangeable blades of different lengths and can be especially helpful.

Step 4: Vessel Preparation and Use of Heparin

The vein is transected and spatulated. A 3-mm olive-tipped cannula is used as a probe to ensure adequate vein diameter. If the cannula is unable to be passed, serial vascular dilators (2-4 mm) are used before exploring other conduits in the arm. Applying proximal limb pressure while flushing heparinized saline dilates the exposed vein and helps identify any sclerotic segments that increase the risk of primary failure. If tunneling, the vein is distended and marked with a sterile surgical marker. At this point, vascular control is obtained with spring-loaded bulldog clamps. Patients are not routinely heparinized during the creation of upper extremity fistulas due to absence of demonstrable benefit in primary patency, increased risk of bleeding complications, and avoidance of the need to administer protamine.[9] An arteriotomy is made using a no. 11 blade scalpel and extended with fine arteriotomy scissors (ie, finger Potts scissors). The arteriotomy should be placed in a geometrically favorable manner to allow for a roughly 30° to 45° angle of the intersecting conduit. The arteriotomy is limited to approximately 4 to 6 mm in maximal length to reduce the likelihood of arterial steal.

Step 5: Anastomosis and Completion Evaluation

The anastomosis is constructed most commonly in an end-to-side fashion with two running 6-0 or 7-0 Prolene sutures (Ethicon, a Johnson & Johnson company). The sutures are placed using the parachute technique, which allows for greater visualization of the critical portions of the anastomosis: the heel and toe where failure most commonly occurs. However, there are times when the four-quadrant suture technique or individually placed sutures are required with small and diseased vessels. Other anastomotic configurations have been described (ie, side-to-side or end-to-end), but these configurations can be associated with an increased risk of venous hypertension or arterial steal related to the fistula. Upon completion, the fistula should have a strong thrill on palpation, paradoxically, with a pulse not ideal and indicative of a distal occlusive process. The low resistance outflow of an AVF should produce a thrill most commonly palpated over the arterial end initially. Serial compression of the outflow venous conduit with maintenance of the thrill may indicate a venous branch that is allowing runoff and is likely large enough to limit maturation. Such a branch should be localized and ligated through a small stab incision.

Step 6: Follow-Up

Patients are seen in clinic postoperatively 4 to 6 weeks after construction of the arteriovenous access. At that time, a physical exam is performed to assess the recent incisions as well as palpate the fistula for the presence of a thrill. A duplex ultrasound is also performed to evaluate AVF diameter, depth, and any stenosis or venous tributaries that have developed to siphon flow from the main fistula. If discovered, these issues are addressed. Duplex ultrasound is also used to mark the skin overlying the access prior to the initial use in the dialysis centers in order to optimize successful initial puncture. Venous conduits that fail to demonstrate adequate increases in diameter for a flow rate < 400 mL/min are either given additional time for maturation if possible or considered for balloon-assisted maturation. Balloon-assisted maturation involves sequential dilation over several weeks with balloon angioplasty, and success is expected in > 75% of cases.[10] The key component to long-term success in HD access is a continued relationship by the surgeon with both the patient and their respective nephrologist. Routine surveillance has not been found to be effective, but early recognition of access problems often means the difference between maintaining access patency versus failure with subsequent dependence on catheter placement.

CONCLUSION

Surgical access remains a critical issue for the increasing patient population in need of HD. Access failure is the most common reason for treatment and hospitalization of the patient on HD. This failure can take the form of thrombosis or lack of maturation, making cannulation of the site difficult. In order to optimize the function of surgically constructed access, the principles and techniques briefly outlined in this article may be beneficial. As with any vascular procedure, careful planning and meticulous technique are keys to success. Maintenance of a functional access depends on knowledge and recognition of the potential complications (such as stenosis, thrombosis, arterial steal, venous hypertension, and pseudoaneurysm formation) that can threaten long-term success. However, intervention with routine angioplasty/stenting is not warranted and can become a major impediment to maintenance of access function, while limiting future access options. Communication between the dialysis center, nephrology, and vascular surgery remains the critical component in the management of these often complex patients. ■

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