OPEN ACCESS TEXTBOOK OF GENERAL SURGERY

ACUTE LIMB ISCHAEMIA

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INTRODUCTION

Acute ischemia of the limb represents one of the toughest challenges encountered by vascular specialists. The diagnosis and initial assessment are largely clinical, and diagnostic errors can result in a high price to the patient—amputation or even death. Amputation and death rates remain high despite intervention, which is in contrast to major advances in the treatment of many other vascular diseases. Acute ischemia is often an end-of-life condition that presents in a patient with multiple medical co-morbidities. Therefore, careful clinical assessment of the individual is as important as assessment of the limb. Unlike many other vascular conditions, there is no one definitive treatment; a variety of modalities are available, including anticoagulation, operative intervention, thrombolysis, and mechanical thrombectomy. Selection of the most appropriate intervention or combination of interventions can be critical to the eventual outcome.

Definition
Acute limb ischemia (ALI) is the result of a sudden deterioration in the arterial supply to the limb. A time period of 14 days from onset of symptoms is utilised to define this clinical entity.

ETIOLOGY AND PATHOLOGY

Excluding trauma and iatrogenic causes, there are two main reasons for acute ischemia to occur: arterial embolism and thrombosis. The distinction between thrombosis and embolism is important in terms of diagnosis, treatment and prognosis.

Embolism

Embolism (from the Greek *embolos,* or “plug”) is the result of material passing through the arterial tree and obstructing a peripheral artery. Usually the source of the embolus is the heart, and the material is mural thrombus that has accumulated and detached. The other main cause is atherosclerotic debris from a diseased proximal artery, often the thoracic aorta, in individuals with a heavy burden of atherosclerotic disease.

Once the embolus detaches, it passes easily through large arteries and lodges peripherally, usually at an arterial bifurcation, where vessels naturally narrow. Emboli can occlude any artery, but in the legs, the common femoral and popliteal arteries are commonly obstructed. Only large emboli, so-called saddle emboli, occlude the normal aortic bifurcation.

Embolic ischemia is usually catastrophic because it often occurs in otherwise normal arteries, without any established collaterals. Typically, the patient presents with an acute white leg, including a complete neurosensory deficit. Embolic occlusion is also progressive; the ischemia worsens as secondary thrombus forms both proximal and distal to the occlusion. The secondary thrombus is the plum-colored clot removed at embolectomy. It is particularly important that this secondary thrombus be removed because it may be responsible for obstruction in smaller distal vessels. If the presentation is delayed, the secondary thrombus adheres to the arterial wall, making it particularly resistant to removal with an embolectomy catheter and less easily lysed by thrombolytics.

Cardiac Embolism

Atrial and Ventricular

Embolism may occur in patients with otherwise normal arteries, with the embolic material usually arising from the heart. Embolic material from the

heart usually consists of platelet-rich thrombus. Often it is organized, giving it the characteristic white surface on removal at embolectomy. The most common cause is atrial fibrillation; thrombus forms in the left atrial appendage as a result of stasis due to uncoordinated contractions of the atrium and ventricle.

Mural thrombus, as a result of acute myocardial injury due to infarction, is a particularly dangerous cause of embolism; the patient has not only an ischemic extremity but also a high-risk medical condition. Left ventricular aneurysm is also a high-risk cause of embolism because these patients have a low cardiac output as a result of the previous infarcts that caused the aneurysm.

In the past, cardiac valve disease was the main cause of arterial embolism, but the active management of these patients and advances in cardiac surgery have virtually eliminated this as a cause. Instead, many patients now have artificial heart valves, and those with metal valves are usually anticoagulated. Embolism is rare in patients with porcine replacement heart valves.

Paradoxical

Paradoxical embolism occurs when a clot from the venous system, usually a deep venous thrombosis, travels through a patent foramen ovale into the arterial system. The clinical clue is acute arterial ischemia in a patient with known deep venous thrombosis.

Endocarditis

Bacterial endocarditis is an infrequent diagnosis since the introduction of widespread echocardiography and antibiotics. However, certain patient groups are at risk, including intravenous drug users, patients with indwelling arterial or venous lines, and those who are immunocompromised.

Cardiac Tumor

Atrial myxoma is a benign tumor of the left atrium that may fragment as it enlarges. Surgeons are advised that if there is anything atypical about the material removed at embolectomy, or if the patient is young with no obvious reason for embolic disease, the specimen should be sent for histology.[1]

Arterial Embolism

Atheroembolism

Along with foreign bodies and material introduced during vascular intervention (which is increasingly common), another source of embolism is the native arteries themselves. Particularly in patients with extensive atherosclerotic disease in major arteries such as the aortic arch or the descending thoracic aorta, fragments of plaque or adherent thrombus may detach and cause symptoms that mimic cardiac embolism. The embolic material may be variable and may consist entirely of platelet-rich thrombus, similar to embolism. More sinister are fragments of atheromatous plaque, which may contain cholesterol elements, that detach; these are more difficult to remove at embolectomy and may irreversibly occlude small distal vessels.

Aortic Mural Thrombi

Occasionally, patients with hypercoagulable conditions develop an aortic mural thrombus in the absence of aortic pathology, which then embolises to a limb. This should be suspected in a patient without atherosclerotic vascular disease and in whom the cardiac evaluation is negative. Although the acutely ischemic limb may need urgent treatment, the underlying aortic pathology can often be treated simply by anticoagulation, with resolution of the thrombus.

Thrombosis

Thrombosis results from blood clotting within an artery, which can be caused by progressive atherosclerotic obstruction, hypercoagulability, or arterial dissection.

Atherosclerotic Obstruction

Thrombotic occlusion is most commonly the result of progressive atherosclerotic narrowing in peripheral arteries of the leg. Once a stenosis becomes critical, platelet thrombus develops on the stenotic lesion, leading to an acute arterial occlusion. The clinical manifestations are seldom as dramatic as those of embolization because the progressive process of atherosclerotic narrowing results in the development of robust collateral circulation. Patients with atherosclerosis deteriorate in a stepwise fashion as thrombosis supervenes on an arterial stenosis. The resulting symptoms of ischemia (usually the acute onset of claudication) improve as collateral vessels expand. Critical ischemia is the end result when this process occurs at multiple levels. Acute stroke or myocardial infarction is the result of atherosclerotic plaque disruption (this plaque can be examined at carotid endarterectomy or autopsy). In the extremities, it is not known whether plaque disruption is a cause of acute-on-chronic arterial thrombosis, because the offending plaque is rarely available for examination. It is possible, however, that the process of plaque disruption is the etiology in certain cases.

In patients with extensive atherosclerotic peripheral vascular disease, a reduction in cardiac output may produce acute limb ischemia by a global reduction in limb arterial perfusion. For example, if a patient with severe claudication develops complicated diverticulitis, the onset of shock may cause low cardiac output and result in acute critical limb ischemia in the absence of thrombosis. It is important to recognize this phenomenon because it is the underlying disease, not the leg that needs urgent treatment.

Hypercoagulable States

In situ vessel thrombosis can also occur in the absence of atherosclerotic disease in states of hypercoagulability, low arterial flow, or hyperviscosity. These hypercoagulable states are associated predominantly with venous thrombosis, but thrombocythemia in particular can cause arterial occlusion, usually in small vessels. Malignant disease is also linked mainly to venous thrombosis, but several authors have observed an association with acute arterial ischemia. It may be worth screening patients with acute leg ischemia for an underlying malignancy. Because the vessel thrombosis is often a marker of advanced malignancy, the outcome in these patients is poor.

Vascular surgeons occasionally encounter heparin-induced thrombocytopenia, in which a patient on heparin develops progressive vessel thrombosis with a falling platelet count. Other hypercoagulable conditions may cause arterial thrombosis and result in acute limb ischemia.

Aortic or Arterial Dissection

Another condition that requires a high index of suspicion for diagnosis is aortic dissection, which may involve the aortic bifurcation and give the appearance of iliac artery thrombosis. These patients typically have back pain and may be hypotensive. Another clinical clue is renal failure if the dissection involves the renal arteries. Isolated arterial dissections of vessels supplying the lower extremity are uncommon but can occur from traumatic or fibrodysplastic causes.

Bypass Graft Occlusion

Another significant cause of acute limb ischemia is the occlusion of an existing patent bypass graft. Clearly, the rate depends on how many bypass grafts exist in a community. In areas that are well endowed with vascular services, patients frequently present emergently with graft thrombosis. In the United Kingdom, a national survey in 1996 reported that graft or angioplasty occlusion was responsible for 15% of acute limb ischemia. The diagnosis is usually easy, and the cause is more likely to be thrombosis than embolism. Assessment and treatment are similar to that for native vessel ischemia, but decisions about treatment can be much more difficult because of the variety of options available

Table 1. Aetio-pathology of Acute Limb Ischaemia

Embolism
• Cardio-embolism
• Arterio-embolism
Thrombosis
• Vascular graft thrombosis
• In-stent thrombosis
• Native artery thrombosis
• Peripheral aneurysms, e.g. popliteal aneurysms (50% present with ALEXI)
Trauma
• Blunt (e.g. knee dislocation)
• Penetrating (stab/gunshot)
Iatrogenic injury
• Post-catheterisation (e.g. post-diagnostic/interventional angiography)
• Following lower extremity surgery in the proximity of major vessels
Malperfusion
• Aortic dissection
• Isolated peripheral arterial dissection
Thrombophilia
• Unexplained graft occlusion
• Occlusion of normal native arteries

CLINICAL ASSESSMENT

The initial assessment of acute critical ischemia involves an evaluation of both the limb and the patient as a whole.

History

The severity of the initial symptoms depends on the severity of ischemia and can range from incapacitating pain to the sudden onset of mild claudication. Obviously, the more severe the ischemia, the faster the patient seeks medical attention. Severe acute ischemia is usually obvious, with extreme pain and loss of sensation and power in the limb. Less severe ischemia can be difficult to diagnose and may be confused with musculoskeletal pain, sciatica, and other causes of limb discomfort. The duration of symptoms is the most important part of the history; in patients with severe ischemia, irreversible muscle necrosis occurs within 6 to 8 hours if the condition is untreated. Patients with an acute white leg require urgent intervention. The symptoms of sensory loss and muscle pain are also evidence of critical ischemia.

The history should include an attempt to define the cause of the ischemia. Historically, patients with emboli had valvular heart disease but no evidence of peripheral vascular disease or other atherosclerotic conditions; however, the presence of atherosclerosis no longer rules out embolism. Patients with acute-on-chronic thrombosis often give a history of prior intermittent claudication in the ipsilateral or contralateral leg. A full medical history is important because it may reveal other associated diseases such as diabetes mellitus. Risk factors for atherosclerotic disease should be sought, including smoking, hypertension, high cholesterol, and family history.

Physical Findings

Examination of the leg is used to define the severity of the ischemia and is therefore fundamental. The well-known rule of P's—pain, pallor, paresis, pulse deficit, paresthesia, and poikilothermy—remains a good guide to both symptoms and signs. The color of the skin reflects its vascular supply.

Marble-white skin is associated with acute total ischemia. Slow capillary refill is a sign that at least a small degree of distal flow is present and runoff vessels are probably patent. Sensation may be lost completely and the foot may be numb, but more often there is loss of fine touch and proprioception, which should be tested specifically. Muscle tenderness, particularly in the calf, is a sign of advanced ischemia. Acute ischemia is associated with the loss of peripheral pulses, which also helps define the level of the occlusion. Palpable normal pulses in the contralateral leg points toward embolism as the cause.

A full vascular examination reveals the level of the occlusion by the loss of arterial pulsation. A strong pulse can, however, mask an occlusion at that level because of the water-hammer effect. Other possible sources of embolization may become apparent, such as aortic or popliteal aneurysm or cardiac abnormalities such as atrial fibrillation. Patients with acute leg ischemia are often elderly with multiple co-morbidities, and a full physical examination should be undertaken because the final outcome may depend as much on associated conditions as on the severity of the leg ischemia.

Hand-held Doppler examination is also a basic part of the examination. Pedal arterial signals may be absent or reduced. The presence of normal biphasic signals excludes the diagnosis. Soft monophasic signals are associated with patent distal vessels but proximal arterial occlusion. Absent Doppler signals in the ankle arteries is a poor prognostic sign. The arteries may be patent but with little flow, or they may be occluded with thrombus. In severe ischemia, ankle Doppler pressures are impossible to measure, partly due to the lack of signal but also due to muscle tenderness. In less severe ischemia, an ankle pressure of 30 to 50 mm Hg can be expected, and an ankle-brachial index of about 0.3 is diagnostic of subcritical acute ischemia. Doppler can also be used to examine the extremity veins. In particular, lack of a venous signal in the popliteal fossa suggests popliteal venous occlusion, which is a particularly poor prognostic sign in a patient with acute arterial ischemia.

CLASSIFICATION OF ACUTE LIMB ISCHEMIA

Acute limb ischemia used to be classified according to cause—thrombosis or embolism—because this had implications for treatment and prognosis. Patients with thrombosis tended to be younger but had a higher risk of major amputation. Patients with emboli tended to be older and had a higher risk of dying after treatment. It has become clear that this is not a useful classification because there is no way of proving definitively whether an occlusion is thrombus or embolus. A more valuable method of classification is based on the severity of the arterial ischemia, which is helpful in determining the urgency of intervention and has implications for outcome.

The Society for Vascular Surgery and the International Society for Cardiovascular Surgery have published definitions of acute leg ischemia that are valuable for treatment and prognosis These standards were modified in 2007 by a larger group—the Trans-Atlantic Inter-Society Consensus—which defined acute ischemia as any sudden decrease in limb perfusion causing a potential threat to limb viability.[1] The categories of ischemia are based on clinical findings and Doppler measurements, which can be performed at the bedside and are immediately available. In patients with class I ischemia (viable) or acute-onset claudication, intervention, particularly with thrombolysis, may be risky, and there is an argument for

conservative treatment consisting of exercise and best medical therapy. In class III or irreversible ischemia, there is no indication to improve the blood supply, which may risk rhabdomyolysis, so the decision is between major amputation and conservative treatment.

Classification of Acute Limb Ischemia

Table 2. Recommended standards for lower extremity ischaemia				
	Doppler signals		Findings	
	Sensory loss	Muscle weakness	Arterial	Venous
I. Viable	None	None	Audible	Audible
II. Threatened				
IIa. Marginally threatened	Minimal (toes)	None	Inaudible	Audible
IIb. Immediately threatened	More than toes Severe rest pain	Mild/ moderate	Inaudible	Audible
III. Irreversible	Profound/ anesthetic	Profound/paralysis (rigor)	Inaudible	Inaudible

From Rutherford RB, Baker JD, Ernst C, et al. Recommended standards for reports dealing with lower extremity ischemia: revised version. J Vasc Surg. 1997;26:517-538.

Patients with class II ischemia require intervention, and the distinction between IIa (marginally threatened) and IIb (immediately threatened) is crucial. Any delay in treating the latter risks irreversible muscle necrosis, whereas in patients with IIa ischemia, there is time for investigation and semi-elective intervention. Class II ischemia encompasses the majority of patients with acute leg ischemia, and it may be helpful to think of class IIa as acute subcritical ischemia and class IIb as acute critical ischemia.[1] The three findings that best differentiate IIa from IIb ischemia are pain at rest, sensory loss, and muscle weakness.

DIAGNOSIS

Following clinical assessment and classification, the anatomic location of the arterial occlusion can be diagnosed with a high degree of reliability.

Aortic Occlusion

The diagnosis of an aortic occlusion is usually obvious. Paralysis of the legs is often the presenting feature; patients are unwell, with mottled skin discoloration that often extends above the inguinal ligament onto the lower abdomen and no palpable extremity pulses. This is a particularly high-risk condition, and urgent treatment is indicated. The kidneys are especially at risk, particularly if the aortic occlusion is due to an aortic dissection. The dissection or occlusion may already involve the renal arteries, in which case the patient presents in established renal failure. Successful revascularization restores the blood supply to a large muscle mass, but the effects of ischemia-reperfusion may cause further renal damage.

Iliac Occlusion

The findings are similar to those for aortic occlusion, but unilateral. The femoral pulse is lost on the affected side, and mottling usually extends to the inguinal level. Aortic dissection should be excluded if there is time for investigation or if symptoms are suggestive.

Femoropopliteal Occlusion

Femoropopliteal occlusion is the most common situation in those with acute leg ischemia. The severity of the ischemia depends on whether the profunda femoris remains patent. The symptoms are more severe if the profunda is involved. Although the femoral pulse may be strongly palpable (owing to the water-hammer effect), the artery may be occluded.

Popliteal and Infrapopliteal Occlusion

In popliteal and infrapopliteal occlusion, the calf muscles are ischemic with a palpable femoral pulse. In young patients, rare diagnoses include popliteal thrombosis due to muscular entrapment or cystic adventitial disease. The most sinister cause is popliteal aneurysm thrombosis or embolization. This diagnosis should be suspected if a generous popliteal pulse is palpable in either leg or there is a nonpulsatile mass in the popliteal fossa of the affected leg. The outcome of this condition is particularly poor, despite aggressive treatment. Chronic embolization of thrombus from within the aneurysm gradually occludes the distal vessels and arterial outflow; the aneurysm then thromboses, leaving no distal arterial targets for revascularization. Tibial embolism is an infrequent diagnosis, because most emboli that produce symptoms are large and obstruct proximal arteries. Very distal emboli can be challenging to treat because the embolectomy catheter is least valuable in small distal vessels. Some authors recommend approaching tibial emboli from below via pedal arteries.

INVESTIGATION

Investigation may be valuable in confirming the clinical diagnosis and planning the appropriate treatment for patients with acute ischemia. However, when the ischemia is critical, there may be no time for investigation if direct operative intervention is required. It is possible to employ on-table angiography to assist in decision making in the operating room. Time permitting, a number of methods can be used to definitively determine the site and nature of the arterial occlusion.

Transfemoral Arteriography

Arteriography has been the mainstay of investigation for acute leg ischemia, provided at least one femoral pulse is palpable. Brachial puncture can be used in the absence of femoral pulses, but patients with aortic occlusion often require hyper acute treatment, leaving little time for investigation. The angiogram can document the level of occlusion and sometimes its nature. Thrombotic occlusion is likely if there are established collateral arteries and evidence of arterial atherosclerosis. Sometimes emboli can be seen in several vessels, establishing the diagnosis. The best reason to perform angiography is when an endovascular solution to the arterial occlusion is likely, because thrombolysis, percutaneous thrombectomy, angioplasty, or stenting can be done at the same sitting. Arteriography may not visualize all the distal vessels in the acute situation because the lack of collaterals and associated spasm limit visualization. It may still be worth exploring distal vessels surgically when contemplating a distal bypass in this situation, although an alternative would be to consider intra-arterial thrombolytic therapy

Ultrasound

Imaging with duplex ultrasonography is the mainstay of investigation for chronic arterial ischemia. It may not be available in all hospitals, but it can be employed in cases of acute ischemia to define the level of the arterial occlusion and the patency of other vessels. Many vascular specialists are becoming expert in duplex imaging, and portable ultrasound machines are getting smaller, so they may be available for bedside use by trained clinicians.

Computed Tomographic Angiography

New-generation computed tomography (CT) scanners acquire images at very high speed and are available in most emergency suites. Intravenous contrast injection with current CT technology provides images that are similar in quality to intra-arterial arteriography. The images sometimes require manipulation to produce the best results, but this is an acquired skill of many young vascular specialists. These images are particularly good for aortoiliac occlusions. Because of its immediate and widespread availability, computed tomographic angiography is the investigation of choice for acute ischemia.

Magnetic Resonance Angiography

Magnetic resonance angiography with gadolinium enhancement is less useful than either CT or ultrasound in the context of acute limb ischemia. It is often unavailable at off hours, takes time for images to be acquired, and is generally inconvenient for sick patients.

Echocardiography

Debate continues about the role of echocardiography. In practical terms, the investigation seldom alters management because most patients are anticoagulated for life after successful treatment for acute ischemia. Some surgeons, however, regard the investigation as a vital part of management. There are certainly some conditions that require echocardiography to make a diagnosis, such as valvular disease (including vegetations), septal defect, and cardiac tumor. Problems associated with the routine application of echocardiography include the variability in results between transthoracic and transesophageal techniques and among different technicians, the inability to visualize the left atrial appendage, the fact that failure to visualize the source of an embolus does not rule out its existence, and the test's lack of influence on overall management. A pragmatic view would be that echocardiography is indicated in young patients, those in whom a cardiac diagnosis is suspected, and those in whom the results might affect decisions about long-term anticoagulation.

Initial Management

Anticoagulation

The threat to the limb escalates with secondary thrombosis of under perfused distal vessels, particularly in patients with emboli. Therefore, immediate anticoagulation with intravenous calcium heparin can stabilize the condition of the leg and prevent deterioration. Whereas low-molecular-weight heparin is a valuable therapy for many conditions, the potential for immediate reversal with protamine makes calcium heparin the drug of choice in this situation. An initial bolus of 5000 U is appropriate for most patients, followed by an intravenous infusion commencing at 1000 U/hr. If urgent operation is not undertaken, the infusion should be monitored using the activated partial thromboplastin time, aiming for a ratio of 2 to 3. It is vital not to assume that anticoagulation is being accomplished

while heparin is being administered; there is a wide variation in response to the drug, and careful monitoring by protocol is needed.

Ancillary Supportive Measures

Other first-aid measures that are beneficial in patients with leg ischemia include the use of oxygen delivered by facemask. This has been shown to improve skin perfusion, even in the ischemic limb. Patients with acute ischemia are often dehydrated, and an intravenous infusion of fluid is necessary, together with catheter monitoring of urine output. Many radiologic maneuvers involve the use of contrast agents that can damage the kidneys, and adequate renal perfusion is important. As part of the diagnostic workup, a full blood screen for blood urea nitrogen and a full blood count are indicated. In patients with recurrent thrombosis, a full thrombophilia screen should be performed at this stage, if indicated, because therapeutic anticoagulation renders these investigations inaccurate. These tests are indicated in patients with a strong family history of arterial and venous thrombosis or those with recurrent disease. Patients are often in severe pain, and adequate analgesia is important. Intramuscular opiates are contraindicated in a patient who may receive thrombolysis, and patient-controlled intravenous analgesia is a good alternative.

TREATMENT

Once the initial assessment is complete, a decision should be made about the intervention required and its timing. The following options are available: anticoagulation alone, operative intervention, and endovascular intervention via mechanical thrombectomy or thrombolysis.

Anticoagulation

Heparin anticoagulation has no direct thrombolytic effect; it is employed to stabilize clot formation and prevent further secondary thrombosis. Use of anticoagulation alone as a treatment implies that the limb is likely to remain viable or that other therapeutic options are limited, perhaps by age or co-morbidity. Before anticoagulants were available, treatment of acute leg ischemia was largely expectant, and historical series documented high morbidity and mortality rates, despite amputation. Heparin and then warfarin made an immediate impact after their introduction. Anticoagulation for stable class I ischemia, followed several weeks later by intervention (usually endovascular) if collaterals do not become established, is safe and effective. Anticoagulation has been shown to improve results after embolectomy. In class III irreversible ischemia, anticoagulation allows stabilization of the patient while his or her medical condition is improved, pending major amputation at a later date. Otherwise, anticoagulation may be a component of treatment but does not constitute definitive treatment for acute leg ischemia.

Operative Intervention

After Fogarty and coworkers described the embolectomy catheter for the remote removal of clot via a groin incision in 1963, surgery became the main treatment for acute leg ischemia.[1] Before this, surgeons had used a variety of ingenious methods to remove clots, often with little success. The new embolectomy procedure could be performed with the patient under local anesthesia, through a relatively small incision, and in combination with anticoagulation; it marked an immediate improvement in outcome. Over the years, the pattern of disease has changed, and emboli now occur in patients with ischemic heart disease, often in association with peripheral vascular disease. Thus, the embolectomy procedure has become more complicated, and the results are

inferior in patients who may have an acute thrombosis. Increasingly, surgical bypass techniques are required in this situation and in the expanding category of acute arterial thrombosis as Western populations live longer. A modern vascular surgeon should be able to offer a full range of bypass procedures to patients with acute leg ischemia, which may include on-table diagnostic angiography and even therapeutic intraoperative thrombolysis. This development has implications for the delivery of treatment. Acute leg ischemia should no longer be managed by occasional operators because specialized vascular procedures are often required to achieve optimal outcomes.

Endovascular Intervention

The last 20 years have witnessed an incredible change in the delivery of vascular services from open surgery toward less invasive endovascular interventions. Two nonsurgical options are available for the removal of obstructing thrombus: mechanical thrombectomy and thrombolysis.

Mechanical Thrombectomy

Mechanical thrombectomy uses homemade (aspiration embolectomy) or commercially available custom-built devices. The procedure is performed in the angiography suite, and in expert hands, it can yield good results in selected patients, particularly those with bypass graft occlusions. If unsuccessful, it can be followed promptly by surgical intervention or thrombolysis.

Thrombolysis

Percutaneous thrombolysis is now an established intervention for all forms of acute arterial occlusion. All current thrombolytic agents are plasminogen activators that accelerate plasmin production with the degradation of fibrin. A potential advantage of thrombolysis is that unlike surgical embolectomy, which simply removes thrombus from the large arteries, thrombolysis lyses clot in both large and small arteries as well as arteriolar and capillary beds.

SELECTION

The choice of intervention depends on the available expertise and the severity of the leg ischemia.

Acute Critical Ischemia

All patients with acute critical (class IIb) ischemia will need urgent intervention. In institutions where vascular and endovascular services are limited, the choice may be restricted to surgical intervention. Where expertise is limited, consideration should be given to transferring the patient to an institution with a full range of vascular and endovascular services; this clinical setting has been shown to improve outcomes. If endovascular treatment is offered for acute critical ischemia, there should be no delay. Percutaneous thrombectomy is a valuable option where expertise exists. Low-dose intra-arterial thrombolysis is contraindicated because it usually takes 12 to 24 hours to be effective. Accelerated thrombolysis may be an option in experienced units, using either high-dose bolus infusion techniques or pulse spray thrombolysis. However, with these few exceptions, most patients with acute class IIb critical limb ischemia are best treated in the operating room. This can usually be rapidly arranged, and a full range of interventions are available, from embolectomy through reconstruction to on-table angioplasty or thrombolysis.

Acute Subcritical Ischemia

The treatment of patients with stable (class IIa) acute ischemia should be individualized, given the greater number of options and the greater time

available for deliberation. These decisions are often best made by multidisciplinary teams reflecting local expertise. Obvious emboli may be treated most appropriately by embolectomy. With this exception, the primary option for class IIa ischemia is intra-arterial thrombolysis with or without adjunctive mechanical thrombectomy. There has been much debate about the advantages and disadvantages of thrombolysis versus a surgical approach, and a number of large randomized trials have compared the two modalities. Premier vascular units are familiar with both surgery and thrombolysis and can make treatment decisions on an individual basis. For instance, many patients with acute leg ischemia are in poor general health and at high risk for complications following operative intervention, particularly if general anesthesia is required. If a good surgical option exists, it is probably best that this be undertaken in a fit patient. Thrombolysis is particularly indicated when the surgical options are poor and the runoff vessels in the leg appear occluded. A meta-analysis of the available trials suggested that thrombolysis was best for short-duration ischemia and bypass graft occlusions.

Acute Upper Limb Ischemia

Arms with acute ischemia account for only a fifth of all acutely threatened limbs. Women are affected twice as often as men, and patients are significantly older than those with acute symptoms in the lower extremity. Because most reports of acute arm ischemia generally involve those who required surgery, the denominator is difficult to calculate. Between 9% and 30% of patients seen by vascular surgeons with upper extremity arterial occlusive disease are managed conservatively because of significant co-morbid conditions or minimal symptomatology. Postoperative mortality rates for brachial embolectomy are as high as 12%. However, after successful brachial embolectomy, 95% of patients will remain free of symptoms. Patients managed conservatively are probably underreported in the literature. Although conservative management is appropriate for some patients with acute ischemia, for those with a reasonable life expectancy, all efforts should be made to restore blood flow.

Transbrachial Embolectomy

The majority of arm emboli are cardiac in origin (75%). The most common site for emboli is the brachial artery (60%), followed by the axillary artery (26%). In situ thrombosis accounts for only 5% of episodes of arm ischemia. Usually, there is an underlying embolic source such as atrial fibrillation. The majority of brachial embolectomies are performed under local anesthesia with monitored anesthesia care.

After closure, an intraoperative continuous wave Doppler probe should be applied to each artery to ensure the presence of adequate flow. Completion angiography is at the discretion of the surgeon but should be performed if the hand still appears ischemic, especially if extensive thrombus has been extracted from forearm arteries. Occasionally, embolization may have been a chronic process and resulted in distal arterial occlusion that cannot be completely resolved with embolectomy, but arteriography can be used to detect residual fresh thromboembolic material. If there is any suspicion of an inflow lesion, intraoperative arteriography can be performed by either the femoral or brachial route to diagnose and treat such lesions.

PROGNOSIS

The medical state of a patient who presents with acute leg ischemia is a good prognostic index of survival. In particular, patients with acute myocardial infarction or poor cardiac output have a high mortality rate.

Outcome can also be predicted from pretreatment POSSUM (Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity) physiology scores. Despite active intervention, the outcome after treatment for acute limb ischemia is often poor. In some patients, limb ischemia is a manifestation of the end of life. Such agonal thrombosis may be recognized in the very elderly with multiple co-morbidities, particularly in hospitalized patients, and is an indication for palliative care rather than active intervention.