Chapter 41
Vascular Access for Hemodialysis

David M. Melnick

Abstract General, vascular and transplant surgeons all perform operations for vascular access. The arteriovenous fistula, when compared with an external catheter or a non-autogenous graft, has the best outcome for vascular access among many patients with end stage renal disease. Professional and governmental organizations emphasize the importance of using autogenous fistulas when appropriate. This chapter will describe the preoperative evaluation, surgical techniques and postoperative care for performing radiocephalic and brachiocephalic arteriovenous fistulas and the basilic vein transposition.

Keywords Hemodialysis • Vascular access • Arteriovenous fistula • Basilic vein transposition

D.M. Melnick, MD, MPH, FACS
Department of Surgery, University of Wisconsin School of Medicine and Public Health, One South Park Street, Madison, WI 53715, USA
e-mail: melnick@surgery.wisc.edu

H. Chen (ed.), *Illustrative Handbook of General Surgery*,
DOI 10.1007/978-3-319-24557-7_41,

Indications

The arteriovenous fistula [AVF], when compared with an external catheter or a non-autogenous graft in multiple non-randomized, non-controlled studies, has the best outcome for vascular access among patients with end stage renal disease [1]. The National Kidney Foundation Kidney Disease Outcomes Quality Initiative (KDOQI) and the Society for Vascular Surgery each have excellent guidelines for the surgeon performing vascular access operations [2, 3]. The Fistula First Initiative, instituted in 2004 and sponsored in part by the Center for Medicare Services, strongly promotes the use of native AV fistulas for access. The initiative's name has changed to "Fistula First, Catheter Last," to promote the primary goal of avoiding catheters, and to recognize the idea that some patients such as the elderly and others may have better outcomes with grafts rather than fistulas. This review will describe the surgical techniques for radiocephalic and brachiocephalic arteriovenous fistulas and the one stage basilic vein transposition [BVT].

Preoperative Care

A successful access requires good arterial inflow and good venous outflow, including patency of the central veins. Important aspects of history specific to vascular access include hand dominance, history of central lines and pacemakers, and history of radial artery operations for coronary artery bypass surgery. If both arms have adequate veins, use the non-dominant arm for access. The patient will then have more mobility of their dominant hand during dialysis. A history of central lines would prompt you to consider evaluation for central venous stenosis with a venogram. The presence of a pacemaker in the ipsilateral subclavian vein predicts a higher risk of complications including subclavian vein thrombosis after AV fistula placement in that arm. History of radial artery excision would preclude a wrist fistula. On physical

exam, evaluate for pulse quality at the radial artery at the wrist and the brachial artery at the elbow. Perform an Allen's test to evaluate the palmer arch prior to consideration of performing a radial-cephalic wrist fistula, to ensure that the ulnar artery will adequately perfuse the hand. Inspect for collateral veins in the upper arm and around the shoulder to evaluate for sequalae of central venous stenosis.

The ultrasound is an excellent instrument you can use in the office to evaluate artery and vein size and course to plan an appropriate operation (Fig. 41.1).

In most cases, a vein 2.5–3 mm or larger would be appropriate to attempt an operation, while an artery 2–2.5 mm at a minimum may work, although larger vessels size will predict a greater likelihood of success [4]. You can gain more information and detail by performing the ultrasound yourself rather than depending upon a radiology report. In patients with a history of multiple failed attempts at access, a concern for central venous stenosis, or other factors that may make the access more likely to fail, a venogram with iodinated contrast or CO_2 may also help delineate the anatomy of the venous system including the central venous system to plan the operation (Fig. 41.2).

Positioning and Anesthesia

You can perform the operations utilizing local anesthesia with sedation (or sometimes without sedation,) monitored anesthesia care, or a regional block. Place the operative arm in the abducted position on an arm board and prep and drape appropriately.

Description of the Procedure

Wrist Fistula (Radiocephalic Fistula)

Dr. Kenneth Appel, a general surgeon in The Bronx in New York City, performed the first radiocephalic wrist fistula

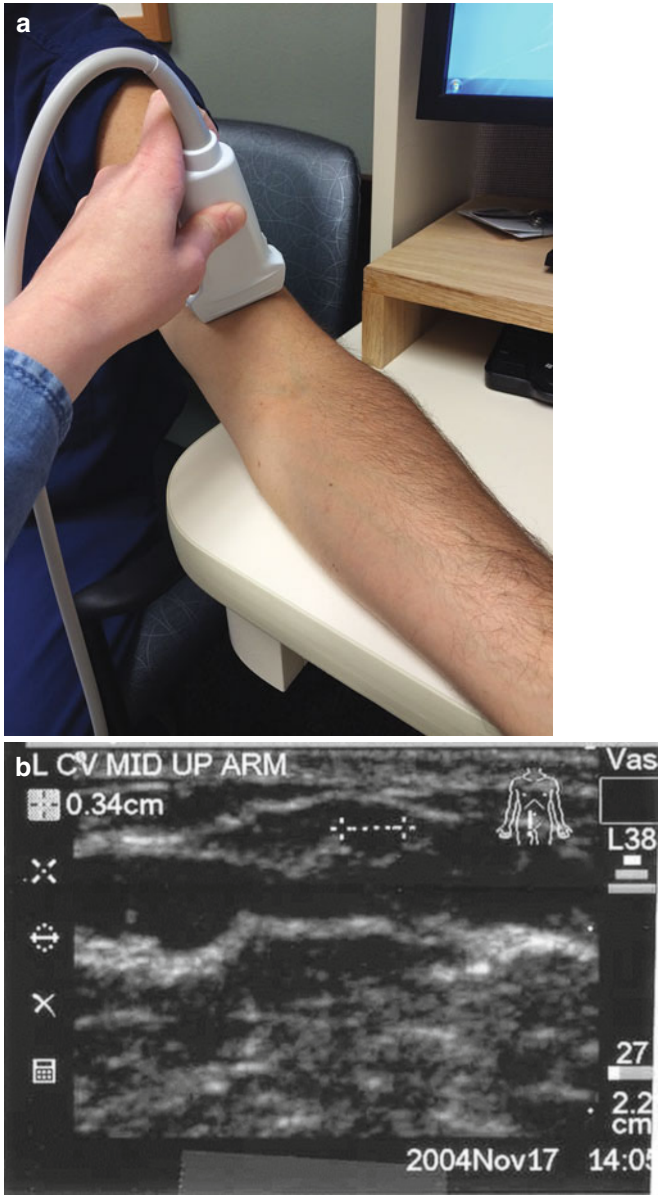

FIGURE 41.1 (**a**, **b**) Ultrasound mapping of veins, performed in the office (Courtesy of David Melnick, MD)

FIGURE 41.2 Right upper arm venogram using iodinated contrast demonstrating the cephalic vein (*upper left*) brachial vein (*middle*) and basilic vein (*lower right*) (Courtesy of Amanda Valliant, MD)

(also known as the Brescia-Cimino-Appel fistula) in 1963 [5]. He improved upon the other option at that time, the Scribner Shunt, an external metallic shunt placed in the forearm associated with significant major complications. The patient should have a normal Allen's test to prevent ischemic complications to the hand. A preoperative ultrasound can sometimes identify an area more proximal than the wrist where the vein and/or artery may have a larger diameter and be easier to work with. After prepping, draping, and anesthetizing, incise the skin longitudinally between the cephalic vein and the palpable radial artery in the distal forearm. Develop a lateral skin flap to expose the cephalic vein. Mobilize it for a distance of 4–5 cm and control it with vessel loops. To expose the radial artery, palpate it or use a Doppler to identify it then incise the overlying fascia. Preserve the superficial branch of the radial nerve lying lateral to the artery as it supplies sensa-

tion to the thumb. Mobilize the artery and gain proximal and distal control with vessel loops. Depending on the quality and location of the vein, you can perform either a side to side or end vein to side artery anastomosis. The initial description of this procedure by Appel utilized a side to side anastomosis, but this chapter will describe an end vein to side artery anastomosis. Divide the vein distally at the appropriate point to prepare for the anastomosis. Locally heparinize the vein and sequentially dilate to 4–5 mm with vessel dilators to ensure lack of stenosis, then heparinize again and place a bulldog on the vein. Some authors recommend a different approach, limiting trauma to the vein and artery by minimizing the contact with them around the area of the anastomosis.

Elbow Fistula (Brachiocephalic Fistula)

After prepping and draping, anesthetize the skin just distal to the antecubital crease and incise the skin transversely at that location. Dissect though the subcutaneous fat to expose the cephalic vein and mobilize it proximally and distally. Often you will find the cephalic vein anastomosing to the basilic vein in an arch formation, with distal venous branches. Using a branch point of the cephalic vein can help with an easier anastomosis. After exposing the vein, palpate or Doppler medially to find the brachial artery and brachial veins then incise the overlying bicipital aponeurosis (*lacertus fibrosus*) to expose them. Mobilize the artery and gain control with vessel loops. You can expose distally and gain control of the proximal radial artery to perform the anastomosis there, with the potential advantage of a lower risk of steal syndrome, or use the main brachial artery for the anastomosis. Ligate and divide small arterial branches to prevent avulsion. Gain proximal and distal control of the artery with vessel loops. Divide the vein distally at the appropriate point to prepare for the anastomosis. Locally heparinize the vein and sequentially dilate to 4–5 mm with vessel dilators to ensure lack of stenosis, then heparinize again and place a bulldog on the vein.

FIGURE 41.3 Preoperative ultrasound mapping of basilic vein (*solid line*). The *dotted line* is the planned tunneled path of the transposed basilic vein (Courtesy of David Melnick, MD)

Basilic Vein Transposition

The BVT may be performed in one stage or two stages. The first stage of the two stage approach involves performing a brachio-basilic AVF at the antecubital fossa or distal upper arm. The transposition is then performed at a later date after the fistula has been evaluated and is working. The one stage approach will be described here. After the patient is positioned with the ipsilateral arm abducted on an arm board, map out the course of the vein using the ultrasound and a marker to aid in dissection (Fig. 41.3).

After mapping out the course of the vein, prep and drape. Anesthetize as appropriate and incise the skin in the distal upper arm where you marked out the course of the vein. Dissect through the subcutaneous fat to expose the vein and control it with a vessel loop. Then sequentially incise the skin

and mobilize the vein, tying off and dividing side branches all the way up the arm to the axilla. Doubly ligate the venous branches coming off the basilic vein to prevent postoperative hemorrhage. Curve the distal end of the skin incision laterally as you approach the antecubital crease to aid with exposure of the brachial artery. After the vein is completely mobilized, expose the artery. Palpate or use doppler to find the artery medially, then incise the overlying fascia to find it. Dissect the brachial veins off the artery and place a vessel loop around the artery. Mobilize the artery for two to three centimeters so you have enough room to perform the anastomosis.

Divide the basilic vein and ligate it distally. Use a marker to indicate the anterior surface of the vein along its course to aid in orienting the vein so it does not get twisted during tunnelling. Locally heparinize the vein and dilate it if appropriate. Secure the vein to a Kelly-Wick tunneller, then tunnel the vein from the axilla, laterally and subcutaneously, to the area around the exposed artery. The more lateral the tunnel, the easier time the vascular access nurses will have cannulating the vein. Cut the stitch securing the vein to the tunneller and locally heparinize the vein, ensuring that it is not twisted.

The Anastomosis

If you have access to a venous bifurcation, divide the vein just distal to that and spatulate the anastomosis by using a right angle Potts scissor to enter one branch and come out the other, then cut to open up the vein. Alternatively, using a right angle Potts scissors make an incision in the vein at the "heel" if needed to make a wider anastomosis. Use a small bulldog to prevent back-bleeding from the vein. Bring the artery and vein next to each other and gain control of the inflow and outflow of the artery with double vessel loops or vascular clamps.

Make an arteriotomy with an 11 blade and extend it with right angle Pott's scissors. Some surgeons use a vascular punch instead of the scissors. Place a 7–0 polypropylene

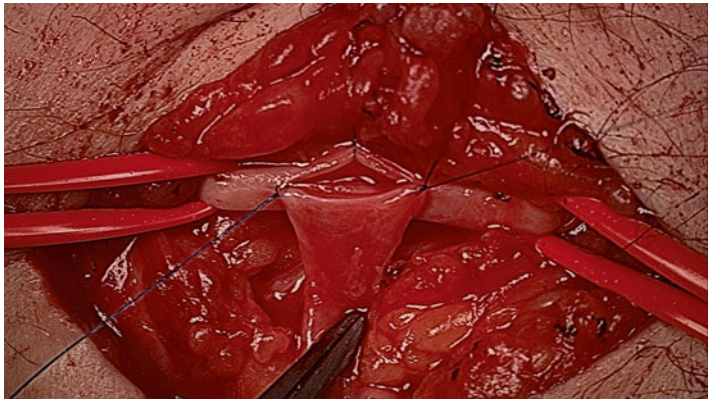

FIGURE 41.4 Preparation for radiocephalic arteriovenous wrist fistula (Courtesy of David Melnick, MD)

suture as a "stay" suture in the center of one wall of the artery to assist in retraction of the wall for exposure. Locally heparinize the artery proximally and distally. Use double armed 6–0 or 7–0 polypropylene sutures for the anastomosis.

Approximate the artery and vein at the "heel" of the anastomosis (located proximally on the arm) with the polypropylene suture and tie that down. Use another suture to bring the "toe" together so now the artery and vein are set up for the anastomosis (Fig. 41.4).

The needle typically travels outside to inside on the vein, and inside to outside on the artery to avoid raising an arterial intimal flap. Close the posterior layer first with one of the "heel" needles, traveling outside to inside on the vein for the first bite. Then travel inside to outside on the artery, then outside to in again on the vein. This will be easy if the anastomosis is set up correctly. Continue with that same suture past the "toe" and around halfway up the anterior anastomosis (Fig. 41.5).

Then change to the other "heel" needle and finish the anastomosis. Prior to tying the sutures, make sure the anastomosis is patent and you have good flow in the vein. If not, you

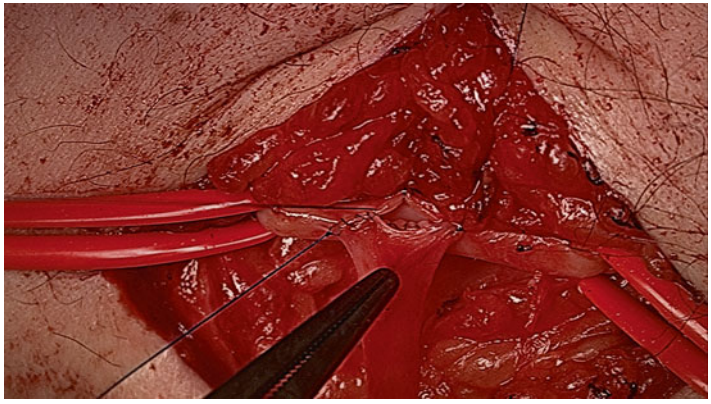

Figure 41.5 Completing the radiocephalic anastomosis (Courtesy of David Melnick, MD)

can explore the anastomosis for technical problems prior to tying the suture. With small vessels, less than 3 mm, you may not appreciate a thrill immediately but only hear a good signal by Doppler demonstrating flow. If the vein had a side branch that you ligated prior to the anastomosis, you can cut that stitch and use the sidebranch to interrogate the anastomosis by passing dilators, thrombectomy catheters, and instilling heparinized saline.

Palpate or doppler the pulse distally to ensure adequate hand perfusion. Ensure hemostasis then close the wound.

Postoperative Care

Evaluate the patients in around two weeks to assess the quality of the AVF. Along with examining for a thrill, use ultrasound if available to assess the size and depth of the fistula. If the thrill is not robust or the size of the vein seems small, you can send the patient for a fistulagram to assess for stenosis and potential balloon angioplasty. It should be apparent within 2–4 weeks whether the fistula will have enough flow to cannulate successfully for dialysis; the patient should not have to

wait months for the fistula to mature. In Appel's original series of 16 patients, aged 28–54 years old and all with end stage renal disease caused by glomerulonephritis, dialysis utilizing the fistula was attempted on postoperative day one. If there is a concern about fistula maturation, obtain a fistulagram and if necessary evaluate for revision or a new site.

Acknowledgment Thank you to Marge Hunter for assisting as a scrub tech in hundreds of these cases.

References

1. Murad MH, Elamin MB, Sidawy AN, et al. Autogenous versus prosthetic vascular access for hemodialysis: a systematic review and meta-analysis. J Vasc Surg. 2008;48(5 Suppl):34S–47.
2. National Kidney Foundation [internet.] Updates clinical practice guidelines and recommendations. 2006 [cited 13 Aug 2014]. Available from http://www.kidney.org/professionals/KDOQI/guideline_upHD_PD_VA/index.htm.
3. Sidawy AN, Spergel LM, Besarab A, et al. The society for vascular surgery: clinical practice guidelines for the surgical placement and maintenance of arteriovenous hemodialysis access. J Vasc Surg. 2008;48(5 Suppl):2S–5.
4. Lauvao LS, Ihnat DM, Goshima KR, et al. Vein diameter is the major predictor of fistula maturation. J Vasc Surg. 2009;49(6):1499–504.
5. Brescia MJ, Cimino JE, Appel K, Baruch J. Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula. N Engl J Med. 1966;275(20):1089–92.