18 Arteriovenous Hemodialysis Access

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Introduction

The goal of placing an arteriovenous fistula or graft is to create a prominent, high flow vascular circuit that can be easily punctured for hemodialysis with minimal complications. To accomplish these goals, the fistula or graft should be at least 6 mm in diameter, have a blood flow rate of 600 ml/min, and be no deeper than 6 mm with discernable margins [1]. To allow multiple needle puncture sites, the usable length of the access should be at least 6 cm, but ideally 10 cm.

Preplacement Evaluation

Timing of Referral

Evaluation for a primary AV fistula should ideally begin at least 6 months in advance of starting dialysis. This time interval allows for evaluation, placement, maturation, and possible revision of an AV fistula. Autogenous fistulas take at least 6 weeks to mature and may require an intervention, such as ligation of competing vein tributaries or angioplasty of a stenotic segment, before being adequate for use. In some patients, a primary fistula never matures and a new fistula must be created. In contrast, an AV graft typically takes only 2 weeks to incorporate into the wound, although it may take slightly longer for the edema to resolve. AV grafts can therefore be placed closer to the time of hemodialysis initiation.

History and Physical Exam

History

A thorough history should be taken prior to dialysis access placement. Particular attention should be paid to conditions which may have damaged the venous integrity including: previous AV access, multiple peripheral intravenous (IV) catheters, peripherally inserted central catheter (PICC) lines, central venous catheters, pacemaker/defibrillator, IV drug abuse, and a history of deep venous thrombosis (DVT) or superficial phlebitis. For example, central venous catheters and pacemakers can lead to central venous stenosis or chronic occlusion. Any known blood pressure asymmetry, prior arterial reconstruction, or history of ischemic steal syndrome must be identified. Choosing the best access site requires knowledge and investigation of anything that could affect the quality of the arteries or veins.

The nondominant arm should be used when possible. If one arm has some disability, such as spastic paralysis or chronic pain, that limb should be avoided for access placement. The patient's pursuits and personal hobbies should be considered as well (e.g., playing guitar, fly fishing, work as an electrician) when selecting the side of the access to avoid interfering with these activities. The patient should be made aware of the potential for functional steal syndrome which may hinder some activities. Any previous surgeries involving the arm, shoulder, or chest should also be noted since they may affect the access location chosen. Table 18.1 lists some pertinent aspects of the history.

Physical

A complete physical examination should be performed giving particular attention to the vascular system. To evaluate the arterial system, bilateral blood pressures and pulses

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Table 18.1 History

History	No	Yes	Comments
Previous AV access			
Previous central catheter, PICC line, pacemaker, or defibrillator			
Previous venous disease (DVT, superficial thrombophlebitis)			
Intravenous drug abuse			
Arm disability, relevant activities			
Previous surgery			
Heart disease or diabetes mellitus			
Anticoagulant therapy or coagulation disorder			
Dominant hand	Right	Left	

AV arteriovenous, *DVT* deep vein thrombosis, *PICC* peripherally inserted central catheter

Table 18.2 Physical exam

Physical exam (vascular)	*Right*	*Left*	*Comments*
Bilateral blood pressures			
Brachial			
Ankle			
Peripheral pulses, +/– Doppler			
Carotid			
Brachial			
Radial			
Ulnar			
Femoral			
Popliteal			
Posterior tibial			
Dorsal pedal			
Allen's test	nl/abnl	nl/abnl	
Tissue loss	yes/no	yes/no	
Edema	yes/no	yes/no	
Discoloration	yes/no	yes/no	
Collateral veins	yes/no	yes/no	
Arm size	nl/abnl	nl/abnl	
Physical exam (other)		*Comments*	
Cardiac	nl/abnl		
Pulmonary	nl/abnl		

nl normal, *abnl* abnormal

should be assessed along with an Allen's test to check for an incomplete palmar arch. A blood pressure difference greater than 15 mmHg between arms is significant and should warrant further testing if the arm with the lower pressure is planned for access placement. In most cases, the arm with the higher blood pressure should be used. Tissue loss in the finger tips or hand should also be noted as this finding could indicate underlying arterial occlusive disease. Since hand perfusion will decrease after access placement, any tissue loss should be resolved before surgery. Venous obstruction can manifest as edema, discoloration, collateral veins on the arms or chest, or a difference in arm size. The cardiopulmonary systems should be evaluated for signs of heart failure. Table 18.2 summarizes the pertinent components of the physical examination.

Imaging

Ultrasound Vein Mapping

As a cost-effective, noninvasive exam that does not require contrast, duplex ultrasound is an ideal imaging modality for evaluating possible autogenous access sites in patients with chronic kidney disease. In addition to measuring the diameter, superficial veins should be assessed for large branches, thrombosis, and thickened walls (evidence of previous phlebitis). The deep venous system should also be evaluated for deep venous thrombosis. A sample vein mapping worksheet is shown (Fig. 18.1) summarizing diameters at multiple points along the upper extremity. In general, a vein diameter of at least 3 mm is preferred for establishing a native arteriovenous fistula.

Venography

Venography should not be routinely performed (especially in patients not on dialysis yet) because it is an invasive exam that requires contrast. Patients who have a pacemaker or a history of central venous catheters (especially subclavian), as well as those with signs of central venous stenosis, should be considered for venography to assess the central veins. Venography to evaluate the veins in the upper extremity should be used selectively.

Order of Site Preference Principles and Guidelines

Fistula First, Catheter Last Principles

The National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) ranks the order in which AV access for dialysis should be attempted, which follows the principles of "fistula first, catheter last". The recommendations generally describe placement of autogenous AV fistulas, followed by grafts in distal to proximal locations in the upper extremities. The first choice is a "snuffbox" radial-cephalic AV fistula followed by more proximal upper extremity AV fistulas, then AV grafts. Once all upper extremity locations have been used, alternative sites, such as axillary and lower extremity fistulas may be considered. Catheters are used for permanent hemodialysis access as a last resort. These guidelines are based on the survival and safety advantages of autogenous AV fistulas over AV grafts and catheters. The order of preferences is summarized in Table 18.3 [1].

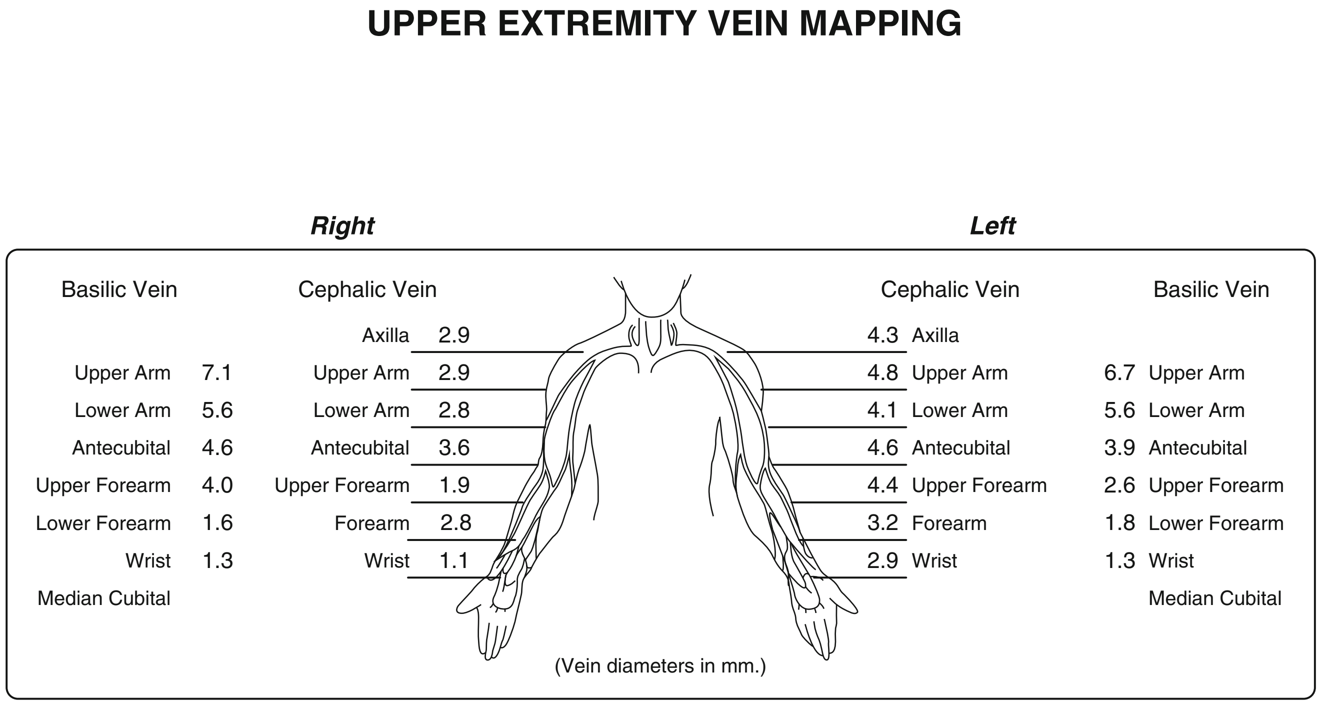

Fig. 18.1 Vein mapping worksheets showing a typical upper extremity mapping of the bilateral basilic and cephalic veins. Note multiple locations for sequential diameters recorded

Table 18.3 Order of preference guidelines for AV access

Fistula/Graft type	Advantages	Drawbacks
Preferred		
Radial-cephalic fistula (snuffbox followed by wrist)	The preferred first location, straightforward procedure, preserves proximal sites	Lower flow, slower maturation, higher risk of hand ischemia
Brachial-cephalic fistula	Higher flow, more reliable maturation	Increased incidence of edema and ischemic steal syndrome may require superficialization
Brachial-basilic (transposition) fistula	Less likely to have been previously accessed due to its deeper and more medial location	Increased pain and edema postop, increased risk of ischemic steal syndrome, kinking if tunneling, requires transposition of length of basilic vein, technically challenging in obese
Acceptable		
Forearm loop AV graft	Shorter lag time, easy cannulation	Infection, thrombosis, postop pain and edema, lower flow than more proximal grafts
Upper arm AV graft (straight or curved followed by loop)	Higher blood flow than distal grafts	Infection, increased risk of ischemic steal syndrome
Femoral AV graft	High blood flow	Infection, ischemia, difficulty positioning for dialysis, difficult if obese
Necklace AV graft		Infection, thrombosis, not for patients who need sternotomy
Avoid if possible		
Tunneled HD catheter	Immediate access	Last resort due to infection and thrombosis

Advantages and Drawbacks of Autogenous AV Fistulas

Patients with autogenous AV fistulas have safer, more effective dialysis and live longer than patients with AV grafts and catheters. AV fistulas are superior to grafts and catheters with regard to infection rate, thrombosis rate, long-term patency, and cost [2]. A drawback of autogenous AV fistulas is their maturation time of at least 6 weeks compared to grafts which require 2 weeks and catheters which are ready for use immediately. Autogenous AV fistulas also have a higher primary failure rate, and some fistulas never mature.

Balloon angioplasty maturation (BAM) has emerged as a promising technique to improve maturation of small caliber autogenous AV fistulas. BAM involves sequential dilation to create a controlled rupture of the vein which then remodels into a large caliber vascular conduit [3].

Technical Details

General Operative Considerations

Anesthesia

AV access placement can be done under general anesthesia, regional block, or local anesthesia with sedation. The author (VG) uses the latter for the vast majority of primary procedures. General anesthesia or regional blocks are generally used for more complex or redo procedures. Selected patients with complicating conditions (e.g., claustrophobia, chronic back pain, psychologic disturbances) may require general anesthesia.

Heparin

Evidence supporting a clear benefit for intraoperative heparin during AV fistula surgery remains elusive. Some studies showed no difference in bleeding complications, and 30-day patency rates with systemic heparin administration [4] and others demonstrated an increased risk of bleeding with heparinization and no benefit in terms of primary patency [5]. The use of systemic heparin in the creation of AV fistulas is therefore based on surgeon preference and experience.

Tunneling

To avoid kinking or twisting of the vein, proper orientation should be maintained by marking the vessel along one surface prior to tunneling. The vein should be tunneled superficially to make it easier to define and puncture for dialysis. It is important to note that the position of the patient's arm during the operation (abduction) is usually different than the more anterior position of the arm during dialysis. Unimpeded access should be possible when the arm is in a natural position for the patient. Access placement issues become more important in patients with redundant tissue or decreased mobility.

Anastomosis

The anastomotic diameter should be limited to minimize the risk of hemodynamic steal syndrome. Although they are not definitive, guidelines for the size of the anastomosis have been proposed. For the brachial artery, the anastomotic diameter should be 4–6 mm [6, 7]. For radial artery fistulas, the anastomotic diameter should be between 5 and 8 mm [8].

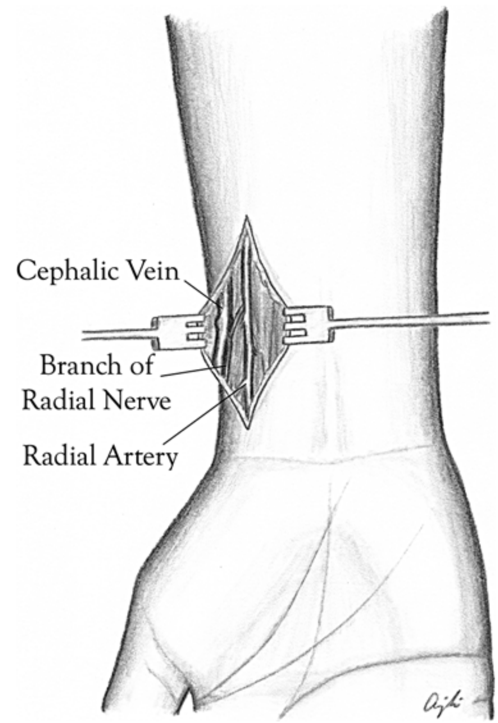

Fig. 18.2 Wrist dissection showing the main structures of the radial artery, cephalic vein, and branch of the radial nerve

Thrill/Pulse

The presence of a thrill over the new AV fistula should be noted both before and after closure of the incisions. A distal pulse should be palpated. If it is not palpable, the pulse should be reevaluated during manual compression of the AVF. If the pulse returns with AVF compression, then the arterial flow is intact. If the pulse does not return, further investigation is warranted for arterial thrombosis or embolus. At a minimum, good distal Doppler signals and capillary refill should be present before leaving the operating room.

Surgical Exposures

This section describes the common exposures for isolating the radial, brachial, axillary, and femoral vessels.

Radial Artery

A longitudinal incision is made along the lateral wrist over or just lateral to the radial pulse (Fig. 18.2). The radial artery is located just lateral to the flexor carpi radialis tendon.

Brachial Artery and Vein

Brachial artery exposure typically involves a transverse incision just distal to the antecubital crease (Fig. 18.3a, b).

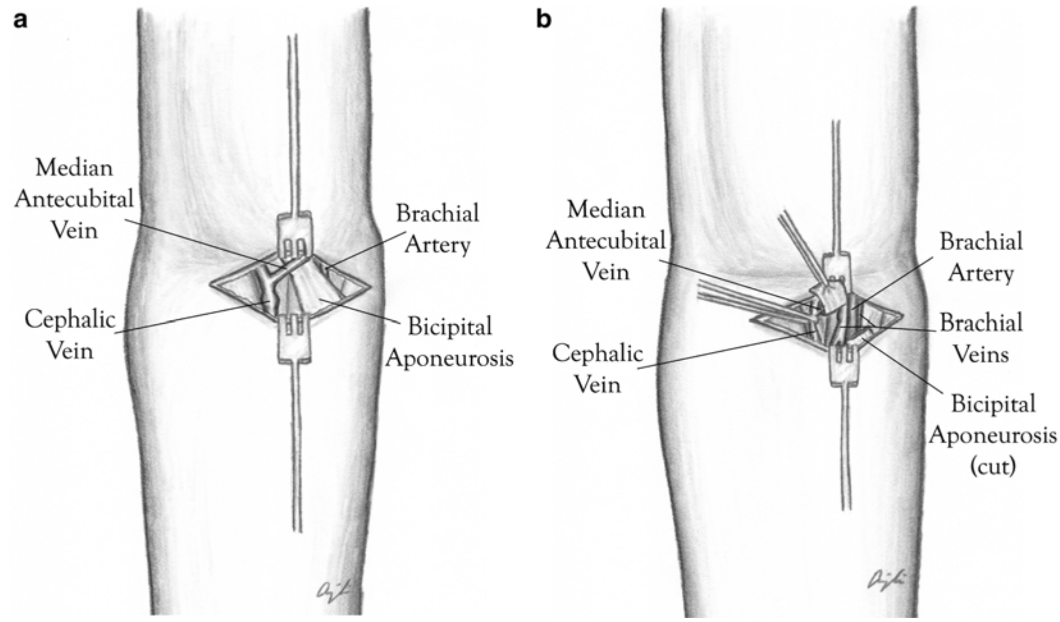

Fig. 18.3 (**a**) Transverse incision just distal to the antecubital crease showing the cephalic vein, median cubital vein, and the bicipital aponeurosis overlying the brachial artery and vein. (**b**) Dissection carried deeper with transaction of the bicipital aponeurosis and exposure of the brachial artery and veins

To expose the brachial artery, the aponeurosis of the biceps tendon is partially divided. The brachial artery should be isolated both proximally and distally with vessel loops. Small arterial branches should also be identified and isolated with vessel loops. The nerve closest to the brachial artery is the median nerve, which is medial to the vessels. This nerve is more prominent during exposure proximal to the antecubital crease.

For dissection proximal to the antecubital crease, the patient's arm is abducted to 90°. A longitudinal incision is made on the medial arm over the groove between the biceps and triceps muscles (Fig. 18.4). The basilic vein can be visualized medial to the brachial sheath. The median and ulnar nerves are usually encountered during the dissection.

Femoral Artery and Vein

A longitudinal or oblique incision should be made just distal to the inguinal ligament (Fig. 18.5). The dissection is carried down to the common femoral artery. The femoral bifurcation is identified and isolated. The dissection is then continued medially to expose the femoral veins. The common femoral, deep femoral, proximal femoral, and saphenofemoral junction are isolated and controlled. The femoral nerve is lateral to the artery and should not be visualized during the standard dissection.

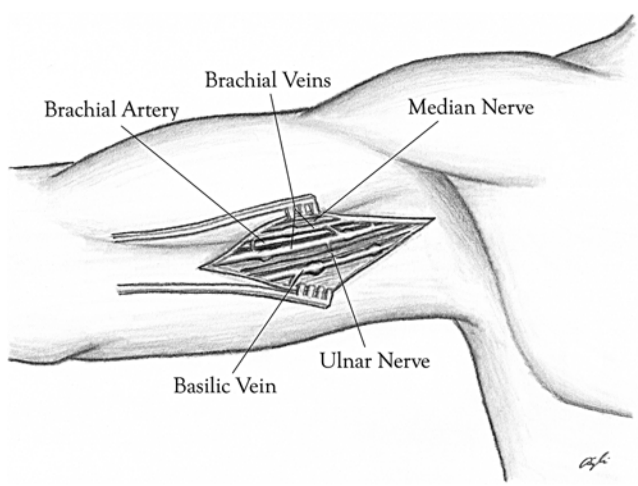

Fig. 18.4 The brachial artery is dissected out proximally. Note the brachial artery and surrounding brachial veins with crossing branches. The median nerve and ulnar nerves can be exposed in this dissection

Access Types

Common access procedures are described below. Most information regarding access failure and outcome are single-center retrospective reviews. Some representative studies are included to give a general sense of outcome; however, there can be variability between different studies and time periods.

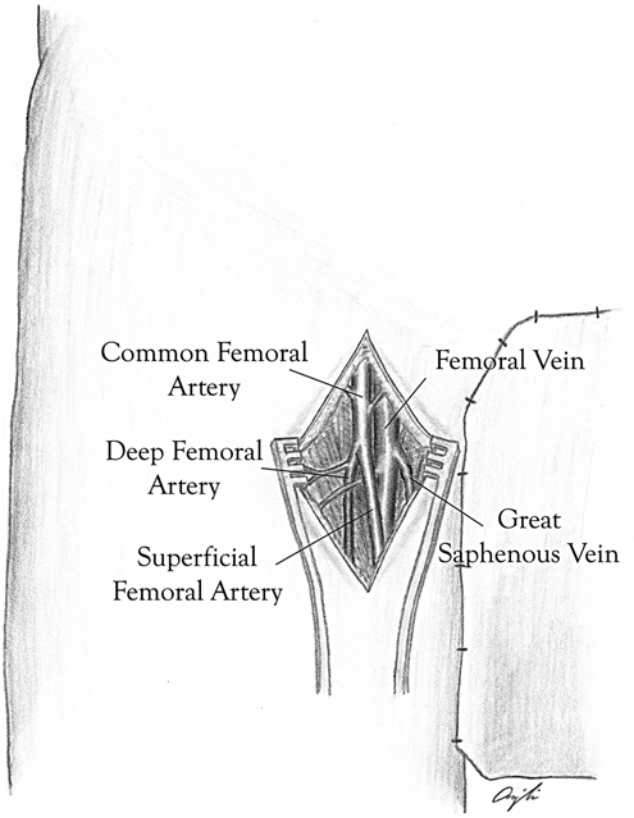

Fig. 18.5 A vertical incision is made over the femoral vessels. The common femoral artery and the bifurcation into the superficial and deep femoral arteries are shown. The medial femoral vein and saphenofemoral junction are also shown

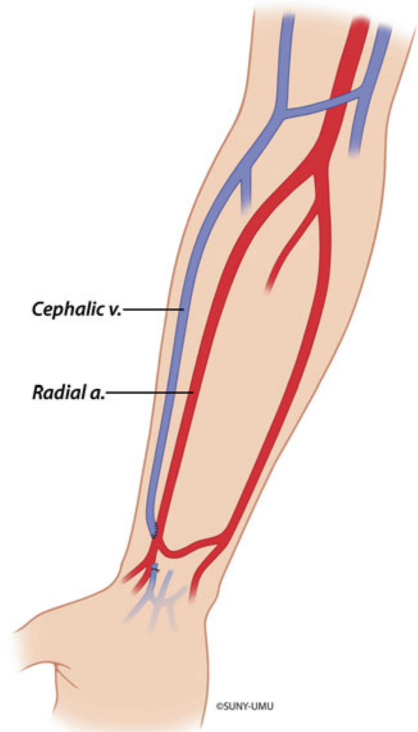

Fig. 18.6 Radial cephalic AV fistula

Wrist/Forearm Fistulas

Radial-Cephalic (Brescia-Cimino) Fistula

Procedure

A radial artery-cephalic vein AV fistula (Fig. 18.6) can be created at either the "snuff box" or the wrist. The "snuff box" is the preferred location. One or two longitudinal incisions can be used depending on patient anatomy and surgeon preference. The cephalic vein is dissected, and side branches ligated and divided so that enough length is obtained to transpose the cephalic vein over to the radial artery. Care should be taken to protect the superficial radial nerve and its branches which lie between the cephalic vein and radial artery. The cephalic vein is then transected, and its distal end suture ligated. When two incisions are used, the natural orientation of the vein must be maintained to avoid twisting and kinking when the vein is tunneled under the skin bridge for the anastomosis with the artery. An end-to-side anastomosis is then created between the end of the cephalic vein and a longitudinal or oblique incision on the radial artery.

Advantages/Drawbacks

A radial-cephalic AV fistula has the advantage of being a straightforward operation with few complications which preserves more proximal vessels for future access.

The drawbacks include a lower blood flow rate and longer maturation time. The overall primary failure rate ranges from 15 to 39 % [9–12] which is higher than brachiocephalic and brachiobasilic AV fistulas [13]. The 1- and 2-year cumulative patency rates for radial-cephalic AVF are 62–69 % and 50–57 %, respectively [9–11]. Because this procedure has an increased risk of hand ischemia, an Allen's test should be performed preoperatively to confirm a patent palmar arch. If a side-to-side anastomosis is performed, venous hypertension in the hand may result. In obese patients, a superficialization procedure may be necessary to make the fistula easier to define and puncture.

Radial-Basilic Fistula

Procedure

A radial artery-basilic vein AV fistula is an uncommon AV access that is used in only a small number of patients compared to the radial artery-cephalic vein AV fistula. A medial incision is made along the length of the forearm to mobilize the basilic vein (Fig. 18.7). The basilic vein is transected near the wrist and transposed anteriorly through

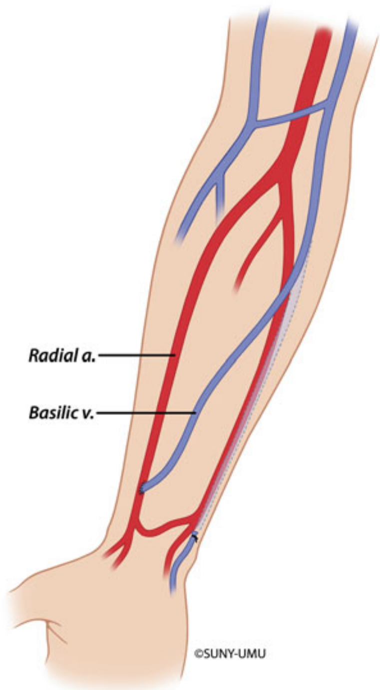

Fig. 18.7 Radial basilic AV fistula

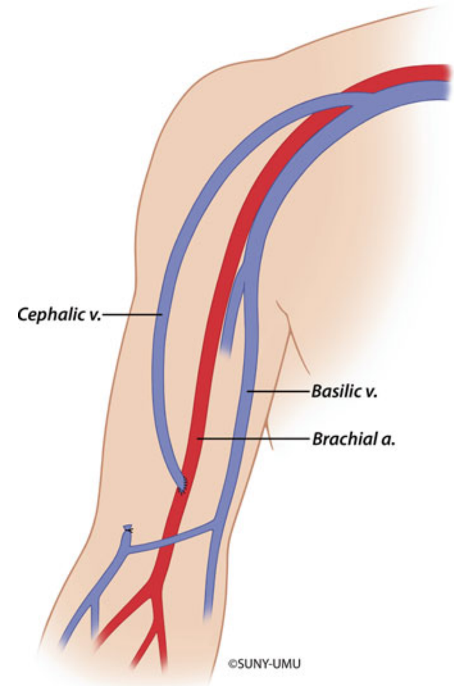

Fig. 18.8 Brachiocephalic AV fistula which is placed proximally to the antecubital crease

a subcutaneous tunnel. The distal end of the basilic vein is then connected to the radial artery by an end-to-side anastomosis. The ulnar artery can also be used for arterial inflow, or the basilic vein can be formed into a loop in the forearm and connected to the brachial artery.

Advantages/Drawbacks

A radial-basilic AV fistula offers another autogenous access option in the forearm before moving on to the upper arm. The maturation rate and patency rates appear relatively comparable to other forearm AV fistulas [14, 15]. The main drawback is the more extensive dissection required to mobilize the basilic vein.

Upper Arm Fistulas

Brachial-Cephalic Fistula

Procedure

A brachial artery-cephalic vein AV fistula can be created through a single transverse incision just proximal or distal to the antecubital fossa or two parallel longitudinal incisions on the upper medial arm (Fig. 18.8). The cephalic vein is dissected and mobilized to gain enough length so that it can reach the brachial artery without tension. The distal end of the cephalic vein is then transected. When using the two-incision technique, the cephalic vein is transposed through a subcutaneous tunnel to create the AV anastomosis. An end-to side anastomosis is then created between the cephalic vein's free end and the side of the brachial artery.

Advantages/Drawbacks

The higher blood flow in brachial-cephalic AV fistulas results in a more reliable maturation rate compared to wrist fistulas. The 1- and 2-year cumulative patency rates were 72–75 % and 75–78 %, respectively [11, 16].

The downside of higher blood flow is a higher incidence of edema and ischemic steal syndrome compared to forearm AV fistulas. The cephalic vein can also be too deep to reliably puncture in obese patients. Since standard dialysis needles are only one inch in length, a superficialization procedure may be necessary if the vein is more than 1 cm deep after arm edema has resolved (usually 4–6 weeks postoperatively). Superficialization is accomplished by either the "fistula elevation procedure", where the vein is dissected free and the subcutaneous tissue is then closed beneath the vein [17], or by lipectomy [18]. These procedures can also be performed on radial-cephalic or brachial-basilic AV fistulas.

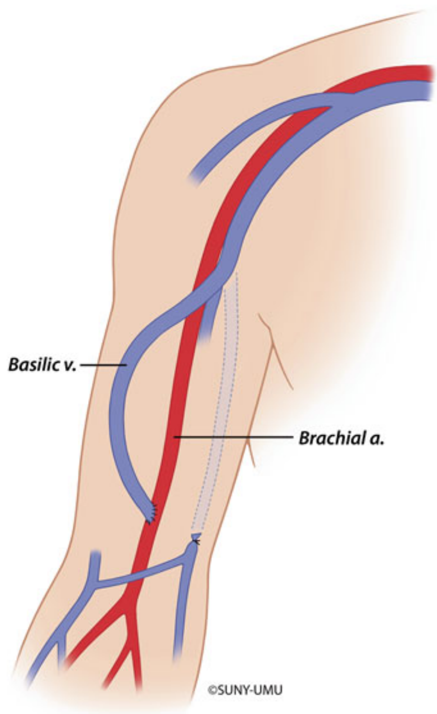

Fig. 18.9 Brachiobasilic AV fistula showing how the basilic vein is mobilized, divided distally and tunneled laterally, and then anastomosed to the brachial artery

Brachial-Basilic (Upper Arm Transposition) AV Fistula

Procedure

A brachial artery-basilic vein AV fistula can be created using a one-stage or two-stage approach. In the one-stage approach, a longitudinal incision on the upper medial arm is used to mobilize the basilic vein from the antecubital crease to its confluence with the brachial vein leading into the axillary vein (Fig. 18.9). Care should be taken to avoid the surrounding nerves. A segment of the brachial artery is then isolated in the distal upper arm. After marking its anterior surface for orientation, the basilic vein is transected distally and tunneled in an anterolateral fashion through the subcutaneous tissue. One or two counter incisions can help facilitate the tunnel. A laterally raised subcutaneous flap can also be used instead of a tunnel. An end-to-side anastomosis is then performed to the brachial artery. Typically a drain is left in the dissection bed.

In the two-stage approach, a single transverse incision is made just distal to the antecubital crease [19, 20]. The basilic vein or the median antecubital vein leading to the basilic vein is transected, and an end-to-side anastomosis is performed to the brachial artery. If, after 4–6 weeks, the basilic vein has reached a diameter of at least 5 mm, a second stage is performed during which the basilic vein is transposed superficially, anteriorly, and slightly laterally. The second stage begins by exposing the upper arm basilic vein with a single longitudinal incision or two incisions with an intervening skin bridge. Although using two incisions adds some time to the vein dissection, this technique can facilitate wound closure by limiting the size of the skin flaps. The basilic vein is then dissected along its entire length from the arterial anastomosis to its confluence with the brachial vein leading into the axillary vein. The basilic vein can then be transposed by securing it in a lateral subcutaneous flap. Alternatively, the basilic vein can be transected, tunneled anteriorly, and reanastomosed to itself. The latter method has the advantage of preserving any crossing structures. If there are a number of crossing nerves, it is usually better to transect the vein, pull the vein out from under the nerves, and reposition and reanastomose the fistula. The authors prefer to perform the transection and reanastamosis within the body of the fistula leaving the original arterial anastomosis undisturbed. This technique decreases the risk of steal since it preserves the original small diameter arterial anastomosis even though the basilic vein may have dilated significantly between the first- and second-stage procedures.

Advantages/Drawbacks

The deep location of the basilic vein makes it less likely to have been accessed or injured prior to fistula creation. In many patients, the upper arm basilic vein is the only healthy superficial vein in the upper extremity.

The drawbacks of a brachial basilic fistula include increased postoperative pain and edema, a longer recovery time, the need for a potentially two-staged procedure, and an increased risk of ischemic steal syndrome [21, 22]. Tunneling can kink or twist the vein, and positioning the vein for unimpeded access can be especially challenging in obese patients.

Transposing the vein has a higher rate of functional success than simply elevating the vein [21]. Additionally, fistulas created using a two-stage procedure may be more successful than fistulas created in one stage [12]. Medium- and long-term patency results for brachial basilic fistulas vary between studies. Segal and colleagues showed an assisted primary patency rate of 64 and 58 % at 1 and 2 years, respectively [23]. In contrast, Humphries and colleagues demonstrated cumulative patency rates of 84 % at 1 year, 73 % at 3 years, 73 % at 5 years, and 52 % at 10 years [24].

Brachial-Median Antecubital Vein Fistula

Procedure

A brachial artery-median antecubital vein AV fistula can be created in a similar fashion to the brachial-cephalic and brachial-basilic fistulas. The median antecubital vein usually lies in close proximity to the distal brachial artery, and both

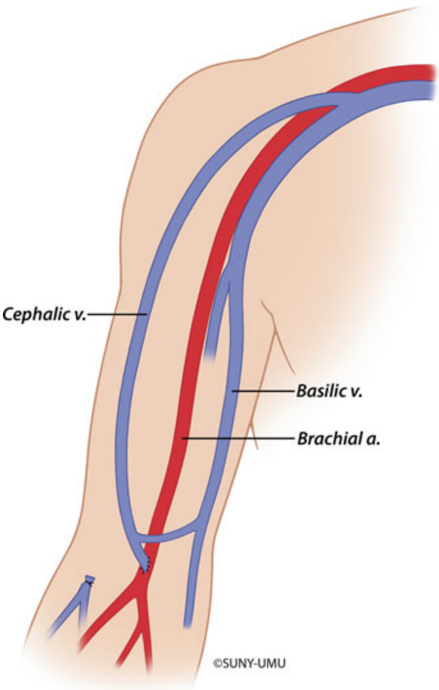

Fig. 18.10 Brachial artery to medial cubital vein AV fistula

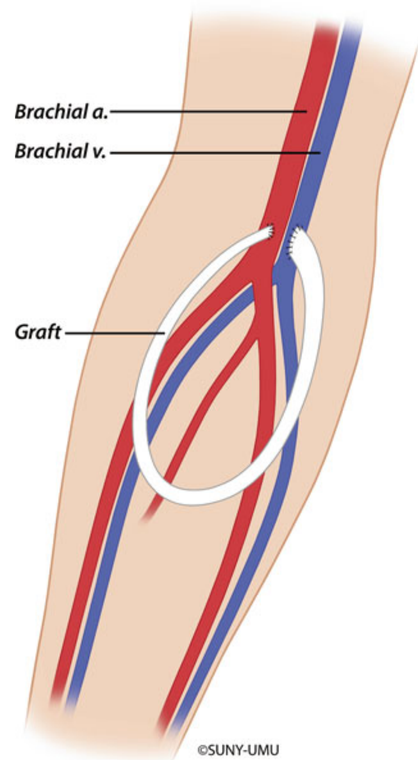

Fig. 18.11 Forearm loop AV graft with the anastomosis to the brachial artery and vein

structures can be isolated through a single transverse incision just distal to the antecubital crease (Fig. 18.10). The median antecubital vein becomes confluent with the upper arm cephalic and basilic veins which are both left intact. After dividing the distal median antecubital vein, it is connected to the brachial artery with an end-to-side anastomosis.

Advantages/Drawbacks

The brachial artery to median antecubital vein fistula has the advantage of preserving flow to both the cephalic and basilic veins. This configuration potentially allows both veins to mature simultaneously for access. Depending on patient anatomy, flow may only occur to one of the two veins using this approach.

Sparks and colleagues showed a patency rate of 80 % at an average follow-up time of 36 months for fistulas created using a perforating median antecubital vein compared to 66 % at 27 months for brachial-cephalic fistulas and 64 % at 7 months for synthetic arm grafts [25].

Prosthetic Grafts

Forearm Loop AV Graft

Procedure

A forearm loop AV graft between the brachial artery and either the cephalic, basilic, median antecubital, or brachial vein can be placed though an incision just distal to the antecubital crease (Fig. 18.11). Once the vessels have been identified and dissected, a small counterincision is made in the mid to distal forearm to aid in tunneling the graft loop through the anterior forearm. Proper orientation of the graft should be maintained while tunneling to avoid kinking, and a semicircular tunneler should be used to maximize the useable length of graft. End-to-side anastomoses are created between one end of the graft and the brachial artery and the other end of the graft and the selected vein. Due to the increased probability of postoperative edema, the authors recommend external sutures for skin closure.

Advantages/Drawbacks

An arteriovenous graft offers an AV access option to patients who lack adequate caliber superficial veins to create a native AV fistula. AV grafts also do not need to mature and can be used as soon as 2 weeks after placement. The larger diameter and superficial location of AV grafts provides an easy and well-defined target for needle puncture.

The drawback of all AV grafts is their higher rate of thrombosis and infection compared to native AV fistulas [1, 2]. Forearm AV grafts also tend to have lower blood flow and increased postoperative edema and pain.

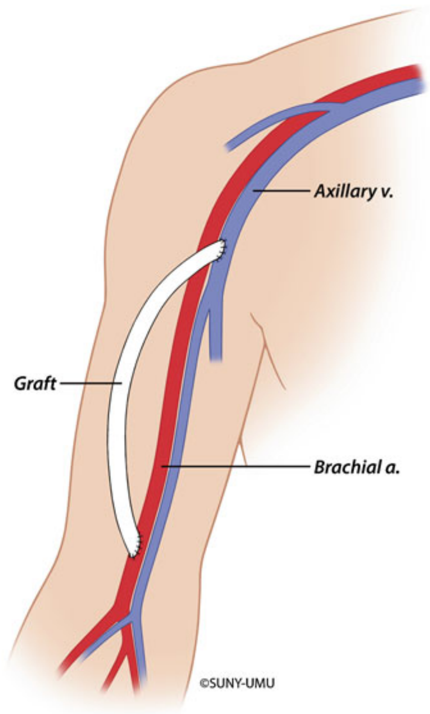

Fig. 18.12 Brachial artery to axillary vein AV fistula

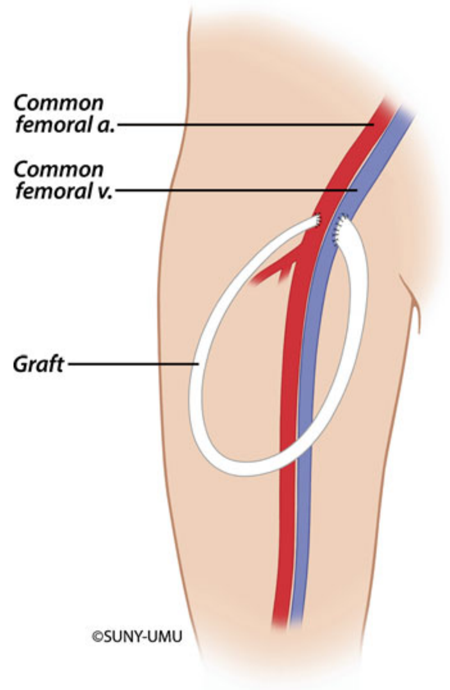

Fig. 18.13 Femoral loop AV graft

Upper Arm AV Graft

Procedure

Upper arm AV grafts can employ a variety of configuration using straight or looped grafts to connect the brachial or axillary artery to the cephalic, basilic, brachial, or axillary vein. A straight graft between the brachial artery and the axillary vein is constructed through two longitudinal incisions: one over the distal arm brachial artery and the other over the axillary vein in the proximal arm (Fig. 18.12). The graft is tunneled through the anterolateral subcutaneous tissue, and end-to-side anastomoses are performed to the artery and vein.

Advantages/Drawbacks

The upper arm AV graft is generally less painful than the forearm loop graft. Because they use larger, more proximal arteries, upper arm AV grafts have a higher rate of hemodynamic steal. In a study examining 193 grafts, Mousa and colleagues did not find a difference in patency rates between forearm and upper arm AV grafts [26]. Whether the graft had a loop or straight configuration also did not affect patency.

Femoral Loop AV Graft

A femoral loop AV graft is usually the next choice of access after exhausting all sites in the upper extremities.

Procedure

A femoral AV graft can be created between the common femoral artery (close to the femoral bifurcation) and the common femoral vein using a transverse or oblique incision in the groin (Fig. 18.13). Typically, the graft used is a 6-mm straight or a 6–8-mm tapered graft, with the smaller end anastomosed to the artery. The graft should be tunneled superficially in a loop configuration on the anterior thigh. Similar to the forearm loop AV graft, a small counterincision helps pass the graft through the tunnel.

Advantages/Drawbacks

In addition to providing access for patients with no upper extremity options, femoral AV grafts have high flow rates. This advantage may account for the reasonable patency rates associated with femoral AV grafts. Tashjian and colleagues reported primary patency rates of 71 and 63 % and secondary patency rates of 83 and 83 % for 1 and 2 years, respectively [27]. Similarly, Geenan et al. found cumulative patency rates to be 75 % at 1 year and 51 % at 5 years [28].

Despite their functionality, femoral AV grafts remain at the bottom of the K-DOQI access preference list because of their high rate of infection and ischemia. Patient selection also plays an important role in femoral AV graft placement. Patients must be able to recline during dialysis, and femoral AV grafts may not be feasible in a patient with a large pannus that overlies the anterior upper thigh.

Alternate Access (Overview)

The more common access procedures have been described above. Other options include the axillary loop AV graft, the "necklace" (axillary artery to contralateral axillary vein AV graft), the mid-thigh loop graft, the femoral vein transposition to distal superficial femoral artery AV fistula, the great saphenous vein AV fistula, and the Hemodialysis Reliable Outflow (HeRO) Device. A brief description of each option follows.

An axillary loop AV graft connects the axillary artery and vein with a graft that loops laterally over the deltoid muscle or medially over the pectoralis major muscle. In a study by Jean-Baptiste and colleagues, axillary loop grafts had a primary patency rate of 51 % at 12 months and a cumulative patency rate of 80 % at 18 months [29].

A necklace AV graft is placed between the axillary artery and the contralateral axillary or internal jugular vein. Since it crosses anteriorly to the sternum, this graft is not appropriate for patients who may need a sternotomy in the future. In a study of 18 patients, the primary patency rate was 83 and 72 % and the cumulative patency rate was 94 and 89 % at 6 months and 1 year from graft placement [30].

A mid-thigh AV graft connects the mid-superficial femoral artery to the femoral vein. This option preserves more proximal femoral vessels for future access or revision and avoids a groin incision. Scott and colleagues found the primary patency rates to be 40 and 18 % and the secondary patency rates to be 68 and 43 % at 1 and 2 years, respectively [31]. Despite the absence of a groin incision, this access configuration still had a high rate of infection resulting in graft removal in 21 % of patients.

The femoral vein transposition (FVT) involves dissecting the femoral vein along its length in the thigh. The vein is then superficially transposed and connected to the distal SFA [32]. Although the patency rates are excellent, FVT has a higher rate of wound complications and ischemia. Wound complications may stem from the deep location of the femoral vein which requires a more extensive dissection. The large size of the vein often leads to a large arterial anastomosis resulting in a higher incidence of hemodynamic steal syndrome. Selectively tapering the femoral vein to reduce its caliber may decrease the incidence of secondary procedures to address ischemia. Hazinedaroglu and colleagues compared the FVT to the femoral loop graft and found a superior 1 year primary patency rate of 87 % for the FVT compared with 38 % for the femoral loop graft. Both types of access had similar infection and ischemia rates [33].

A fistula can be created by forming the great saphenous vein into a loop that connects to the common femoral artery (Fig. 18.14). In a study by Pierre-Paul and colleagues, the mean primary patency was 7 months, the mean primary-assisted patency was 15 months, and the mean secondary patency was 16 months [34]. The GSV did not dilate as much as upper extremity veins, and therefore, the preoperative diameter should be equal or close to the diameter required for successful hemodialysis. Stenoses throughout the body of the AV fistula were common.

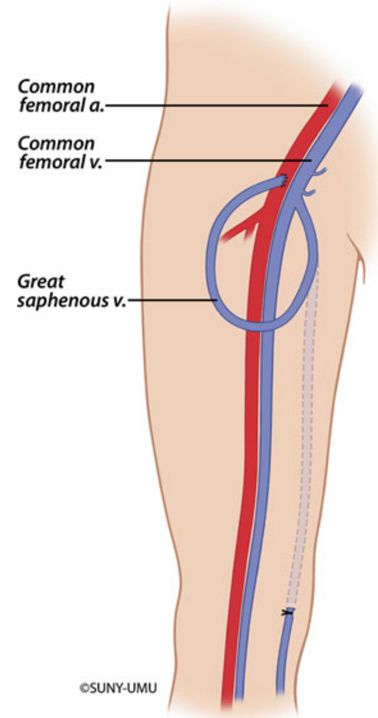

Fig. 18.14 Great saphenous vein to common femoral artery AV fistula

The HeRO is a hybrid device in which a prosthetic graft is anastomosed to the brachial artery, superficially tunneled on the anterior upper arm, and connected to a catheter extending into the internal jugular vein. This access was designed for patients with adequate arterial inflow but no suitable venous outflow proximal to the superior vena cava or right atrium. In a study by Katzman and colleagues, the HeRO device had a primary patency of 39 %, an assisted primary patency of 86 %, and a secondary patency of 72 % at a mean follow-up of 8.6 months [35]. A subsequent study comparing outcomes of the HeRO device to conventional AV grafts showed comparable patency, adequacy of dialysis, and bacteremia rates [36].

Summary

The concept of vascular access for hemodialysis is deceptively simple: arterial inflow connected to venous outflow creates a high blood flow circuit that can be regularly diverted into the dialysis machine. In practice, vascular access can be a challenging problem that often defies a simple solution or a single operation. Planning, persistence, and sound clinical judgment are required to create a functional AV fistula or graft without jeopardizing future access options. This chapter gives surgeons a framework for managing hemodialysis patients by outlining the fundamental procedures and principles for hemodialysis AV access.

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