Part VII

Surgical treatments

Femoropopliteal Occlusive Disease

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Lower extremity arterial occlusive disease affects 5% of men and 2.5% of women over the age of 60. The vast majority of patients have stable disease that is treated conservatively. Approximately 10% of these patients eventually require operation. This is a challenging group of patients who harbor systemic atherosclerotic disease and its attendant cardiac risk factors.

Femoropopliteal bypass is technically demanding and requires strict attention to detail. The results can be rewarding in terms of limb preservation and maintained patient productivity. Improved perioperative care and refined technique make today's femoropopliteal bypasses extraordinarily successful.

The field of infrainguinal bypass is constantly evolving. Twenty years ago amputation may have been the primary option in severe cases of lower extremity atherosclerotic diseases. Today, even patients with extensive comorbidities and severely diseased runoff exhibit acceptable patency and limb salvage in long infrainguinal bypasses.

History

Understanding the pathophysiology of femoropopliteal occlusive disease began in 1855, when Barth described a patient with claudication (1). At necropsy Barth noted thrombosis of the terminal aorta and described a lesion consistent with either a thrombosed hypoplastic terminal aorta or a contracted atherosclerotic plaque.

Jean-Martin Charcot was the first to use the term claudication (from the Greek claudare, meaning to limp) in his 1858 work describing intermittent claudication in a horse and human (2). Charcot attributed the symptoms in his human patient to an occlusion of the common iliac artery distal to a traumatic aneurysm.

Alexis Carrel provided the foundation for surgical correction of arterial occlusive disease when he described the technique for vascular end-to-end anastomosis in 1904 (3), for which he was awarded the Nobel Prize in Medicine Three years later, at the Johns Hopkins Hospital, William Halsted unsuccessfully attempted an autologous bypass using saphenous vein between the proximal femoral artery and the popliteal vein (4). The first successful arterial bypass using autologous vein as the conduit was described by the German surgeons Hopfner and Jeger in the early 1900s (5,6).

In 1949 Kunlin reported the first femoropopliteal bypass graft using reversed saphenous vein as the conduit (7). Ten years later, George Morris and his colleagues from Baylor University documented their work with infrapopliteal bypass grafts (8).

Karl Hall was the first to use an in situ vein as conduit for arterial bypasses (9). Although largely ignored for 20 years, Leather and colleagues revived the technique with their description of infrapopliteal bypass using the in situ greater saphenous vein as a conduit (10).

During the early period of bypass for arterial occlusive disease, Jack Cannon and Wylie Barker reported favorable results for endarterectomy for occlusive femoral atherosclerosis (11). They described a semi-closed technique using an intraluminal stripper to perform the endarterectomy. This was reported to be a less-invasive method to relieve lower extremity ischemia

Endarterectomy as a surgical option fell out of favor during the 1970s and 1980s. Today there is renewed interest in endarterectomy and the principle of minimally invasive revascularization techniques. In 2001, many groups are investigating percutaneous endoluminal techniques, however femoropopliteal bypass continues to be the gold standard.

Etiology

Atherosclerosis is the cause of lower extremity occlusive disease in the vast majority of patients. The exact etiology of atherosclerosis is not yet know, however numerous factors have been associated with its incidence and progression. Tobacco smoking is the most prominent risk factor (12,13). This was clearly demonstrated in the large population-based Framingham study. Other clearly associated risk factors include diabetes mellitus, hypertension, and hyperlipidemia (13).

Inflammatory and microbial factors have been correlated with the development of atherosclerosis. Increased systemic levels of the inflammatory biomarker C-reactive protein indicate higher risk for atherosclerosis (14), although other common markers of systemic inflammation, such as fibrinogen, do not. Bacterial pathogens

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such as Chlamydia pneumoniae are associated with atherosclerotic coronary artery disease (15). Additionally, this organism has been discovered in extracoronary atherosclerotic plaques (16), suggesting a role in peripheral vascular disease.

Thromboangitis obliterans (Buerger's Disease) is a cause of peripheral vascular disease that must be distinguished from atherosclerotic occlusive disease. It typically occurs during the 3rd and 4th decades of life. The patients are heavy tobacco users who present with chronic lower extremity ischemia. As a result of transmural inflammation and distal locations, these lesions are usually not amenable to revascularization. Tobacco cessation has been demonstrated to halt progression of disease.

Other rare causes of distal ischemia include popliteal entrapment syndrome and cystic adventitial disease. These processes typically occur in young healthy individuals and can be ameliorated with appropriate recognition and treatment. A young healthy man who is a non-smoker presenting with calf claudication suggests popliteal entrapment. With recognition before premature atherosclerotic changes, surgical division of the medial head of the gastrocnemius muscle can relieve the symptoms (17). With a delay in diagnosis, however, atherosclerotic plaque may form and require bypass grafting. In cystic adventitial disease, subadventitial cysts compress the arterial lumen. The etiology is unclear, although some postulate repeated arterial microtrauma (18). Only rarely cases are amenable to simple cyst aspiration; most cases mandate excision of the lesion and bypass grafting (19).

Clinical Presentation

A thorough history and physical is the cornerstone in the evaluation of the patient with lower extremity arterial occlusive disease. Most patients with short segment occlusion of the superficial femoral artery, the most common site of lower extremity occlusion, present with mild intermittent claudication. They describe pain or tiredness in the leg that arises after a specific amount of exercise and then diminishes quickly with rest. Two separate groups of patients deserve particular attention: those with neurogenic claudication and those with venous claudication. Patients with neurogenic claudication describe leg pain at variable walking distances and with changes in leg position. Those with venous claudication complain of a bursting sensation in the calf that remits with elevation and requires 30 minutes or more for complete relief. These patients must be differentiated from arterial occlusive disease, as the treatment is quite different.

Patients with severe arterial occlusive disease and a threatened limb are easily distinguishable from those with short-segment partial arterial occlusion. Patients with limb-threatening ischemia have rest pain or tissue loss. Rest pain usually affects the toes and dorsal surface of the forefoot. The pain originates in the skin, compared with the muscular pain of claudication, and is relieved by placing the affected foot in a dependent position. Tissue loss is easily identifiable and may consist of a non-healing ulcer. Most ischemic ulcers are found on the plantar surface of the foot. They are painful and frequently occur at the site of previous trauma. These must be differentiated from venous stasis ulcers, which are located over the medial malleolus and are painless, and pressure (decubitus) ulcers that typically affect the heel.

The physical examination for patients with lower extremity ischemia should be thorough. The presence and quality of femoral, popliteal, dorsalis pedis, and posterior tibial pulses must be assessed. Patients typically have reduction in the amount of hair on the legs and trophic changes of the skin and nails. As atherosclerosis is a systemic disease, the carotid arteries should be auscultated and the epigastrium palpated for the aortic pulse.

All patients should have ankle-brachial indexes (ABI) assessed. The systolic blood pressure of the ankle, usually detected by a hand-held Doppler probe, is divided by the systolic brachial blood pressure. In normal patients, the value is greater than 0.9. Patients with intermittent claudication commonly have an ABI greater than 0.6. A value less that 0.6 usually signifies critical ischemia. Diabetic patients with calcified arteries may have a falsely elevated ABI. When following patients serially, changes of 0.15 are considered significant indications of the progression or regression of the disease process.

Ankle-brachial indexes before and after exercise may be useful to confirm intermittent claudication. The patient walks to the onset of pain. An abnormal response and indication of the presence of arterial occlusive disease is a decrease in the ABI of more than 20% of the baseline value.

On the basis of the history and physical most candidates for revascularization will be identified. Those patients subsequently undergo appropriate cardiac evaluation and contrast angiography in preparation for infrainguinal bypass.

Indications

Rest pain and limb threatening ischemia are established indications for intervention. The efficacy of infrainguinal bypass for foot and limb salvage in diabetic patients has been questioned because of purported low patency and high mortality. However, advances in technique and post-operative care have resulted in a high rate of limb salvage for nonsmoking diabetics (20). At 5 years, no difference has been observed in mortality or patency between diabetics and non-diabetics, and the rate of limb salvage exceeds 80% (21). Limb salvage in diabetics is a valid indication for lower extremity bypass.

Controversy arises when considering claudication as an indication for operation. The majority of patients with claudication remain stable throughout their lifetime. Ultimate limb loss is less than 7% is patients treated medically and followed for up to 8 years (22, 23). Patients with claudication should be encouraged to quit smoking tobacco, lose weight, and initiate a graduated exercise program. The importance of tobacco cessation cannot be overemphasized. Continued smoking leads to progression of atherosclerotic plaques and also dramatically lowers success rates following revascularization (24).

An exercise program should span 3-6 months before intervention is considered. The patients should strive to walk beyond the point of claudication and they should realize that the pain itself is not harmful. The mechanism for improvement of symptoms was formerly believed to be due to formation of collaterals. Now it is generally thought that improved efficiency of muscle enzymes leads to more effective oxygen uptake and utilization.

One pharmaceutical that has shown potential in alleviating the symptoms of claudication is cilostazol. Cilostazol is a type III phosphodiesterase inhibitor that was approved in the United States in 1999 for the reduction of symptoms due to intermittent claudication. Cilostazol inhibits platelet aggregation and vasodilates (25). In muliticenter, prospective, randomized trials cilostazol has been found to be more effective than the rheologic agent pentoxifylline in improving walking distances (26,27,28). After 24 weeks of treatment with doses of 100 mg twice daily, average walking distances have doubled (27,28).

Failure of conservative management and disabling symptoms can be an indication for surgical intervention. Disabling symptoms inhibit the patient's ability to earn a living or enjoy life. The inability to walk distances due to claudication should be distinguished from limitations due to angina. Before proceeding with operation for claudication, the informed consent regarding the magnitude of the operation and the attendant cardiac morbidities must be achieved.

Preoperative evaluation

The systemic manifestations of atherosclerosis must be recognized prior to operation. The Framingham study clearly demonstrated that claudicators have a higher incidence of coronary artery disease, cerebrovascular occlusive disease, and hypertension than does the nonclaudicating population (29).

Half of all vascular surgery patients have clinically overt coronary artery disease, and another 20% have clinically silent coronary artery disease (30). A history consistent with angina or ischemic changes on an electrocardiogram should prompt further cardiac workup. The authors' approach is a consultation with the patient's cardiologist, usually followed by an adenosine-thallium stress test and Holter monitor. Positive findings lead to a cardiac catheterization and intervention as indicated. Myocardial revascularization should take precedence over lower extremity revascularization. Conversely, patients with a negative cardiac history and no EKG changes may safely undergo revascularization without extensive cardiac evaluation (31).

All patients considered for operation should undergo a high-quality aortogram to examine inflow (aortoiliac arteries), areas of occlusion, and runoff (popliteal trifurcation and distal vessels). Choosing the target of the distal anastomosis requires detailed views of the runoff and pedal arch. Patients with renal insufficiency should be repleted with intravenous fluids prior to the procedure. The antioxidant N-acetylcysteine (Mucomyst), when combined with saline hydration, has been shown to reduce the incidence of contrast-induced renal failure (32). Administration of the dopamine agonist fenoldopam, a renal vasodilator, has also been shown to minimize the risk of contrast nephropathy in patients with creatinine above 1.5. mg/dl (33). Diabetics who take metformin are at risk for lactic acidosis when administered intravenous contrast. Lactic acidosis has been found to arise in the setting of renal failure and glucophage administration, therefore glucophage should be withheld for 48 hours after aortography. If after 48 hours renal function is normal, then glucophage can be resumed. In patients with a contraindication to contrast administration, gadolinium-enhanced magnetic resonance arteriography is a useful alternative (34,35).

Preoperative duplex sonography of the greater saphenous vein is helpful in planning femoropopliteal bypasses. This procedure may reveal a vein defect and spare the surgeon the frustration of harvesting a conduit that cannot be used. In addition, when planning on using the in situ technique, a preoperative duplex locates and can mark the vein branches that require ligation during the procedure.

In cases of acute ischemia, an embolus from the heart or a proximal aneurysm should be considered. These are almost always superimposed on atherosclerotic disease. For this reason, the surgeon treating a presumed embolic event should be prepared for arterial reconstruction or bypass. Recently, thrombolytic therapy for acute arterial occlusion has been successfully implemented (36,37). In acute occlusion of femoropopliteal bypasses thrombolytics have reduced the need for open surgical procedures in 60% of cases, and amputation-free survival exceeds 75%. Its use, however, is controversial and should be reserved for extraordinary cases (38,39). Continuous infusion of a thrombolytic agent provides gradual reperfusion, which may prevent reperfusion injury and its systemic manifestations. This approach, however, does not provide the durability of additional reconstruction, and should be reserved for high-risk cases and those patients whose predicted lifespan is short.

Operative Management

Femoropopliteal bypass is usually performed under general or regional anesthesia. Given the high incidence of cardiac disease in the patient population, most should have an arterial line for continuous blood pressure monitoring and selective use of a pulmonary artery catheter.

The infrainguinal bypass can be constructed in the following ways:

1. reversed saphenous vein to a patent runoff vessel;
2. in situ vein technique;
3. nonreversed saphenous vein;
4. a sequential bypass (in which the proximal segment consists of PTFE anastomosed to a patent popliteal segment and a separate vein segment is anastomosed from the graft to a distal tibial or peroneal artery), or
5. the use of a vein cuff at the distal anastomosis of a PTFE conduit.

Exposure for the proximal anastomosis begins with an oblique incision centered over the femoral pulse.

The incision is carried down to the native common femoral artery, which should be exposed beginning at the inguinal ligament. Both the superficial femoral and deep femoral arteries are exposed to a level that allows distal occlusive control. Care should be taken to preserve the femoral lymphatics located medial to the artery. Disruption of these lymphatics may play a role in postoperative lower extremity edema and wound complications (40).

Distal exposure for the suprageniculate popliteal artery is achieved through a medial incision. The sartorius muscle is retracted posterolaterally and the underlying deep muscular fascia is incised over the distal adductor canal. The popliteal artery is dissected free from surrounding structures just posterior to the femur. The infrageniculate popliteal artery is exposed through a medial incision posterior to the medial femoral condyle. Care must be taken to avoid trauma to the greater saphenous vein during dissection. The deep muscular fascia is entered and the medial head of the gastrocnemius muscle is retracted posterolaterally to gain entrance to the popliteal fossa. The distal popliteal artery is dissected from the posterior tibial nerve posteriorly and the popliteal vein medially. Dissection must be adequate both proximally and distally to allow placement of Rummel tourniquets or vessel loops.

In the scarred or infected leg two alternative approaches have been described. In the total posterior approach the patient is placed in the prone position (41). An incision is made below the gluteal crease longitudinally between the sartorius and gracilis muscles. The adductor and gracilis muscles are retracted laterally, and the sartorius is retracted medially. The superficial femoral artery can be approached within 5 cm of its origin and the greater saphenous vein can be harvested through this incision. The popliteal artery is then exposed through the standard posterior approach, and the bypass is completed with the patient remaining in the prone position. In the lateral approach to the suprageniculate popliteal artery an incision is made between the iliotibial tract and the biceps femoris muscle (42). The dissection is carried into the popliteal fossa where the neurovascular bundle is palpated and the artery isolated. A lateral tunnel is then used to pass the conduit from the femoral artery.

Before anticoagulation and formation of the anastomoses, when using the reversed saphenous vein or prosthetic graft technique, tunnels are constructed. A subsartorial tunnel is developed from the groin incision to the popliteal space. The tunnel is extended between the heads of the gastrocnemius muscle into the popliteal fossa for below the knee bypasses.

In reoperative situations or when there is infection medially, a tunnel may be constructed to course anteriorly over the thigh and laterally along the knee joint. The in situ technique requires tunneling only occasionally when the infrageniculate popliteal artery is chosen for the distal anastomosis. The angle of the vein graft to the popliteal artery may approach 90 degrees if the native position is used. To correct the angle, the vein is mobilized from the distal anastomosis to above the knee. The vein is subsequently tunneled between the heads of the gastrocnemius muscle to provide a less acute angle of entry to the distal anastomosis.

Reversed saphenous vein technique

The patient is first systemically anticoagulated with heparin. The greater saphenous vein can be harvested through small longitudinal incisions with intervening skin bridges, which minimized post-operative wound complications. Vein branches are ligated and the vein is handled with great care to minimize trauma. After removal, the vein is irrigated with sterile saline combined with heparin and papaverine. Care is taken to maintain the proper reversed orientation of the vein. The distal anastomosis is constructed first with fine monofilament suture and the vein is delivered through the tunnel to the proximal femoral artery. Care must be taken not to twist the vein while traversing the tunnel. This may be achieved by marking the anterior surface of the vein graft. The vein is then flushed from the proximal opening with heparinized saline. The proximal anastomosis is then constructed and completed after sequential irrigation with heparinized saline to minimize embolism.

In situ technique

The authors preferred technique uses the in situ greater saphenous vein as the conduit. In contrast to the reversed saphenous vein technique, the proximal anastomosis is constructed first. The saphenous vein is mobilized to its junction with the femoral vein, in order to form a vein hood and avoid spatulation, and the saphenofemoral junction is oversewn (Figure 1). Ideally the anastomosis is constructed with the common femoral artery, however the vein may not be long enough to perform the anastomosis without tension. In that case an end-to-end anastomosis may be constructed with the proximal superficial femoral artery, after performing an endarterecomy of the artery. The first valve of the greater saphenous vein should be lysed under direct vision. The patient is systemically heparinized. Proximal and distal control is attained and arteriotomy is made in the common femoral artery. The proximal anastomosis is then constructed in the standard fashion.

The infrageniculate popliteal artery is the optimal site of the distal anastomosis. This is approached through a medial incision as previously described. Branches of the saphenous vein that had been localized with the preoperative Duplex ultrasound are ligated though small cutdown incisions and a lighted retractor. A LeMaitre valvulotome is passed from below to lyse the 3-5 intervening sets of valves that are generally present. The valvulotome should be passed until the surgeon is assured that no valves remain intact as indicated by one "clean" pass and arterial flow through the conduit. After complete valve lysis arterial inflow to the vein is allowed and distal control on the recipient vessel is secured with standard intravascular clamps or internal balloon catheters. In order to avoid using clamps on the infrageniculate vessels, a thigh tourniquet may be used to provide proximal control. A standard arteriotomy is made and the distal anastomosis is constructed. Proximal and distal control is released and a completion angiogram may be performed. At the conclusion, missed vein branches should be sought with a handheld Doppler and ligated as appropriate.

Nonreversed saphenous vein

The major advantage of in the situ saphenous vein technique is the size correlation between the artery and vein at the proximal and distal anastomosis. Some authors report the same advantage when using the nonreversed greater saphenous for bypass (43). In this technique the entire greater saphenous vein is exposed and

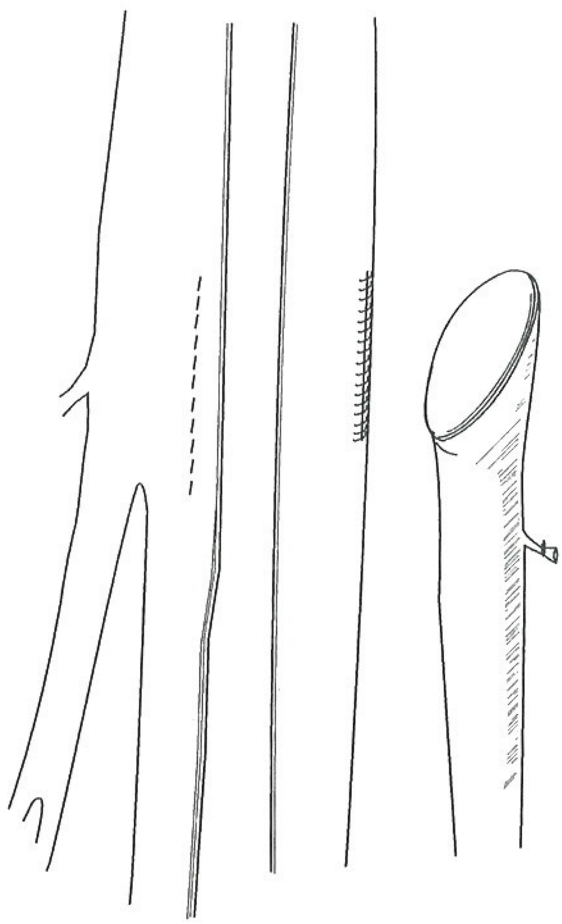

FIGURE 1

Preparation for the proximal anastomosis using the in in situ technique in which a vein hood is formed in order to avoid spatulation the branches are ligated. After harvesting the vein, the valves are lysed retrograde with a Mills valvulotome. The proximal then distal anastomoses are then constructed and a completion angiogram may be performed. While the in situ technique is still preferred, some authors report equivalent patency rates between the in situ and nonreversed saphenous vein techniques.

Sequential Graft

Distal bypasses to small infrageniculate arteries are often plagued with high peripheral resistance due to severely diseased runoff. One proposed method to combat the high resistance is a sequential bypass using multiple outflow sites, and multiple anastomoses, from a single femoral artery bypass. The technique is believed by some groups to improve long-term patency with diseased runoff (44), however there is no evidence that with graft patency or limb salvage is improved (45). The chance for technical error may be increased by multiple anastomoses. The most common sequential bypass consists of a proximal segment of PTFE from the common femoral artery to the popliteal artery. A second segment of vein graft is used to anastomose the PTFE to a distal tibial or peroneal artery. These complex procedures should be reserved for limb and only in cases in which adequate autologous vein is not available.

Saphenous vein alternatives

Many patients presenting for femoropopliteal bypass will have had their saphenous veins used for prior bypass procedures or for coronary revascularization. If available, the contralateral greater saphenous vein is the conduit of choice. If neither greater saphenous vein is available, the ipsilateral lesser saphenous vein can be harvested. This is usually done with the patient in the prone position. After harvesting, the patient is placed in the supine position, and prepped and draped in the normal fashion. Primary patency rates are 75 % at 2 years and 50 % at 3 years (46).

Arm veins may be used if neither greater saphenous is available. Arm veins are thin-walled and more difficult to manipulate than saphenous veins. They often have focal areas of stenosis due to prior venipuncture. Intraoperative angioscopy may be useful in evaluating these veins and discarding diseased segments (47). Patency rates for arm veins range from 40 percent at 3 years to 50 percent at 5 years, consistently 50% less than greater saphenous veins (48,49,50).

Given the poor long-term patency of autogenous saphenous vein alternatives, prosthetic material is a reasonable option for femoropopliteal bypass. The authors prefer externally supported PTFE, although no differences in patency have been described between PTFE and Dacron. Eight millimeters diameter is appropriate for most patients, although small women may require 6 mm. Prosthetic material handles well and is readily available. However, long-term patency is much lower than saphenous vein grafts, especially in infrapopliteal bypasses. In difficult infrapopliteal cases, 3-year primary patency may be as low as 35%, compared to 80% with in situ grafts in a similar patient population (51). A major source of graft failure in PTFE is smooth muscle proliferation at the distal anastomosis, resulting in stenosis. Several techniques of interposing vein cuffs between the PTFE and native artery have been developed. These compliant vein cuffs are proposed to dissipate the kinetic energy stored in the non-compliant PTFE. This results in less turbulence at the distal anastomosis, which decreases the proliferative response to trauma.

Miller and colleagues described a collar of vein anastomosed end-to-side with the recipient vessel, and anastomosed end-to-end with the spatulated end of the PTFE (52). Taylor and colleagues reported a hood of vein across a spatulated PTFE-artery anastomosis (53). The authors always use a vein patch when using PTFE for femoropopliteal bypasses – primarily a variation of the Miller technique in which a vein overlay is placed over the arteriotomy and then a venotomy is made for anastomosis of the prosthetic graft. (Figure 2) All patients with prosthetic graft are started on Coumadin post-operatively to achieve an INR of 2-3.

Post-operative care

Epidural anesthesia can be used intraoperatively and continued in the post-operative period to control pain. Distal pulses should be frequently assessed by Doppler and post-revascularization ABI in order to ensure patency. A decrease in the ABI of greater than 0.15 could be an indication of a failing graft, and deserves further investigation.

A large Dutch study of low-dose aspirin versus Coumadin in the post-operative period showed similar rates of graft thrombosis (54). We continue to use Coumadin in patients with prosthetic grafts and 325 mg of aspirin in those with autogenous vein grafts. If the runoff is poor and the patient does not suffer from congestive heart failure, Dextran can be used in the immediate post-operative period to minimize platelet adhesion.

Patients without tissue necrosis should undergo an aggressive physical therapy regimen to include ambulation on the first post-operative day. If the recovery is

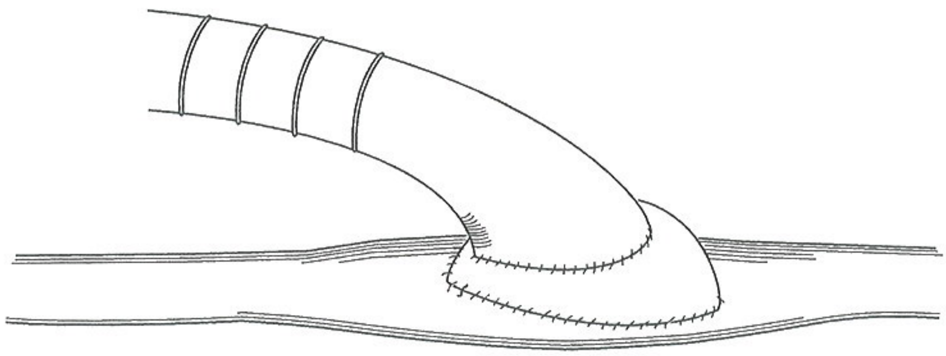

FIGURE 2
Vein cuff with prosthetic conduit in which a vein overlay is placed over the arteriotomy and a veinotomy is made for anastomosis of the prosthetic

smooth, patients usually are discharged two to four days after the operation.

Before discharge, all patients with saphenous vein grafts should have a baseline Duplex scan to assess patency and velocities. The graft should then be examined every 3 months for one year, every 6 months for another year, and yearly thereafter. Twenty percent of vein grafts show focal areas of increased velocity or valve cusp stenosis. No treatment is necessary until the velocity increases to 3.5 times the baseline values. At that point an angiogram is indicated. Focal areas of stenosis may be treated with a vein patch under local anesthesia, which is easily applied to subcutaneous in situ grafts. If the graft has been in place over 6 months, angioplasty may be useful to correct a focal stenosis (55), although open vein patch over the area of stenosis results in superior patency.

The 30-day mortality for infrainguinal bypasses ranges from 2-6% and most commonly results from coronary artery disease (56,57,58). Overall major morbidity varies by series but ranges from 5-10% and is mainly cardiac in origin. Despite the low operative mortality, only 50% of patients who have arterial bypasses are alive at 5 years (55). Most late deaths are due to myocardial infarction.

Early graft failure, within the first 30 post-operative days, complicates 2-7% of procedures and is most commonly due to technical errors (59). Common technical shortcomings include kinks or twists in the graft and intimal flaps. At least 30% of early graft failure is due to a hypercoagulable state, most commonly antiphospholipid syndrome or Factor V Leiden state (59).

Arteriovenous fistulae after infrainguinal bypass may be asymptomatic, present with lower extremity edema, or even cause distal ischemia in cases of severe steal. Arteriovenous fistulae may be suspected if a bruit is auscultated over the graft and confirmed by Duplex studies of the graft. If the patient is asymptomatic or the fistula is small, no treatment is necessary. Exploration and ligation of the fistula may be necessary in symptomatic patients. In patients treated with the in situ technique this may be done as an office procedure using local anesthesia, as the vein is located subcutaneously.

Wound infections occur in 8-20% of cases (60,61). Most are due to superficial skin necrosis and are amenable to local wound care. A seroma due to transection of lymphatics predisposes to infection. This can be minimized by meticulous techniques during exposure of the common femoral artery and closure of the groin incision in multiple layers. When infections involve the suture line of an underlying graft, excision of the graft is necessary (62).

Graft infections in femoropopliteal bypasses occur in approximately 9% of cases (63,64). The usual etiology is intraoperative contamination and the usual bacteriology reflects contamination with skin flora. Treatment of an infected graft requires removal of the conduit in its entirety and observation of the infected limb for viability. A limb that appears ischemic requires either amputation or revascularization through uninfected tissue planes. Mortality in cases of infected grafts approximates 25% (65).

Results

Graft patency is normally reported as either primary or secondary. Primary patency refers to those grafts that remain patent without intervention. Grafts that require some form of revision while still patent are considered to have "primary assisted" patency. Some authors combine primary and primary assisted patency. Secondary patency encompasses thrombosed grafts that require thrombolysis or thrombectomy to remain patent.

Patency figures are frequently derived from life table analysis (Kaplan-Meier curves). This technique reports the actuarial probability of future patency. The results are reliable when the number of grafts of interest is sufficient. For example, if estimating the 5-year patency of 5 grafts placed one year prior, the margin of error may be high.

Graft patency is influenced by a number of factors (Tables I-IV). The most important factors are type of conduit, choice of procedure, patient selection, and distal target. For above the knee bypasses the conduit is less important. When considering infrageniculate targets, the preferred conduit is autogenous vein. Primary patency at 3 years for reversed, nonreversed, and in situ greater saphenous vein techniques is over 85%. The 3-year secondary patency using prosthetic materials ranges from 48%-80%. When compared to prosthetic conduit alone, vein cuffs improve 2-year patency of below knee bypasses from 29% to 52% 70 Arm veins are a valuable alternative when the saphenous vein is unavailable. Secondary patency rates approach 60% at 5 years (71). Arm veins are clearly superior to prosthetic material in cases of severely diseased runoff (72).

When using autologous vein, the highest patency rates are achieved with the in situ technique (Figure 3). A large 1999 series reports secondary patency at 3 years for in situ veins at 97% compared with 89% 3-year secondary patency for reversed saphenous veins (66). The superior results likely result from less traumatic handling of the vein , optimal matching of size at the proximal and distal anastomoses, and no ischemia time for the in situ vein graft.

Variations in patient selection make comparing studies difficult. More patients whose indication for operation is claudication leads to higher patency rates. For instance, Rutherford and colleagues reported on 249 difficult bypasses for threatened limbs (51), and the patency rates are lower than studies including a higher percentage of claudicators.

Clearly, when autologous saphenous vein is available it should be used. The authors recommend the in situ technique. Graft surveillance is facilitated by the subcutaneous location of the vein. Lower extremity edema is lower, which lowers rates of wound complications. Most importantly, long-term patency is the best of any available technique. When autologous vein is unavailable, other options such as PTFE with vein cuff should be considered.

TABLE I
Reversed saphenous vein

		Primary Patency (%)			Secondary Patency(%)		
Study	n. Limbs	1 yr	3 yr	5 yr	1 yr	3 yr	5 yr
Gupta et al (46)	120	75	57	57	94	89	83
Taylor et al (66)	51	86	78	75	90	81	80
Rutherford et al (51)	49	80	66	X	X	73	X

X= Not reported

TABLE II
In situ saphenous vein

Study	n. Limbs	Primary Patency (%) 1 yr	3 yr	5 yr	Secondary Patency(%) 1 yr	3 yr	5 yr
Gupta et al (46)	131	89	85	85	99	97	97
Shah et al (67)	2058	85	X	71	91	X	70
Belkin et al (43)	521	85	X	72	87	X	82
Rutherford et al (51)	70	85	84	X	X	90	X

X= Not reported

TABLE III
Saphenous vein alternates

Study	n. Limbs	Primary Patency (%) 1 yr	3 yr	5 yr	Secondary Patency(%) 1 yr	3 yr	5 yr
Gupta et al (46)	39	71	51	X	90	76	X
Holzenbaum et al (50)	250	70	52	X	76	65	X
Rutherford et al (51)	70	45	24	X	X	32	X

X= Not reported

TABLE IV
Prosthetic Grafts

Study	n. Limbs	Primary Patency (%) 1 yr	3 yr	5 yr	Secondary Patency(%) 1 yr	3 yr	5 yr
Abbott et al (68)	244	75	60	X	88	75	X
AbuRahma (69)	137	65	50	45	90	65	58
Rutherford et al (51)	60	54	35	X	X	48	X

X= Not reported

FIGURE 3A

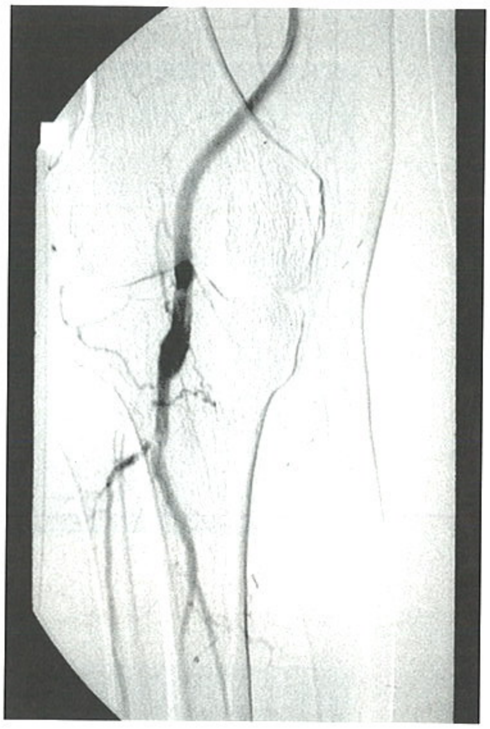

FIGURE 3C

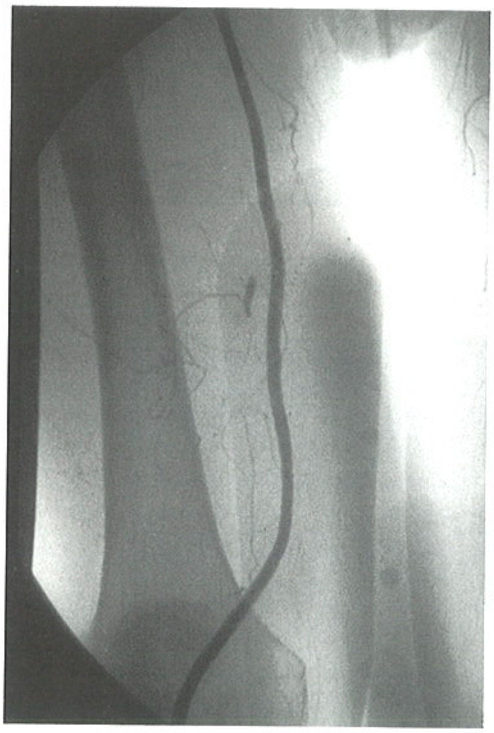

FIGURE 3B

Ten-year follow-up of an in situ femoropopliteal bypass showing the suprageniculate
(a) perigeniculate,
(b) and distal,
(c) segments of the graft

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