24 Femoropopliteal Bypass Using Prosthetic or Vein

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[AQ:3] INDICATIONS/CONTRAINDICATIONS

The accepted indications for revascularization in the setting of femoropopliteal segment occlusive disease remain the same as they have been for decades, namely femoropopliteal disease associated with: (1) nonhealing foot wound (including foot ulcer or gangrene), (2) foot or leg pain at rest that appears to be due to an ischemic etiology, or (3) severe claudication that is both limiting in one's daily activities and recalcitrant to supervised exercise regimen. In most contemporary vascular surgical practices, an attempt at endovascular intervention is usually the first-line option for patients meeting the above criteria, and surgical bypass is reserved for cases that cannot be successfully treated with percutaneous endovascular techniques. Proceeding directly to open surgical bypass is a perfectly valid treatment option, however, in cases that are unlikely to have an effective or durable response to endovascular intervention—for example, young patients with long-segment occlusion of the superficial femoral artery, good-caliber ipsilateral saphenous vein, and debilitating claudication. So, although the indications for revascularization have remained unchanged, the ultimate decision between endovascular intervention and femoropopliteal bypass requires judgment based on both the clinical situation and one's own technical experience and expertise.

[AQ:4] PREOPERATIVE PLANNING

Once the decision for femoropopliteal bypass has been made, the surgeon has three main tasks: (1) delineation of the arterial anatomy (i.e., identifying the source of proximal inflow and the distal target), (2) identification of optimal conduit options, and (3) risk stratification and ensuring medical optimization.

Delineation of Arterial Anatomy

Digital subtraction angiography (DSA) still remains the standard preoperative imaging modality for patients with femoropopliteal occlusive disease who are being considered

for surgical revascularization. In contemporary practice many patients may have this performed as part of an attempted endovascular intervention; if this is not the case, DSA for purely diagnostic purposes should be considered as it provides a level of resolution/anatomic detail that still remains unrivaled. An appropriate popliteal distal target will have the following qualities on DSA:

- Provides in-line flow to at least the ankle
- No significant atherosclerotic disease

Although computed tomography with angiography (CTA) is a noninvasive alternative that can provide anatomic imaging with good resolution, the assessment of popliteal- and tibial-level atherosclerotic disease can be limited by spatial resolution as well as by artifact caused by concentric calcification of the media layer of the arterial wall. In addition, it requires much larger contrast doses than DSA (typically 120 mL or more versus ~40 mL, respectively). Magnetic resonance arteriography (MRA) is another noninvasive alternative, but commonly overestimates the degree of stenosis in arteries.

Conduit Planning

The optimal conduit for femoropopliteal bypass—to both the above-knee and the below-knee segments of the popliteal artery—is undoubtedly good-caliber single segment autogenous vein. There are three very strong reasons for this:

- Patency is better
- The consequences of failure are smaller
- Resistance to infection

The ipsilateral greater saphenous vein would be the obvious first choice for this conduit if ultrasound imaging or intraoperative assessments demonstrate that this is good caliber (generally at least 3.5 mm in diameter in vivo or at least 2.5 mm on ultrasound) throughout the length needed for the bypass. If the ipsilateral saphenous vein is absent or atretic, the contralateral greater saphenous vein would typically be the next best alternative for patients in whom the adequate caliber ipsilateral greater saphenous vein is not present. Careful decision making is needed in patients without adequate ipsilateral or contralateral greater saphenous vein conduit. Arm vein and lesser (small) saphenous vein can be good alternatives if adequate caliber and good length are present, though multiple segments (i.e., splicing) are necessary to reach a below-knee popliteal target. Although these require alternative autologous vein conduits require longer operative times, additional incisions and more frequent postoperative intervention, their clinical outcomes are generally better than that of prosthetic conduits. [AQ:5]

Polytetrafluoroethylene (PTFE) conduit has a role when autologous conduit is not a good option. If PTFE is to be used, 6- or 8-mm ringed PTFE should be the standard choice. There is some evidence to suggest heparin-bonded ePTFE has an advantage over PTFE. Distal vein cuffs probably do not provide benefit for the above-knee popliteal artery but may improve the patency of distal anastomoses to the below-knee popliteal artery. Cryopreserved venous and arterial allografts have dismal poor long-term patency, so its role as a conduit for femoropopliteal bypass should probably be limited to use in patients who merit revascularization for healing of a foot wound (especially if infected) and who have no other reasonable conduit options.

Risk Stratification and Medical Optimization

Risk stratification should be done according to standard consensus recommendations or according to local multidisciplinary consensus guidelines. Patients with active cardiac conditions, including unstable angina, severe exertional angina, decompensated heart failure, severe valvular disorders, ventricular arrhythmias, or myocardial infarct within 30 days should generally undergo coronary angiography. Patients who can achieve less than 4 METS and have three or more minor predictors (ischemic heart disease, history of stroke, compensated heart failure, diabetes mellitus, or chronic kidney disease) should [AQ:6]

generally undergo some type of noninvasive cardiac evaluation (stress EKG, dobutamine echocardiogram, or nuclear myocardial perfusion scan with stress) before going to the operating room.

SURGERY

Preparation on the Day of Surgery

Surgeons familiar with the performance of duplex ultrasound examinations should evaluate the ipsilateral greater saphenous vein and mark its course on the morning of surgery, preferably before the patient enters the operating room. This practice not only allows the surgeon to confirm the presence and adequacy of an adequate venous conduit option but also has been shown to decrease wound infection rates, perhaps through the avoidance of asymmetric or thinned soft tissue flaps, creation of dead space, etc.

Preparation and Positioning in the Operating Room

Once in the operating room the patient is placed on a fluoroscopy-compatible operating room table with the pedestal of the bed centered under the chest or upper abdomen (i.e., not under the lower extremities). Once the anesthetic of choice (general or regional) has been administered, the patient is placed in supine position for the operation. If the surgeon is confident that adequate saphenous vein is present, one or both arms can be padded and tucked alongside the torso. One or both arms should be secured on arm boards (and possibly prepared and draped a priori) if there is a possible (or high) likelihood that arm vein will be needed.

A Foley catheter should be placed. Two electrocautery grounding pads should be placed if two operative surgeons work simultaneously. Hair clippers should be used to remove hair in all areas that will be prepared and draped in the surgical field. At minimum, this field includes the lower abdomen (level of the umbilicus and below), the ipsilateral groin, and the circumferential surface of the ipsilateral lower extremity in its entirety (i.e., from the upper thigh to the toes). Obviously, the contralateral lower extremity and/or one or both arms may also be prepared if these sites may be needed for autologous vein harvesting. Isopropyl alcohol solution may be used on gauze dressings to perform a preliminary cleansing and sterilization of the operative fields; this should then be followed by ChloraPrep (isopropyl alcohol/chlorhexidine gluconate solution) over all intact skin surfaces. Betadine/iodine solution may be needed on the foot if an open wound or ulcer is present. Draping is done as in other areas using towels at the margins of the prepared/unprepared skin surfaces; generally, two U-shaped drapes work best to isolated the prepared field. A stockinette or isolation bag is used to cover the foot. Use of Ioban antimicrobial adhesive drapes may also be considered to further reduce the risk of wound infection.

Vein Harvesting

Beginning the operation with exposure of the vein conduit is advantageous for two main reasons. First, it is the ultimate assessment to ensure that the vein is indeed adequate in caliber and length for bypass. Finding that the intended autologous vein conduit is inadequate allows the surgical team to move toward investigating second-line options or forgoing vein harvesting in favor of a prosthetic conduit earlier in the case. Second, if identified and protected, exposure of the vein will minimize the risk of inadvertent injury to it while exposing the popliteal artery or creating tunnels (see below).

Vein harvesting should begin with an incision in the thigh. As stated above, the surgeon familiar with bedside duplex ultrasonography can direct incision immediately over the greater saphenous vein if a skin marker has been used to identify the course. Otherwise, the surgeon should start in the proximal to mid-thigh, where the greater

saphenous vein typically courses medially and posteriorly before passing along the posteromedial aspect of the knee. The edges of the skin incision should only be retracted with toothed forceps or self-retaining retractors; Debakey or other smooth-tip (e.g., vascular) forceps should never be used on the skin edges. Metzenbaum scissors should be used to spread or sharply cut the dermis and subcuticular adipose tissue until the saphenous vein is clearly identified. Electrocautery use should be minimized or avoided altogether to avoid thermal injury to the vein—injury which may not be recognized at the time of the harvest.

The numerous trials and studies of endoscopic vein harvesting for both coronary and leg bypasses demonstrating the negative impact of this technique on graft patency have suggested that harvesting is an important factor in determining long-term outcomes. Thus, once the vein conduit is identified, the "no touch" technique of vein harvesting should be employed. Specifically, trauma to the vein conduit can be minimized by approaching the vein harvesting in two steps. First, the superficial-most aspect of the vein is exposed to identify the precise course of the vein and to examine its caliber. This is best done with Metzenbaum scissors, working from the proximal aspect of the thigh toward the calf. Either single incisions can be used in the thigh and calf with a skin bridge at the knee, or several shorter "skip" incisions can be used throughout the thigh and calf; no difference in outcome between these two strategies has been demonstrated. The vein should be exposed for 4 to 6 cm beyond the anticipated length needed to assure that the conduit will not be too short.

The second step can be completed after sufficient vein length has been exposed or after exposure of the arterial segments and tunneling (see below). The distal-most aspect of the exposed vein is clamped with a right ankle and sharply transected immediately proximal. The distal end is ligated with a silk or polyglactin (Vicryl) ligature, and a small metal or plastic cannula with an olive-shaped tip is inserted into the vein to distend the vein with a syringe filled with heparinized saline or physiologic vein solution. The tip of this cannula can be secured by the placement of a silk ligature at the distal-most end of the vein. The cannula and syringe can then be used to manipulate the vein and expose the vein branches to the surgeon or assistant on the other side of the table (Fig. 24.1). The distal aspect of the vein branches (the portion far from the main segment of the vein) can be ligated with a small (3-0 or 4-0) silk ligature or with small or medium metallic clips. The proximal aspect (i.e., that closest to the harvested vein conduit) should be ligated securely with a silk ligature approximately 1 to 2 mm from the lumen of the vein before dividing the branch to avoid constraining its caliber.

Throughout this process the harvested vein conduit should not be grasped with forceps or metal instruments. The cannula and syringe should be used for most of the manipulation of the vein that is necessary to expose and dissect branches. In the times when this does not suffice (e.g., when working just beyond a skin bridge), the vein can be *gently* retracted with vessel loop placed once around the artery.

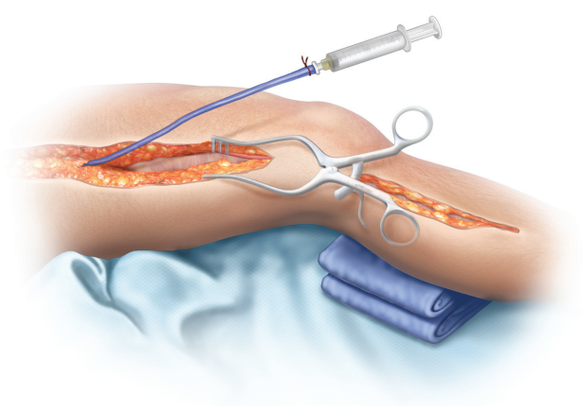

Figure 24.1 Harvesting of the great saphenous vein. This should proceed from the distal to the proximal aspect of the vein. A syringe with vein solution can be attached to the distal end to gently distend the vein and help retract in an atraumatic fashion.

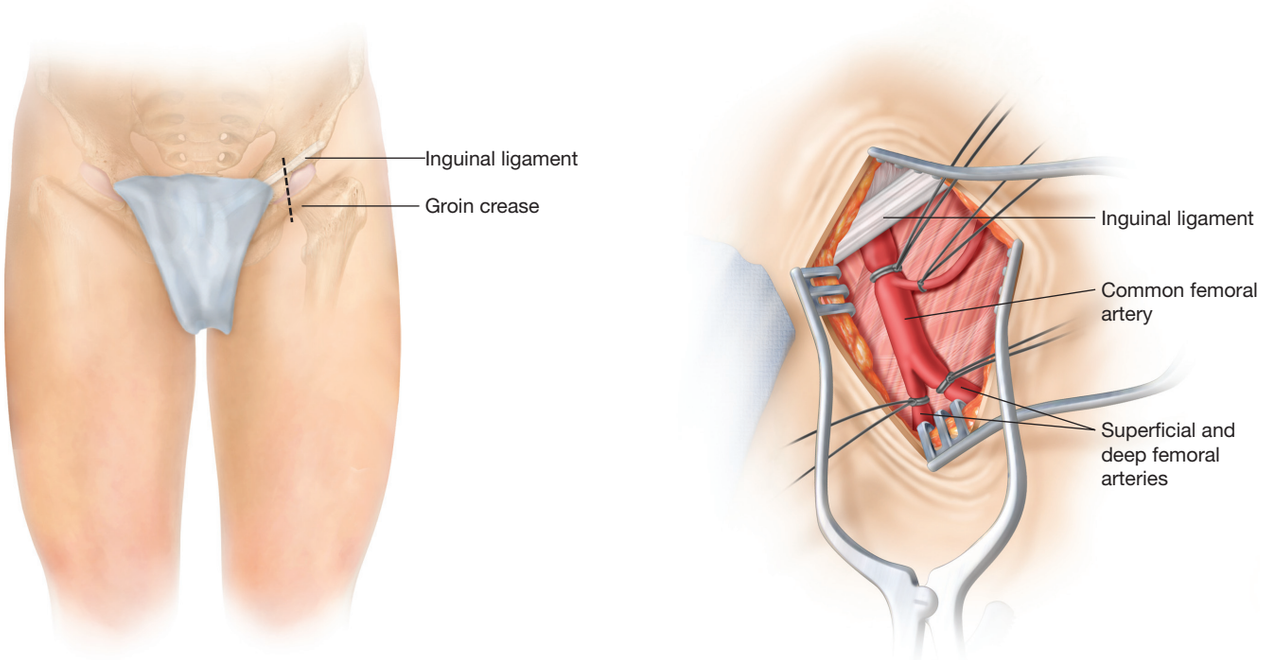

Figure 24.2 Exposure of the common femoral artery for inflow. A longitudinal incision should be centered over the common femoral artery, which is located below the inguinal ligament (which runs from the pubic tubercle to the anterior superior iliac spine) and above the groin crease.

Exposure of the Common Femoral Artery for Inflow

The common femoral artery should be exposed through an incision in the groin. If the surgeon is confident that there is not enough atherosclerotic disease in the femoral artery to merit an endarterectomy, profundaplasty, or patch angioplasty, a transverse or oblique incision can be used. Otherwise, a longitudinal incision is best, as this incision allows for the extension needed to expose the proximal superficial and deep femoral arteries should this prove necessary to address significant atherosclerotic disease there (Fig. 24.2).

Exposure of the Popliteal Artery as a Distal Target

The above-knee popliteal artery is exposed through a longitudinal incision in the upper thigh. The skin incision used for harvesting the ipsilateral greater saphenous vein should be utilized if one exists. If other conduit is being used, a 10-cm skin incision should be placed at about the midpoint of the medial thigh, in the groove between the bulky muscle mass of the vastus medialis muscle and its insertion on the patellar tendon and the thinner sartorius muscle and its attachment to the medial condyle of the femur. Stacked towels placed behind the knee joint can help flex the hip and knee and facilitate identification of the groove between these muscles. Electrocautery should be used to divide subcutaneous fat and enter the muscle fascia. Once entered, the muscle fibers of the sartorius should be retracted posteriorly while the muscle fibers of the vastus medialis muscle should be retracted anteriorly. A Henley retractor (Fig. 24.3) can help greatly with this exposure. Once retracted, one should divide the loose adventitial tissue that often lies between these muscles and palpate for the artery and vein. Although the artery will be pulseless here, there is often some degree of calcification that can often be palpated in the wall of the artery and used to identify the exact location of the artery. Circumferential exposure of some portion of the artery usually also requires at [AQ:7]

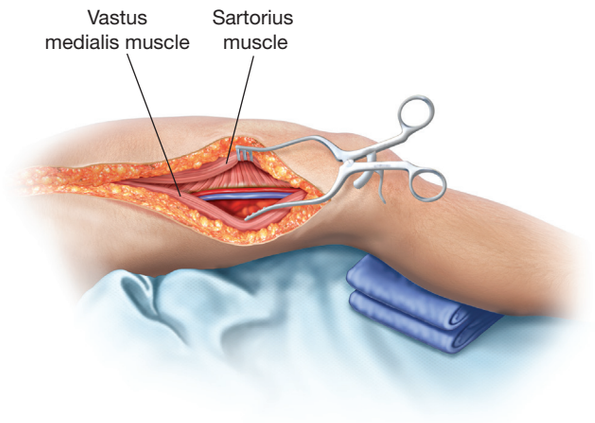

Figure 24.3 Exposure of the above-knee popliteal artery. Note the use of the Henley retractor for posterior retraction of the vastus medialis muscle and anterior retraction of the sartorius muscle.

least some degree of exposure of the femoropopliteal vein to allow this vessel to be retracted posteriorly, away from the artery. The goal should be to expose a length of at least 3 to 4 cm of artery that is without circumferential calcification.

The below-knee popliteal artery is exposed through a medial calf incision. Here too any skin incision made for ipsilateral greater saphenous vein harvesting should be utilized. If not present, a 10-cm skin incision along the medial calf should be made. Specifically, this incision should be approximately 2 cm posterior to the medial edge of the tibia and should start just inferior to the medial condyle of the knee. Electrocautery should be used to divide subcutaneous fat and enter the muscle fascia of the calf. Once this is done, the gastrocnemius muscle fibers will be seen coursing toward the medial condyle of the femur; these should be retracted inferiorly with the use of a Henley retractor (Fig. 24.4). The origin of the soleus muscle where it attaches to the mid-tibia will then be seen. Just cephalad to these muscle fibers is a space that is the popliteal fossa. Loose adventitial tissue is often found within this space; it can be freed up with gentle digital dissection. A thin band of popliteus muscle may also be seen; this can be divided as needed without functional consequence.

A finger can be placed along the posterior aspect of the popliteal fossa, then turned anteriorly. The structures felt between one's finger and the posterior aspect of the tibia are the tibial nerve, the popliteal artery, the popliteal veins (below the knee, the popliteal vein is usually split into two paired veins, each flanking the artery) (Fig. 24.5). Similar to the above-knee exposure, adequate exposure of 3 to 4 cm of below-knee popliteal artery generally requires some degree of dissection of the popliteal vein or veins. Small vein branches crossing over the artery and between the two main popliteal veins should be ligated with small (3-0 or 4-0) silk ligatures and divided.

Retractors should be removed and moist laparotomy pads should be placed in any field which is not being utilized. This minimizes dessication of soft tissues and injury from prolonged retraction.

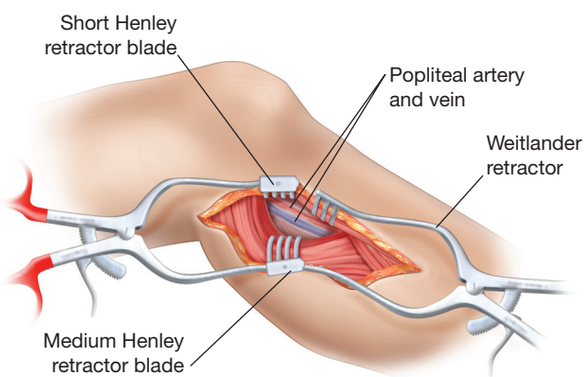

Figure 24.4 The combination of a Henley retractor with changeable blades and a Weitlander retractor can be very effective in exposing the below-knee popliteal artery. A short (1-in deep) blade is placed along the superior aspect of the field, on the posterior aspect of the tibia. A medium (2-in deep) or long (3-in deep) blade is placed along the inferior aspect of the field, on the gastrocnemius muscle.

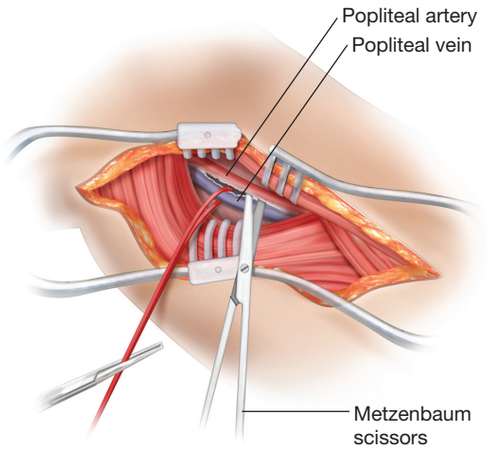

Figure 24.5 Exposing the below-knee segment of the popliteal artery. The popliteal vein is retracted in a medial direction, and thin adventitial tissue lying between this and the popliteal artery is gently dissected.

Creating a Tunnel for the Conduit

A decision needs to be made between anatomic and subcutaneous tunneling of the bypass graft. There are advantages and disadvantages to each of these approaches (Table 24.1). In contrast to femorotibial or pedal bypasses, however, the arterial exposures necessary for femoropopliteal bypass grafting already expose much of what is needed for anatomic tunneling. In this author's opinion, this and the risk of graft kinking associated with the sharp angulation that is needed to subcutaneously tunnel a graft to the below-knee segment of the popliteal artery would generally favor anatomic tunneling for femoropopliteal bypasses. Regardless, each clinical situation should be assessed on a case-by-case basis.

Anatomic tunneling is achieved by placing the bypass graft behind (i.e., lateral to) the sartorius muscle in the thigh and—if needed—through the popliteal fossa in the knee. Tunneling in the knee is best achieved with an aortic clamp that is placed directly behind the sartorius muscle. Pre-existing skin incisions made for vein harvesting should be utilized to divide the thin adventitial tissue along the anterior border of the sartorius muscle, retract this muscle posteriorly, and directly visualize the tip of the clamp passing behind it. If skin incisions have not been made for vein harvesting, a short (1 to 2 cm) skin incision should be made in the mid-thigh to facilitate tunneling to at least the distal thigh. Errors in tunneling, such as tunneling through muscle fibers (and risking subsequent early occlusion because of kinking with muscle contraction), may be made more frequently if these steps are not done. Once the clamp has been passed in the appropriate plane, an umbilical tape should be grasped with the tip of the clamp and pulled partially through the tunnel to maintain its position.

TABLE 24.1 Relative Advantages and Disadvantages of Tunneling Options

	Anatomic Tunneling	Subcutaneous Tunneling
Advantages	Shorter distance (i.e., shorter conduit required)	Easier surveillance for pulse examination and duplex ultrasound examination
	Deeper; may be more protective against infection	Allows for percutaneous antegrade access for subsequent endovascular interventions to maintain patency
Disadvantages	May be more prone to kinking with imprecise tunneling	Requires slightly more conduit length
	Subsequent endovascular interventions to maintain patency require contralateral retrograde femoral access	At risk for inadvertent external compression/occlusion
	Tunneling may be more difficult in reoperative cases	

Likewise, the best way to ensure optimal anatomic tunneling through the popliteal fossa for distal anastomoses to the below-knee popliteal artery is with some degree of direct exposure. The thin adventitial tissue along the anterior border of the sartorius muscle should be divided with electrocautery through an incision in the distal medial thigh. Standing on the contralateral side of the table to see the medial leg (i.e., on patient's right side for a left femoropopliteal bypass), the index finger of one hand is passed anterolateral to the sartorius muscle and behind the medial condyle of the femur. Meanwhile, the index finger of the other hand is passed through the upper calf wound, alongside the popliteal vessels, and into the popliteal fossa. At this point only thin adventitial tissues should separate the fingertips of each hand, and these are divided with careful digital dissection (Fig. 24.6). Ensuring adequate tunneling through the popliteal fossa can be done by appreciating the following.

- Having plenty of space through which index fingers easily pass without feeling constrained by muscle fibers or other soft tissue
- Feeling the knee joint (distal femur and proximal tibia) ± femoral vessels immediately anterior
- Feeling all the muscles that attach to the medial condyles of the tibia and femur (including sartorius, semitendinosus, and medial head of gastrocnemius) when pulling the index fingers medially

Once through this space, a curved aortic clamp is passed through this same space from the calf incision to the popliteal fossa by placing the tip of the clamp placed on the

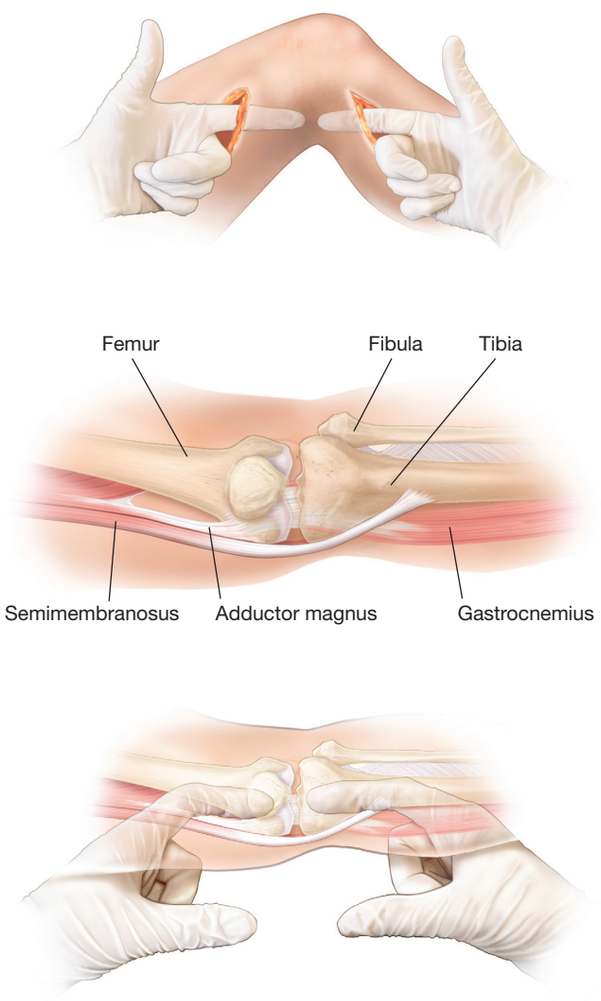

Figure 24.6 Creating an anatomic tunnel in the popliteal fossa behind the knee. The index fingers of the surgeon are inserted lateral to the insertions of the adductor magnus and semimembranosus muscles on the medial condyles of the femur and tibia, respectively, and the origin of the gastrocnemius muscle from the medial condyle of the femur. Correctly finding the popliteal fossa identifies a space that contains the popliteal vessels and loose adventitial tissue; it is not constrained by muscle bands.

tip of the index finger, then retracting both through the distal thigh incision. As with the thigh tunnels, an umbilical tape should be used to maintain this tunnel until the graft is passed through.

Subcutaneous tunneling should also be performed using a long semicurved aortic clamp. A gentle arc (rather than an abrupt angle) should be created from the groin incision to the upper medial thigh. Two short (1 to 2 cm) incisions are generally needed along the anteromedial thigh for tunneling to the knee joint, but one incision may suffice if the above-knee popliteal artery is the intended target. Tunneling subcutaneously across the knee joint needs to be done at exactly the midpoint of the medial circumference of the knee (i.e., 3 o'clock or 9 o'clock positions for the right and left legs) to avoid kinking with knee flexion.

A metallic tunneling device is an alternative means of creating both anatomic and subcutaneous tunnels. This device can be somewhat less reliable, however, in creating the intended tunnel (e.g., passing within fibers of the sartorius muscle).

Completion of Vein Harvesting and Systemic Anticoagulation

The second step of vein harvesting should be completed at this time if not done already. The patient should then be given intravenous heparin at a dose of 70 to 100 units/kg body weight (typically 5,000 to 7,000 total units for the initial dose). An activated clotting time should be checked 3 or more minutes after infusion if a radial arterial line or central venous catheter is present. The goal activated clotting time is >250 seconds. After the therapeutic goal has been achieved, activated clotting times should be rechecked every 20 to 30 minutes until the distal anastomosis is complete and bypass graft patency has been verified (see below). Heparin should be redosed in 1,000 to 2,000 unit aliquots to maintain the activated clotting time >250 seconds.

The Proximal Anastomosis

The proximal and distal common femoral artery (or proximal deep femoral artery) should be clamped. A longitudinal arteriotomy is made that is approximately 10 mm in length, and the proximal anastomosis is fashioned to the prosthetic graft or the widest end of a vein graft after making a 45-degree bevel. The anastomosis is done from the heel to the toe of the anastomosis to the toe with 5-0 Prolene placed in a running fashion, either by tying a knot at the heel or by using the "parachute" technique without a knot at the heel. The proximal and distal femoral artery can be flushed prior to completion of this anastomosis, or these vessels can be flushed through the graft. The anastomosis should be checked for hemostasis, and additional 5-0 Prolene sutures should be placed as needed for hemostasis.

Valvulotomy should be performed next if a vein graft was used in a nonreversed fashion. This can be done effectively with the Mills or LeMaitre valvulotome depending on the surgeon's familiarity with these instruments.

Tunneling the Conduit

After completion of the proximal anastomosis and any necessary valvulotomy, the graft is placed through the previously created tunnel. Curved aortic clamps are very helpful with this step. The distal end of the umbilical tape is grasped by the tip of the clamp and used to guide the clamp through the tunnel. The distal-most aspect of the graft is then grasped by the aortic clamp, then the clamp is withdrawn through the tunnel along with the graft. The graft should be flushed after placement through each tunnel to identify any inadvertent kinking or twisting that may have occurred.

Distal Anastomosis Without a Vein Patch

Once the graft has been tunneled to the field of the distal anastomosis the following steps should be followed to help effectively complete the distal anastomosis if done without a distal vein patch (Fig. 24.7):

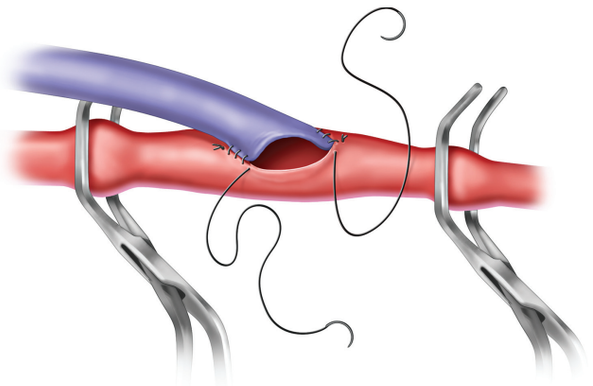

Figure 24.7 The distal anastomosis of a femoropopliteal bypass done with an autogenous vein conduit.

- Retractors are put back in place in the field; again, Henley retractors are often helpful in retracting muscle (sartorius or gastrocnemius) posteriorly.
- Elastic vessel loops are placed around the proximal and distal aspects of the exposed arterial segment. These ensure adequate exposure, facilitate effective clamping, and also provide vascular control.
- The popliteal artery is clamped proximally and distally. In both the above-knee and below-knee locations, basic angled vascular clamps (e.g., angled Debakey iliac clamp) can work well for proximal control; a small profunda clamp often works well to occlude the distal portion of the artery without obstructing the view of the surgical field.
- A longitudinal arteriotomy is begun with a no. 11 blade scalpel and completed with Potts scissors. The total length of the arteriotomy should be 8 to 12 mm. The lumen of the vessel is visually inspected for significant atherosclerotic disease; if present, the arteriotomy may need to be extended.
- The conduit is cut to the appropriate length. This is best done with the leg straight and the graft under very slight tension. The graft is then cut to the length necessary to reach the distal-most aspect (the "toe") of the arteriotomy. Leaving the graft too long may produce redundant length and risk kinking when the knee is bent, while cutting it too short may risk avulsing the graft from the anastomosis when the knee is extended. After cutting to the appropriate length, the distal end is beveled to match the length of the arteriotomy.
- Wet laparotomy pads are used to cover the self-retaining retractors. This minimizes the risk of fine Prolene suture ends being inadvertently tangled around these retractors.
- The heel (proximal end) of the anastomosis is completed with 6-0 Prolene sutures, either by the placement of a knot at the heel or by the "parachute" technique.
- The lateral aspect of the distal anastomosis is typically completed first, as this is more difficult to visualize than the medial aspect.
- A second suture should then be placed at the "toe" of the anastomosis to prevent "purse-stringing" of the suture line (i.e., narrowing the anastomosis by putting too much tension on a single running suture used around the entire circumference of the anastomosis). One end is run toward and eventually tied to the first suture along the lateral aspect of the suture line.
- The running suture line at the heel on the medial aspect is then begun. A few passes are taken using the second suture line at the toe on this medial aspect.
- Prior to completion of the anastomosis, the distal and proximal aspects of the popliteal artery and the bypass graft are flushed thoroughly.
- The remainder of the anastomosis is completed. The clamp on the proximal portion of the popliteal artery should be removed first, followed by the graft, and then the distal portion of the popliteal artery. Any additional sutures needed for hemostasis should then be placed.

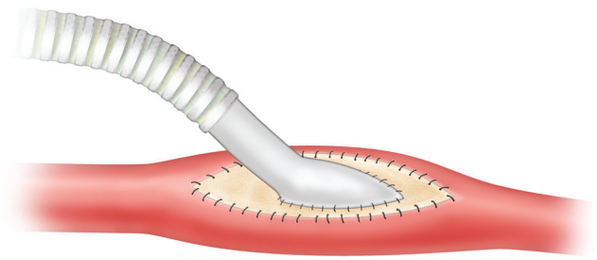

Figure 24.8 The distal anastomosis of a femoropopliteal bypass done with polytetrafluoroethylene (PTFE) and a simple vein patch.

Creation of a Distal Vein Patch

As mentioned above, some consideration should be given to the creation of a distal vein patch if a prosthetic graft is being used in a bypass to the below-knee popliteal artery. A simple and effective manner in which this can be done is by placing a vein patch on a long arteriotomy in the distal target vessel in a manner similar to that of a patch angioplasty (Fig. 24.8). Specifically, an arteriotomy approximately 25 to 30 mm in length should be made in the popliteal artery. A segment of vein that is at least as long should then be opened longitudinally. Any valves seen inside the vein should be excised completely with Potts scissors. One end of the vein should then be cut to shape it in a triangular fashion, and this end should be sutured to the proximal end of the arteriotomy using 5-0 or 6-0 Prolene in a running fashion. Similar to a typical distal anastomosis, two strands of Prolene should be used to complete the toe with precision and avoid purse-stringing of the suture line.

Verification of Graft Patency

The surgeon should be certain that the bypass is patent and revascularization has been adequate before completing the operation. The simplest manner to ensure this is to appreciate a palpable pulse in the foot. Use of a continuous wave (handheld/audio) Doppler ultrasound probe on the popliteal artery distal to the distal anastomosis is another method. A strongly biphasic signal should be heard here, and this signal should convincingly diminish and augment when the graft is digitally compressed and released, respectively. Lack of a change with this compression and release should be suspicious for suboptimal flow through the graft. Intraoperative duplex ultrasound with a 12- to 15-MHz probe can also be used by surgeons familiar with the performance of ultrasound. The presence of a pulse in the graft should *not* be used as the only means of assessing graft patency, as even a graft with no flow can initially have pulsatility. (Indeed, the pulsations present in a graft with the distal end clamped but not yet connected via a distal anastomosis perfectly demonstrate this point.) A completion angiogram is not standard nor required in the setting of femoropopliteal bypass; it should be reserved for cases in which there is doubt about the patency of the bypass based on the above-described assessments or for some other atypical situations that might merit the additional information provided by an angiogram (e.g., spliced vein conduit, suboptimal distal target, reoperative cases).

Once the bypass has been assessed for patency, the vascular anastomoses should be reassessed for hemostasis. Repair sutures should be placed as needed. Protamine may be given once the surgeon is confident that any further efforts to achieve hemostasis will not require temporary clamping of the bypass graft.

Wound Closure

The incidence of wound complications associated with leg incisions done for bypass and/or saphenectomy has been reported to be as low as 4% and as high as 20%. Marking the saphenous vein location prior to the start of the operation, perioperative antibiotics, and careful wound closure technique may help minimize the morbidity that can be associated with wound closure.

Closure of the incisions is done in layers. In the groin wound, the femoral sheath may be reapproximated with interrupted 3-0 or 2-0 Vicryl sutures. Care must be taken to avoid incorporating the femoral nerve, located immediately lateral to the femoral artery, within the bites taken to reapproximate the femoral sheath. Dead space within the subcutaneous layers should also be reapproximated with interrupted 2-0 Vicryl sutures, and the dermis is reapproximated with interrupted 3-0 Vicryl sutures. Skin may be closed with staples or absorbable subcuticular sutures.

Thigh and calf incisions are closed in a similar fashion. Fascia need not be reapproximated; instead, any dead space in the subcutaneous tissue should be reapproximated with 2-0 Vicryl sutures. As with the groin incision, dermis should be reapproximated using 3-0 Vicryl sutures, and skin may be reapproximated with staples or absorbable subcutaneous sutures.

The standard dressing for leg incisions has been sterile gauze, but ongoing studies have been investigating alternative dressings as a means of decreasing the wound complication rate.

[AQ:8] These alternatives include antimicrobial-impregnated dressings may be used for dressings. Some consideration may be given to the use of negative-pressure wound therapy (e.g., KCI Wound VAC) on the closed incision for obese patients and/or reoperative groin wounds.

POSTOPERATIVE MANAGEMENT

Patients should be admitted to a regular hospital ward or a step-down unit following femoropopliteal bypass, depending on local practice and staffing resources. Admission to the intensive care unit can be guided by the presence of severe comorbidities. Bed rest is given for 12 to 24 hours following the operation, followed by gradual reambulation. If the operation was done for claudication or rest pain, this can be done over the course of 2 to 4 days. If the operation was done for a foot wound, reambulation efforts should be mindful of any weight-bearing precautions in place on account of this foot wound (e.g., touch-down weight bearing with a rollator walker and a fracture boot). Pain control should be addressed with the liberal use of narcotic analgesics. There need not be any dietary restrictions. Daily aspirin is continued, along with all other prescribed medications. Like all surgical patients, bypass patients should receive anticoagulation to reduce the risk of thromboembolism. Long-term and/or therapeutic anticoagulation do/does not improve graft patency and is therefore not indicated for this purpose.

COMPLICATIONS

The early postoperative course after femoropopliteal bypass grafting is usually uneventful. Any wound erythema should be treated with oral antibiotics. Early graft thrombosis should occur only rarely (<5% of cases) in most centers. Patients with peripheral arterial disease are at clear risk for developing cardiac complications including myocardial infarct or arrhythmias.

Outpatient follow-up should occur at 2 weeks, 1 month, and at least every 6 to 12 months thereafter. Wound complications are more often identified during the initial follow-up visits. Erythema noted around the incisions should be treated with antibiotics and staple removal if no other wound complications are noted, but a follow-up should be scheduled within 1 to 2 weeks to identify and treat any wound dehiscence or deep surgical site infection that may develop over this time.

Surveillance ultrasound examinations of vein grafts should be done at 1, 6, 12, 18, and 24 months. Ultrasound surveillance of prosthetic grafts is optional; although these grafts occlude at least as often as vein grafts, they more often do so without stenosis that can be identified on ultrasound studies.

RESULTS

The long-term results of bypasses to the above-knee popliteal artery are good. For bypasses done with vein, one may expect primary and secondary patency rates of 88% and 90%, respectively, at 1 year and 77% and 80%, respectively, at 5 years. For femoral to above-knee popliteal artery bypasses done with prosthetic, these rates are somewhat lower: 85% and 90% at 1 year and 57% and 73% at 5 years.

Published patency rates for bypasses done to the below-knee popliteal artery are comparable. Overall, one should expect primary and secondary patency rates of 80% and 90%, respectively at 1 year and 65% and 85% at 5 years when using single-segment saphenous vein graft. The 5-year patency rates are expectedly lower when using either alternative vein conduit (spliced saphenous and/or arm vein segment) or PTFE: approximately 50% to 55% and 65% to 70% primary and secondary patency rates, respectively.

The consequences of graft failure are somewhat different among graft types as well. Occlusion of a vein graft most may be asymptomatic (especially in the case of bypasses done for nonhealing wounds) or may return the patient to their previous clinical state. Limb-threatening acute limb ischemia due to occlusion of a vein graft may occur, but is rare, and the arterial circulation distal to an occluded vein graft only rarely changes after graft occlusion. Occlusion of a PTFE graft, in contrast, very commonly leads to limb-threatening acute limb ischemia and may also affect the arterial circulation distal to the distal anastomosis, thereby constraining the options for secondary reconstructions.

CONCLUSIONS

Preoperative planning is important in cases of femoropopliteal bypass grafting. This planning should identify a source of inflow, a sufficient distal target, and two or more potential conduit options (preferably autologous vein). The operation should generally begin with harvesting the vein. Tunneling for femoropopliteal bypass grafting is generally done anatomically. The use of vein cuffs should be considered for bypasses done to the below-knee popliteal artery if a PTFE conduit is used.

Recommended References and Readings

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AQ1: Please check carefully all figure in-text citations and legends. Many of these were added by editorial staff and need to be verified.
AQ2: The chapter title has been given in the TOC as "Femoropopliteal Bypass Using Prosthetic and Vein." Also th author name has been given in the TOC as "Near Barshes." Please check which one is to be followed.
AQ3: Please check whether all the head levels are given as intended.
AQ4: The sentence "Although these require … of prosthetic conduits" seems to have lack of clarity. Please check.
AQ5: Please provide the expansion of the abbreviation "METS" if deemed necessary.
AQ6: Please check and confirm whether the change made in the sentence "Once retracted … and vein" preserves its intended meaning.
AQ7: The sentence "These alternatives … for dressings" seems to have lack of clarity. Please check.