Femoral and popliteal artery aneurysms constitute the majority of peripheral aneurysms. Recognition of these aneurysms is increasing, perhaps because of better surveillance of the aging population, as well as improvements in and more widespread use of vascular imaging modalities. Femoral and popliteal aneurysms rarely rupture, but they have a significant potential for limb-threatening complications such as embolization and thrombosis. Large aneurysms can also exert a mass effect and thereby cause compression of veins or nerves.

In general, with both femoral and popliteal aneurysms, elective repair and reconstruction tend to be associated with significantly better postoperative outcomes than is emergency repair undertaken after a limb-threatening complication. Specific treatment decisions may be influenced by the presence or absence of symptoms of aneurysmal disease. There is little disagreement regarding optimal management of symptomatic femoral or popliteal aneurysms, but there is some controversy regarding optimal management of aneurysms that are asymptomatic when detected, especially if they are small. The extent of aneurysmal disease may also influence management choices. For example, a more extensive and complex reconstruction is required for treatment of diffuse arteriomegaly than is necessary for treatment of a focal femoral or popliteal aneurysm.

Lower extremity aneurysms may be either true aneurysms, in which the degenerative process involves all three layers of the arterial wall, or pseudoaneurysms, which result from trauma, anastomotic disruption, or infection. The pathogenesis of true (i.e., degenerative) lower extremity aneurysmal disease has not been definitively established, but it is known that the disease is much more common in men than in women; in fact, men with true femoral or popliteal aneurysms may outnumber women with such lesions by a factor of 2.1,2 One of the factors proposed as a possible contributor to aneurysm formation is turbulent flow beyond a relative stenosis. At the groin, the inguinal ligament may act as a constricting band, and at the popliteal level, the tendinous hiatus, the heads of the gastrocnemius, and the popliteal ligament may compress the artery in certain susceptible individuals. In addition, there is evidence for the existence of a genetic predisposition to true aneurysm formation in the femoral and popliteal arteries, in view of the demonstrated association of femoral and popliteal aneurysms with abdominal aortic aneurysms.4 Accordingly, all patients presenting with femoral or popliteal aneurysms should be carefully evaluated for other aneurysms, especially in the aortoiliac segment and in the contralateral limb.

Regardless of the underlying cause of disease, repair of peripheral artery aneurysms follows the same basic principles applicable to repair of aneurysms in other locations. Specifically, the objectives of treatment are (1) to eliminate the embolic source, (2) to minimize the risk of rupture, (3) to eliminate the mass effect produced by the aneurysm (if present), (4) to restore adequate distal limb perfusion, and (5) to accomplish all of the preceding objectives in a durable fashion. In what follows, we describe key components of the management of femoral and popliteal artery aneurysms, with specific attention to preoperative planning and intraoperative exposure and technique.

Repair of Femoral Artery Aneurysms

True (degenerative) aneurysms of the femoral artery are relatively unusual. They are generally confined to the common femoral artery, but in approximately 50% of cases, they extend to the femoral artery bifurcation. According to a classification scheme proposed by Cutler and Darling in 1973, femoral artery aneurysms are classified as type I if they are confined to the common femoral artery and as type II if they involve the orifice of the profunda femoris artery.5 This classification scheme is convenient for the discussion of operative repair, in that type II aneurysms frequently necessitate more extensive surgical reconstruction than type I aneurysms do.

Like peripheral aneurysms elsewhere, true femoral artery aneurysms are frequently associated with abdominal aortic aneurysms, as well as with aneurysms in other locations. In a large series of patients with multiple aneurysms, 95% of patients with a femoral artery aneurysm had a second aneurysm, 92% had an aortoiliac aneurysm, and 62% had an aneurysm in the contralateral femoral artery.6 The natural history of these lesions is not fully understood; it may be relatively benign unless they are symptomatic or large at presentation.

Femoral pseudoaneurysms, on the other hand, are increasingly encountered after trauma (e.g., iatrogenic catheter injury) or after arterial reconstruction. These lesions, especially those arising from disrupted anastomoses, are thought to have a more ominous course if untreated. Aneurysms confined to the superficial femoral artery or the profunda femoris artery alone are distinctly unusual and are often of mycotic or traumatic origin.

PREOPERATIVE EVALUATION

Asymptomatic patients may present with a smooth, fusiform, nontender, pulsatile mass discovered either during physical examination or incidentally on imaging studies done for other reasons. Symptoms may result from local compression of the femoral nerve, which causes pain in the groin or the anterior thigh, or compression of the femoral vein, which may be associated with lower extremity edema and skin changes suggestive of venous stasis. Arterial symptoms (e.g., claudication or lower extremity ischemia) may be present in as many as 40% of patients with femoral artery aneurysms. Atheroemboli originating from the aneurysm can cause painful ischemic lesions; however, such lesions may also be partly a result of concomitant atherosclerotic occlusive disease rather than a direct result of the aneurysm itself.6 Complications of femoral artery aneurysms include thrombosis, embolization, and rupture. In one series of 45 patients with 63 aneurysms, nearly one half (47%) of the patients had experienced a complication by the time of initial presentation.4 Acute thrombo-
sis, because it involves compromise of both the profunda femoris artery and the superficial femoral artery, may result in a critically threatened limb that initially exhibits sensory or motor deficits and eventually manifests frank gangrene. Acute thrombosis secondary to a femoral artery aneurysm is associated with substantial morbidity: limb loss is reported to occur in more than 28% of cases. Patients with gradual or chronic thrombosis, who have had time to develop collateral circulation, may present with claudication. Embolization from a femoral artery aneurysm may be clinically silent or, if extensive, may present as the so-called blue toe syndrome [see 6:5 Pulseless Extremity and Atheroembolism]. Embolic debris originating in the aneurysm may lodge in the digital arteries or obstruct the microcirculation, leading to characteristic painful distal ischemic lesions, despite the presence of palpable distal pulses [see Figure 1]. In more severe cases, obstruction of the outflow bed may compromise blood flow to the entire limb, resulting in limb-threatening ischemia. Rupture of a femoral pseudoaneurysm is not unusual, especially if the lesion is enlarging. Rupture of a true femoral artery aneurysm, however, is a relatively uncommon event, with reported rupture rates ranging from 1% to 12%, and is accompanied by severe groin pain, ecchymosis, and swelling.3,6

Femoral artery aneurysms can usually be diagnosed by means of physical examination alone. Ultrasonography is a useful adjunctive measure for delineating the aneurysm, as well as for screening patients for associated popliteal or aortoiliac aneurysms [see Figure 2a]. CT and MRI scans can be helpful in delineating the extent and morphology of the aneurysm, as well as the status of the adjacent arteries, especially in obese patients [see Figure 2b]. Once the diagnosis has been made, angiography should be performed to establish the extent of aneurysmal and associated occlusive or embolic disease by providing detailed information about the inflow and outflow vessels [see Figure 3]. In selected circumstances (e.g., the presence of recent thrombosis of the outflow bed), arteriography may provide the opportunity for a trial of thrombolytic therapy to improve outflow. Good judgment must be exercised, however, in that there may not be enough time for adequate thrombolysis if the limb is severely ischemic.

Finally, preoperative evaluation should include careful assessment and optimization of comorbid medical conditions often present in patients with femoral artery aneurysms. Because cardiac complications are a major source of early postoperative and late morbidity in this population, special emphasis should be placed on evaluating patients for associated coronary artery disease by means of cardiac stress testing or coronary angiography and on following evaluation with appropriate treatment when indicated. Similarly, imaging of the contralateral limb and the aortoiliac vessels is prudent to detect associated aneurysms and establish treatment priorities.

**OPERATIVE PLANNING**

Repair is clearly indicated for all symptomatic femoral aneurysms, irrespective of cause. Patients who present with limb-threatening complications require expeditious intervention. Asymptomatic femoral pseudoaneurysms should also be repaired once the diagnosis is established because they are often associated with

---

**Figure 1** Shown is an example of extensive atheroembolization to the foot. The source of the atheromatous debris may be a proximal aneurysm or an ulcerating atherosclerotic lesion.

**Figure 2** (a) Shown is a duplex ultrasonogram of a left common femoral artery aneurysm (sagittal view). (b) Shown is a CT scan of a left common femoral aneurysm (arrow). In practice, multiple slices are used to delineate the proximal and distal extent of the aneurysm.
complications. Currently, however, there is no firm consensus on the indications for treatment of asymptomatic true femoral aneurysms, because the natural history of these lesions is not known with certainty and is thought to be relatively benign. Furthermore, no specific aneurysm size has been identified at which the incidence of complications increases dramatically, though it appears that symptomatic lesions tend to be larger than asymptomatic ones. Most surgeons, however, would probably agree that true femoral artery aneurysms larger than 2.5 cm in diameter should be repaired in good-risk patients, especially if the aneurysm is known to have enlarged. Smaller asymptomatic true femoral artery aneurysms, particularly in high-risk patients, should be followed, with intervention reserved for cases in which symptoms develop or the lesion enlarges significantly. On occasion, it may also be necessary to repair a small asymptomatic true femoral aneurysm in conjunction with an aortofemoral or femoropopliteal bypass graft procedure in order to avoid performing an anastomosis to a diseased artery.

OPERATIVE TECHNIQUE

At present, endovascular approaches to definitive treatment of femoral artery aneurysms are limited because the femoral artery crosses the groin crease and is subject to repeated flexion and extension stresses in this location. Current endoprostheses are likely to fail at this site because of kinking, migration, or metal fatigue. Furthermore, the femoral incision required for standard surgical repair is not extensive and is usually well tolerated by most patients. Consequently, the potential advantages of an endovascular approach are less apparent with respect to the repair of femoral artery aneurysms than they are with respect to repair of abdominal or thoracic aneurysms.

Small femoral pseudoaneurysms arising after catheter diagnostic or interventional procedures may resolve over time or, sometimes, may be managed with ultrasound-guided compression or thrombin injection at the time of diagnostic imaging. Surgical repair is usually reserved for pseudoaneurysms that enlarge, become symptomatic, or do not resolve spontaneously [see Figure 4]. A potential advantage of open repair of large pseudoaneurysms is the capacity for decompression of large hematomas, which may be especially important if continued anticoagulation is likely to be required.

The common femoral artery may be approached through

Figure 3  Anteroposterior arteriogram demonstrates a localized common femoral artery aneurysm (arrow).

Figure 4  Repair of femoral artery aneurysms (pseudoaneurysms) (a). Depicted are commonly employed options for repair of femoral artery pseudoaneurysms: (b) primary closure and (c) patch angioplasty with either autogenous or synthetic patch material. Also depicted is repair of anastomotic femoral pseudoaneurysms (d). An interposition graft is placed to the profunda femoris (e), and a jump graft is placed to the superficial femoral artery.
either a longitudinal or an oblique incision over the femoral artery. The usual preference, however, is a longitudinal incision angled approximately 20° medially, which permits exposure of the distal profunda femoris artery without the creation of a skin flap. Both the distal extent of the femoral aneurysm and the degree of associated occlusive disease may influence the configuration of open surgical repair [see Figure 5]. Type I aneurysms, which spare the origins of the profunda femoris and superficial femoral arteries, are usually managed by constructing a short interposition graft with the proximal anastomosis at the level of the distal external iliac artery or the proximal common femoral artery [see Figure 6]. Occasionally, if proximal control of the retroperitoneal iliac artery is required, a flank incision may be needed. When it is necessary to repair additional proximal or distal aneurysms, the short femoral interposition graft may also act as the recipient of an aortofemoral or iliofemoral graft [see 6:12 Aortoiliac Reconstruction] or as the origin of a femorodistal bypass graft [see 6:17 Infrainguinal Arterial Procedures].

If the femoral aneurysm is more extensive, a bypass from the common femoral artery to the profunda femoris artery with a jump graft to the superficial femoral artery is usually preferred [see Figures 5d and 7]. This approach allows the surgeon to work sequentially from the deep tissue planes to the more superficial ones.

Alternatively, some surgeons favor implantation of the distal profunda femoris artery into an interposition graft placed between the common femoral artery and the superficial femoral artery [see Figure 5b]. Others have described joining the superficial and deep femoral arteries at their bifurcation to form a common outflow tract that serves as the distal anastomotic end point for the interposition graft, a technique sometimes referred to as syndactylization [see Figure 5e]. Application of these two methods...
may be hampered by the presence of associated occlusive disease, which is frequently present. Nevertheless, the surgeon should be familiar with all of the available options for reconstruction and should be prepared to adapt his or her choice of reconstruction method to the details of the local anatomy.

For treatment of noninfected femoral aneurysms, especially anastomotic pseudoaneurysms, synthetic grafts have been used with good results; they usually offer a better size match with the native femoral arteries [see Figure 4d]. If local infection is present or the potential for wound complications is high, autogenous grafts are preferred.

OUTCOME EVALUATION

The results of operative repair of femoral artery aneurysms are generally excellent. In published series, the perioperative mortality ranges from 0 (for isolated asymptomatic femoral aneurysm repair) to approximately 4% (if aneurysm repair is combined with more extensive aortic procedures). The reported 5-year patency rate for saphenous vein and Dacron interposition grafts used for repair of isolated femoral artery aneurysms is 80% to 83%. In general, patients who are operated on before they show evidence of impaired limb perfusion fare better than those presenting with lower extremity complications.

Repair of Popliteal Artery Aneurysms

Aneurysms of the popliteal artery are the most commonly encountered peripheral aneurysms. Unlike femoral aneurysms, popliteal aneurysms are more likely to be true (i.e., degenerative) aneurysms than pseudoaneurysms. True popliteal aneurysms typically occur in men in their fifth and sixth decades. Their clinical importance lies in their propensity to cause limb-threatening complications. When true popliteal aneurysms are left untreated, the future incidence of thromboembolic events in initially asymptomatic patients is high. In one series of patients who were managed conservatively, only 32% had no complications at 5 years’ follow-up. Multiple aneurysms are common in this population, and it has been reported that nearly 50% of patients presenting with a popliteal aneurysm have associated abdominal aortic aneurysms and that 40% may also have coexisting femoral artery aneurysms. In the largest reported series, 70% of these patients had a popliteal artery aneurysm in the contralateral extremity. The clear link between the presence of popliteal aneurysms and the presence of other associated aneurysms underscores the importance of careful investigation of all patients who present with a newly diagnosed popliteal artery aneurysm. In approximately 50% of cases, popliteal artery aneurysms are confined to the popliteal artery itself; in the remaining cases, aneurysmal degeneration may extend proximally to involve the superficial femoral artery or distally down to the level of the tibioperoneal trunk.
PREOPERATIVE EVALUATION

Popliteal artery aneurysms may be asymptomatic on initial presentation. The diagnosis is usually suspected on the basis of the detection of a prominent pulsatile mass behind the knee during physical examination. The mass is often best felt with the knee in a slightly flexed position. Small aneurysms may be more difficult to detect during physical examination, especially if thrombosis has already occurred. A high index of suspicion, usually based on recognition of an aneurysm in another location, is helpful in identifying these lesions.

The most frequent initial presentation of a symptomatic popliteal aneurysm is the development of acute limb-threatening ischemia as a consequence of arterial occlusion from thrombosis of the aneurysm or distal embolization. Early manifestations (i.e., those occurring before complete occlusion of the popliteal artery itself) may be limited to painful petechial hemorrhages or localized gangrenous changes in the digital arteries that result from microembolization. In some series, claudication has been a presenting symptom in 40% to 75% of patients with popliteal aneurysms. Rupture is a distinctly unusual event: fewer than 5% of patients present with this complication. In rare instances, patients with very large popliteal aneurysms may present with symptoms resulting from compression of adjacent structures, such as paresthesias or neuropraxia involving the lower leg (from direct popliteal nerve compression) or deep vein thrombosis, superficial varicosity formation, and phlebitis (from popliteal vein compression).

Plain radiographs of the knee may demonstrate calcium in the aneurysm wall; however, once the diagnosis is suspected, it is best confirmed by means of ultrasonography, computed tomography, or magnetic resonance imaging. These imaging modalities are particularly helpful in distinguishing popliteal aneurysms from other space-occupying lesions of the popliteal fossa (e.g., Baker’s cyst).

Angiography is less useful for the diagnosis of popliteal artery aneurysms: it demonstrates only the flow channel of the vessel, and any intramural thrombus that is present may obscure the presence of the popliteal aneurysm. Nevertheless, angiography plays a valuable role in the planning of operative reconstruction because it can delineate the extent of aneurysmal involvement of the popliteal and adjacent arteries and detect the presence of associated occlusive disease. In addition, as noted (see above), it may facilitate the use of adjunctive thrombolytic therapy, which may be particularly beneficial if the outflow bed has been severely compromised by distal thrombosis or embolization. The goal of thrombolysis of occluded outflow vessels is to uncover a suitable target vessel that can be used to provide outflow for a surgical bypass; this modality is particularly useful in this setting, in that intraoperative balloon thromboembolectomy sometimes cannot clear sufficient thrombus from small vessels to maintain long-term graft patency. In one study of selected patients with poor outflow, thrombolytic therapy followed by surgical repair yielded results that compared favorably with those of isolated surgical repair, and the combined approach was associated with lower amputation rates. It should be kept in mind, however, that thrombolytic therapy is more rapid and effective if thrombosis is recent and the volume of thrombus is not large. If limb ischemia
is severe, the length of time required to establish reperfusion may be prohibitive, and it may be best to proceed with direct surgical intervention before irreversible tissue loss occurs.

In patients with popliteal artery aneurysms, as in those with femoral artery aneurysms, there is a high incidence of associated atherosclerotic disorders: nearly 50% have some degree of myocardial dysfunction, and nearly two thirds are hypertensive. Consequently, preoperative evaluation of patients under consideration for popliteal aneurysm repair should include careful optimization of associated coexisting medical conditions, especially associated coronary artery disease.

OPERATIVE PLANNING

There is a consensus that all patients with symptomatic popliteal aneurysms should undergo expeditious operative repair; conservative management in these cases is associated with a substantial risk of limb loss, especially in the presence of limb-threatening ischemia. There is also general agreement that asymptomatic popliteal aneurysms should be repaired upon diagnosis; such lesions are associated with the development of limb-threatening complications in a substantial number of patients. In a series of 94 patients with asymptomatic popliteal artery aneurysms who were followed for nearly 7 years, 18% of the limbs with aneurysms eventually became symptomatic (25% acutely and 75% chronically), and 4% had to be amputated. In this cohort, aneurysm size greater than 2 cm, the presence of mural thrombus, and poor distal lower extremity runoff were significant predictors of the development of symptoms. In a meta-analysis of the published literature that encompassed nearly 2,500 popliteal artery aneurysms, nearly 35% of the patients who were treated conservatively eventually experienced ischemic complications, and 25% of the patients who required surgical treatment for an ischemic complication eventually required amputation. Given these results, most surgeons would agree that surgical repair of asymptomatic popliteal artery aneurysms is indicated for all but extremely high risk patients.

Although the likelihood that popliteal aneurysms will give rise to complications does not appear to be related to the size of the aneurysms, optimal management of small asymptomatic popliteal aneurysms remains controversial—in part because of problems with their definition, especially in the presence of generalized arteriomegaly. Factors believed to be associated with the eventual development of ischemic complications include size greater than 2 cm, deformation of the artery itself, and the existence of intraluminal thrombus. The presence of these factors, especially if the popliteal aneurysm is localized, makes a case for operative repair.

OPERATIVE TECHNIQUE

The primary therapeutic objectives of popliteal artery aneurysm repair are (1) to eliminate the aneurysm as a source of emboli or thrombosis and (2) to maintain distal perfusion in a dur-
Figure 11  Repair of popliteal artery aneurysms. Depicted is the posterior approach to the popliteal fossa.

Figure 12  Repair of popliteal artery aneurysms (a). Depicted are various bypass configurations that can be employed for repair of popliteal aneurysms. (b) An interposition graft may be placed within a large aneurysm. (c) If the graft and the artery are sufficiently well matched in terms of size, ligation and bypass of the aneurysm with end-to-end proximal and distal anastomoses may be employed. (d) If there is a significant size mismatch between the graft and the artery, ligation and bypass of the aneurysm with an end-to-side proximal anastomosis may be employed.
able fashion. Other objectives are to prevent hemorrhage resulting from rupture, to eliminate the mass effect exerted by large aneurysms, and to prevent recurrence. Several reports have evaluated endovascular treatment of popliteal aneurysms with covered stents delivered under fluoroscopic guidance; however, to date, the results have been inferior to those of open surgical treatment. At present, endovascular treatment of popliteal aneurysms remains investigational and should be confined to those patients who are considered to be at unacceptable risk with standard surgical therapy. If endovascular therapy is employed, close late follow-up is necessary to detect fracture or migration of the stent, as well as expansion or thrombosis of the aneurysm.

The two most important factors influencing the surgical approach to popliteal aneurysm repair and the configuration of the reconstruction used are (1) the extent of the aneurysmal disease and (2) the size of the aneurysm. In most settings, the medial approach with the patient in the supine position is preferred. This approach allows exposure of the entire popliteal artery, if necessary, through division of the semimembranosus, semitendinosus, and gastrocnemius tendons, which can be repaired at the time of closure. In addition, it offers the most flexibility for expanding the reconstruction if the aneurysm is large, extensive, or multilobed [see Figure 10]. The posterior approach to the popliteal artery, which is favored by some surgeons, can also provide adequate exposure of localized popliteal aneurysms, but it requires that the patient be prone [see Figure 11]. Although it is well tolerated, the posterior approach precludes exposure of the common and superficial femoral arteries or the greater saphenous vein and offers less flexibility for proximal or distal extension. Familiarity with both approaches permits the vascular surgeon to choose the one that best suits the given clinical situation.

A small, localized popliteal artery aneurysm with few side branches may be treated with simple proximal and distal ligation of the aneurysm sac, accompanied by construction of a bypass graft with a short segment of autologous saphenous vein. The venous graft may be tunneled in the anatomic position, deep to the medial head of the gastrocnemius muscle. The proximal and distal anastomoses are fashioned in either an end-to-end or an end-to-side configuration, depending on the compatibility of the graft’s diameter with that of the artery [see Figure 12].
In the case of a large aneurysm for which evacuation of mural thrombus is required to relieve mass effect symptoms, it may be feasible to construct a short interposition graft [see Figure 13]. Opening the sac also allows ligation of the feeding geniculate branches, which may help minimize the risk of late enlargement of the aneurysm sac associated with recurrence of mass effect symptoms.

If the superficial femoral artery is severely involved with occlusive or aneurysmal disease, it may be necessary to construct a long saphenous vein bypass graft originating from the common femoral artery, in either an in situ or a reversed configuration [see Figure 14]. The distal anastomotic site is determined on the basis of the preoperative angiographic findings, in conjunction with intraoperative assessment.

As a rule, grafts constructed from autogenous vein are preferred, but synthetic grafts may be required if the autogenous vein is unavailable or inadequate. An effort should be made to keep graft length to the minimum necessary to treat the aneurysmal disease. Intraoperative completion angiography is recommended to allow detection and correction of technical problems with the reconstruction before closure [see Figure 15].

OUTCOME EVALUATION

In a study from the Cleveland Clinic that described the surgical management of 110 popliteal aneurysms, there were eight (7.3%) early postoperative deaths. Six (75%) of the eight early postoperative deaths were attributable to cardiac complications—an observation that highlights the need for careful cardiac evaluation, when feasible, before the treatment of popliteal artery aneurysms.

The presence of symptoms, the adequacy of the outflow bed on presentation, and the choice of autogenous graft material for reconstruction are the main factors that influence limb salvage and graft patency rates after repair of popliteal artery aneurysms. In one study, the 5-year patency rate for saphenous vein grafts was 92% for patients who had asymptomatic popliteal aneurysms and in whom good outflow vessels were identified, compared with 66% for a matched cohort with known occlusive disease. In other studies that included similar patients, the 10-year patency rate was in excess of 80%, and the limb salvage rate was approximately 95%.

Patients who undergo urgent surgical treatment of popliteal aneurysms that were symptomatic on presentation have less favorable outcomes. In one study, when thrombosis of the popliteal aneurysm was apparent on presentation or distal outflow was poor, the 5-year patency rate was approximately 50%, and the limb salvage rate was only 60%. Several studies documented the influence of the choice of conduit graft material on bypass durability; each demonstrated that patency rates were nearly four times higher with saphenous vein grafts than with nonvenous alternative grafts. Limb salvage rates were also higher with autogenous saphenous vein grafts. For example, in one report, 23% (7/31) of the popliteal artery bypasses performed with a prosthetic conduit resulted in limb loss, whereas only 2% (1/42) performed with a saphenous vein graft resulted in amputation.

In the past few years, instances of continued expansion of the popliteal aneurysm sac despite ligation and bypass have been reported. This phenomenon may result from inadequate ligation of the aneurysm sac, but it may also result from retrograde perfusion of the sac via patent geniculate collateral vessels. Consequently, it seems advisable to ligate all large collateral vessels feeding the aneurysm sac at the time of the initial aneurysm repair. If the aneurysm is large, it may be necessary to perform the ligation from within the evacuated sac.
References


Acknowledgment

Figures 4, 5, 10, 11, 12, and 14 Alice Y. Chen.