

An Overview on Acute Lower Limb Ischemia

**Abdelrahman Mohamed Gameel, Mohamed Hamed Zedan, Sherif Mamdouh
Mohamed Mustafa, Mahmoud Ahmed Elsabbagh**

Department of vascular Surgery, Faculty of Medicine, Zagazig University, Egypt

***Corresponding author:** Sherif Mamdouh Mohamed Mustafa,

E-mail: sherifmamdoh2018@gmail.com

Abstract:

Acute limb ischemia (ALI) is a vascular emergency associated with a high risk for limb loss and death. Most cases result from in situ thrombosis in patients with preexisting peripheral arterial disease or those who have undergone vascular procedures including stenting and bypass grafts. The other common source is cardioembolic. The incidence has decreased in recent times due to better anticoagulation strategies. Patients with suspected ALI should be evaluated promptly by a vascular specialist and consideration should be given for transfer to a higher level of care if such expertise is not available locally. Initial assessment should focus on staging severity of ischemic injury and potential for limb salvage. Neurological deficits can occur early and are an important poor prognostic sign. Duplex ultrasound and computed tomography angiography help plan intervention in patients with a still-viable limb and prompt catheter-based angiography is mandated in patients with an immediately threatened limb. Further investigations need to be pursued to differentiate embolic from thrombotic cause for acute occlusion as this can change management. Options include intravascular interventions, surgical bypass, or a hybrid approach.

Keywords: Acute limb ischemia - limb viability - etiology - thromboembolism - thrombolysis - thrombectomy - amputation.

Introduction:

An estimated 15 cases of ALI occur for every 100,000 people annually. In the general population, the prevalence is less than 0.1%, whereas in patients with additional cardiovascular disease risk factors, it is between 5% and 10%. The majority of cases involve the lower limbs and are mostly caused by acute artery thrombosis. Only 1/5 of all ALI occurrences are acute ischemia of the upper limbs, with an annual incidence of 2.4 incidents per 100,000 people (1).

The pattern of etiology for ALI has changed within the past 30 years. According to Dryjski et al., 19% of the cases they observed in their patient population were thrombotic, while 81% of cases were embolic (2).

Currently, embolism only accounts for 14% of all ALI cases. There are several factors contributing to the decline in the incidence of arterial embolism. Rheumatic fever and, consequently, rheumatic heart disease (RHD) have decreased somewhat in the industrialized world; in the less developed world, however, RHD remains a major cause of cardiovascular morbidity and mortality among young people. Intensive surgical treatment of rheumatic heart lesions has also improved mortality and reduced the risk of cardiovascular complications resulting from RHD. Moreover, the incidence of cardiac embolisms has significantly dropped due to developments in the treatment of heart valve disease and anticoagulation for atrial fibrillation. Arterial thrombosis has risen over time due to an older population and a larger prevalence of peripheral arterial disease (PAD) (3).

Etiology of Acute lower limb ischemia

1-Thrombosis

Generally speaking, thrombosis happens when there is already a vascular lesion. Patients with thrombosis on atherosclerotic stenosis (also known as acute on top of chronic ischemia) may appear with a less severe clinical presentation than those with embolic occlusion because in the former situation, there may be adequate collaterals present. It is critical to find out about any history of claudication or pain at rest, to check for changes indicative of chronic ischemia, such as atrophy of skin appendages, and to check for loss of pulse in the opposite foot (4).

Thrombosis on Atherosclerotic Plaque

Acute arterial thrombosis results from platelet thrombus developing on the stenotic lesion when a stenosis reaches a critical stage. Because the abnormal plaque is rarely available for investigation, it is unknown if disruption of the plaque causes acute arterial thrombosis in addition to persistent thrombosis in the extremities. But in other circumstances, it's probable that the rupture of the plaque is the cause. A decrease in cardiac output may result in acute limb ischemia in patients with severe atherosclerotic peripheral vascular disease by decreasing limb arterial perfusion worldwide. For instance, in the absence of thrombosis, shock in a patient with severe claudication may result in decreased cardiac output and acute limb ischemia. This situation should be recognized because the leg does not require immediate treatment; rather, the underlying condition does (5).

Thrombosis on pathological non-atheromatous artery

Patients with adventitial cystic disease, aneurysm, Buerger disease, and vasculitis may experience this condition. A persistent constriction of the blood vessel causes thrombosis, which presents clinically as acute limb ischemia (ALI) in individuals with atherosclerotic plaques (6).

Thrombosis on Healthy Artery

Moreover, thrombosis can happen on a healthy artery. This is a less common cause of (ALI) that can also result from hyperviscosity (hemoconcentration in severe hypotension, hemoglobinopathies, popliteal entrapment), systemic coagulation disorder (congenital anomalies like protein C or S and antithrombin III deficiencies, cancer), or drugs (drug addiction, chemotherapy). Another key factor contributing to ALI in healthy arteries is heparin-induced thrombosis, which is typically identified by a marked thrombocytopenia during heparin therapy and the thrombosis's appearance (4).

2-Embolism

The cause of embolism is evolving; whereas rheumatic heart disease (60%) accounted for the bulk of acute limb ischemia (ALI) cases prior to 1950, currently it only accounts for approximately 8% of cases. These days, after a myocardial infarction, atrial fibrillation or mural thrombus are frequently linked to cardiac emboli. In rare cases, atrial myxomas or valve vegetation are the source of the embolus. It is important to palpate the abdomen and popliteal fossa carefully since emboli can also originate from abdominal or popliteal aneurysms. Distal emboli can also result from atheromatous arteries when a plaque ruptures (4).

3-Post-traumatic Thrombosis

While blunt trauma might result in indirect injuries like spasm, mural hematoma, or intimal dissection with subsequent thrombosis, penetrating trauma can cause direct damage to the artery. An artery injury linked to a fracture can also result from blunt trauma (4).

4-Distal Progression of Aortic Dissection

Aortic dissection, which can affect the aortic bifurcation and mimic iliac artery thrombosis, is another cause that necessitates a high index of suspicion for diagnosis. These patients may also have hypotension in addition to their regular back pain. If the dissection affects the renal arteries, renal failure is another indicator of a clinical diagnosis (5).

5-Bypass Graft Occlusion

With reported 5-year primary patency of 74% for autologous vein and 39% for synthetic above-the-knee bypass, infrainguinal bypass graft occlusion is common. The most frequent reason for inadequate arterial inflow or decreased native artery outflow in cases with synthetic arterial bypass graft occlusion. Myointimal hyperplasia in autologous vein grafts causes anastomotic and midportion stenosis. When infrainguinal artery repair involves insitu saphenous vein bypass, inadequate valve stripping may cause localized stenosis (7).

Diagnosis of Acute Limb Ischemia

Clinical Presentation

When acute limb ischemia strikes, it's an emergency situation where timely intervention to restore circulation can save the limb, but waiting too long might have serious consequences. involving the loss of limbs. The abrupt cutoff of blood flow and nutrients to the limb's metabolically active tissues, such as the skin, muscles, and nerves, causes limb ischemia to develop quickly. The degree of obstruction and, most crucially, the existence of sufficient collateral vessels determine how severe the symptoms are (8).

If the clinical presentation happens within two weeks after the initiation of symptoms, it is considered acute; symptoms can take hours or days to manifest. Patients with peripheral embolization or occlusion of vascular reconstruction caused by cardiac embolism, trauma, and aneurysms often present early (in hours) because of the severity of symptoms associated with either the absence of collaterals, the extension of thrombus to arterial outflow, or a combination of the two. However, subsequent appearance, defined as within a few days, is typically limited to patients who have native thrombosis that is "acute on top of chronic ischemia." The patient's medical history, a thorough physical examination, and investigations should all be part of the clinical evaluation of acute limb ischemia because these elements taken together may be able to shed light on the cause of ALI. The focus of the medical record gathering should be on the patient's past ischemia symptoms, vascular reconstruction or diagnostic cardiac catheterization, and heart disease history. Furthermore, it is important to thoroughly examine any potential risk factor or disease that may have contributed to the genesis of the ALI, such as hypertension, diabetes, smoking, hypercholesterolemia, blood clots, arterial aneurysms as potential embolic sources, a family history of cardiovascular disease, or hematologic disorders. An accurate diagnosis must take into account the location, intensity, suddenness, and duration of the pain, as well as any changes over time and the existence of any motor or sensory deficiencies. Important suspicions about the pre-ischemic condition of the affected limb are raised by a concurrent evaluation of the contralateral lower limb (4).

Clinical features	Embolic	Thrombotic
Severity	Marked, rapidly progressive	Less severe, slowly progressive
Onset	Minutes/hours	Generally days
Contralateral leg pulses	Present	Absent
Femoral arteries palpated	Soft, tender	Hard, calcified
Dystrophic limb features	Absent	Present
Cardiac abnormalities	Present	Generally absent
Iliac/femoral bruits	Absent	May be present
History of claudication	Absent	Present

Fig 1: clinical features of thrombotic and embolic lower limb ischemia

the usual clinical manifestations of acute limb ischemia (ALI) are The six Ps—pain, paresthesia, paralysis, pallor, pulselessness, and poikilothermia—:

Pain: Usually, it is constant and restricted to the foot and toes for the patient. Its intensity is independent of the ischemia's severity. For example, it is less pronounced when the ischemia is so bad that the nerve fibers responsible for pain transmission are harmed. Diabetes patients frequently experience neuropathy and a diminished sense of pain (9).

Paresthesia: When blood perfusion is disrupted, nerves are quickly injured because they are often extremely sensitive to ischemia. The most ischemia-sensitive fibers are those that process touch impulses, whereas pain fibers are less sensitive. This explains why paresthesia is so common in ALI patients, and why over half of them also experience tingling and numbness. Patients with diabetes may already have a sensory impairment that obscures the change due to underlying neuropathy. Anesthesia results from paresthesia when ischemia lasts longer (4).

Paralysis: Ischemia-induced loss of motor nerve fibers is the primary cause of motor function loss in the leg. Later on, ischemia also directly affects muscle tissue. Ischemic muscles feel spongy and are tender. As a result, following proximal severe ischemia, the entire leg may become paretic and be misdiagnosed as a stroke. One sign of limb-threatening ischemia is paralysis. Determining the degree of paralysis is crucial, since it suggests a more proximal level of occlusion than only toe paralysis. Loss of dorsiflexion and plantar flexion are indicators of paralysis. When motor function is substantially compromised, the likelihood of saving a functional limb is decreased, which emphasizes the significance of urgent revascularization for patients experiencing extreme pain in a cold limb (10).

Pallor: Skin color changes are a very common observation in ALI. The distal arterial tree experiences severe spasm in the event of acute arterial occlusion, and the affected limb first appears "marble" (Fig. 2a.). One joint above the pallor demarcation level is usually the obstacle. The spasm usually subsides in the hours that follow, and the skin fills with deoxygenated blood, resulting in light blue or purple mottling with a thin reticular pattern that blanches in response to pressure (Fig. 2b.). Static blood clots after prolonged ischemia, resulting in mottling that is deeper in color, has an unattractive pattern, and does not blanch. Large regions of fixed staining eventually lead to liquefaction and blistering (Fig. 2c.) (4).

Pulselessness: The investigation of palpable pulses at several lower extremity levels, such as the femoral, popliteal, anterior, and posterior tibial pulses, should always be a part of a physical examination. A perceptible pulse indicates that ischemia is farther away and that there is adequate flow at that level. When the palpation is done precisely at the level of the occlusion's commencement, there are certain circumstances. A pulse that is even greater than usual in this situation could indicate stump flow at the level of vascular occlusion. Consequently, the fundamental idea that a detectable pulse disproves the theory of blockage at that level. It is always a good idea to confirm data from pulse palpation with a continuous wave Doppler (CW Doppler) measurement at a different level. The ankle/brachial index is then essential for estimating the prognosis and determining the severity of ALI (4).

Poikilothermia: The loss of distal flow causes the limb to feel cold to the touch. This temperature shift contributes to the ischemic cascade's spread and is secondary to vasoconstriction. To aid identify progression, coolness, which is typically present one level below the blocked artery, should be noted upon presentation (10).



Fig.2a . Pallor representing early acute limb ischemia (11).



Fig.2b. Non fixed mottling of skin representing impending limb loss (12).



Fig.2c. Fixed mottled patches of skin with blistering representing irreversible ischemia (13).

Clinical Classification:

Assessing the severity of ALI at diagnosis is essential for determining the event's prognosis. The American Society for Vascular Surgery/International Society for Cardiovascular Surgery has provided a classification of ALI that takes into account the patient's complaints, objective findings, and prognosis (Table 1).

class I: A viable limb with ischemia does not have a pedal pulse, rest discomfort, sensory loss, or muscular weakness. There are both venous and arterial Doppler tones.

Class II: ischemia, which is further classified into class IIa and class IIb, is defined as a threatened limb. Intervention is necessary for both of these patient groups; however, depending on where ischemia lies on this spectrum, the urgency of the intervention may differ. As a result, it's critical to differentiate between these two categories.

class IIa : Marginally threatened ischemia is the term used to describe. Individuals in this group usually experience nerve damage for a longer period of time before it becomes permanent. We refer to this group as subacute critical ischemia. Clinically, category IIa ischemia is characterized by a lack of muscle weakness, mild sensory loss, and weak monophasic or missing pedal Doppler tones.

class IIb : is considered immediately dangerous if there is sensory loss, mild to moderate muscle weakness, and no pedal Doppler tones. To stop permanent tissue damage, these individuals need to receive prompt care. Class IIb is the traditional cold, severely painful limb.

class III : Ischemia is severe and unreversible. Clinically, it is marked by persistent nerve injury, paralysis with imminent substantial tissue loss, and profound sensory loss. There is pain with passive foot movement and tense muscle groups. There is a considerable risk of acute renal failure and rhabdomyolysis after revascularization. Amputation or palliative care are preferable options for these patients (10).

Table 1: Classification system by the society of vascular surgery and international society of cardiovascular surgery

Category	Description	Findings		Doppler signals	
		Sensory loss	Muscle weakness	Arterial	Venous
I. Viable	Not immediately threatened	None	None	Audible	Audible
IIa. Marginally threatened	Salvageable if promptly treated	Minimal (toes) or none	None	(Often) inaudible	Audible
IIb. Immediately threatened	Salvageable with immediate revascularization	More than toes, associated with rest pain	Mild, moderate	(Usually) inaudible	Audible
III. Irreversible	Major tissue loss or permanent nerve damage	Profound, anesthetic	Profound, paralysis (rigor)	Inaudible	Inaudible

Investigations

Even though a clinical examination is the primary method of diagnosing acute limb ischemia, technical studies may provide a more accurate assessment of the degree of occlusion and severity of ischemia. Any additional vascular or radiologic laboratory testing may not be required in the case of immediately threatened limbs and should not be carried out in order to prevent therapeutic delays. A more accurate diagnostic assessment can be made when the ischemia limb is still functional or only slightly in danger (4).

1-Duplex Ultrasound

The benefits of duplex ultrasound (DUS) study are well established; in particular, the examination's noninvasiveness, affordability, and repeatability make it a popular first-level diagnostic method for the diagnosis of ALI in all vascular surgery centers. It has been demonstrated that, when used by skilled practitioners, DUS can provide data of the same caliber as angiography when examining hemodynamic arterial lesions in the lower extremity vascularization (14).

Two-dimensional (2D) ultrasonography and color Doppler mapping can be used to find the lesions, and Doppler waveform analysis and peak systolic velocities are the primary methods for estimating the degree of stenosis.

DUS is useful in distinguishing between embolic and thrombotic occlusions; the embolus typically localizes at bifurcation locations; and there are no indications of an atherosclerotic lesion on the artery walls, which appear healthy with a normal lumen and profile. Irregular arterial profile and calcifications appear as hyperechoic thickening of the artery wall. Sometimes severe shadowing caused by calcified plaque can hide thrombosis (14).

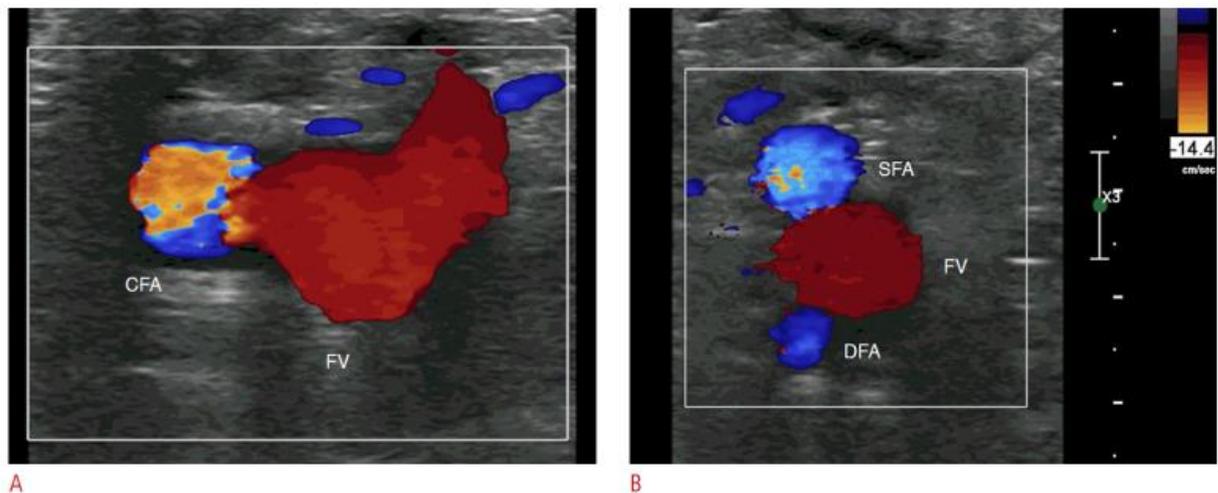


Fig. 3: Normal color Doppler ultrasonography of the femoral arteries in the inguinal area. A. The common femoral artery is lateral to the femoral vein on a transverse scan at the inguinal crease. B. The superficial femoral artery, the deep femoral artery and the Femoral vein (15).

2-Computed Tomographic Angiography

The preferred examination for acute ischemia is computed tomographic angiography because to its immediate and extensive accessibility (5).

It offers precise mapping of the arterial tree and collateral circulation with high overall sensitivity and specificity, as well as the capacity to show the arterial wall. It also offers precise analysis of the location, severity, and grading of steno-obstructive disease. CTA has a 93% specificity and a 92% sensitivity (16).

The drawbacks of CTA are The use of ionizing radiation, the nephrotoxicity of iodinated contrast media, and the challenge of analyzing small, calcified arteries . The "blooming artifact," which affects the assessment of the lumen of diffusely calcified vessels and increases with the reduction of the caliber of the vessels in question (especially at the level of below-the-knee vessels), is actually the most significant limitation of CT angiography (4).



Fig 4: occlusion of the left popliteal artery

3-Magnetic Resonance Angiography

MRA with gadolinium enhancement is less effective than CT or ultrasonography for acute limb ischemia. It takes time to obtain photos, is frequently unavailable during off-peak hours, and is generally annoying for patient (5).

4-Transfemoral Arteriography

Angiograms as a stand-alone diagnostic tool are no longer as common. Even now, The role of arteriography in the preoperative diagnosis has been called into doubt by the development of less invasive imaging techniques; at this point, it is no longer the gold standard for diagnosing acute arterial disease. Angiography plays a more specific function in the endovascular treatment of ALI, which is increasingly seen as a therapeutic option that can be used in addition to, instead of, or instead of the traditional surgical method. In certain cases, angiogram may be able to provide a catheter-based treatment in addition to providing comprehensive and accurate information about the source, the location of the blockage, and the severity of the insult that resulted in acute limb ischemia(ALI). Angiography is seen as an invasive diagnostic procedure. that exposes the patient at risk of post-procedural access difficulties, radiation exposure, CKD patients. In order to distinguish between emboli and thrombus, different angiographic images may be very helpful. An embolus, for example, may appear as the squashing of contrast material just above the blocked place (also known as a "abrupt interruption"), with the identification of a crescent-shaped occlusion (meniscus sign) in an otherwise normal artery (Fig. a); in the case of acute thrombosis on plaque, there may be a break in the contrastive material in the shape of a diagonal cloth line shape, and a typical collateral arterial circulation (Fig. b) as well as atherosclerotic signs in other arterial segments. The location of the emboli often lodge in areas of bifurcations, therefore occlusion may also be beneficial. This differentiation, though, may not always be evident when it comes to the spread of clots, which can happen following both thrombotic and embolic events (4).



Fig. 5 (a) typical angiographic picture of embolic acute limb ischemia.

(b) Angiographic aspect of acute thrombosis on chronic atherosclerotic plaque (4).

5-Exploration of embolic sources

in order to look into embolic origins Electrocardiography is required to assess myocardial infarction, valvular heart disease, and atrial fibrillation. Echocardiography(ECHO) is helpful in assessing cardiac function and the presence of an embolic source, such as a left atrial myxoma, a floating thrombus in the left atrium, or a mural thrombus in the left ventricle. When treating patients with infective endocarditis or mural or floating thrombi in

the left ventricle or atrium, endovascular therapy with a fibrinolytic drug is not recommended. If an embolus is thought to be a tumor embolism from the heart, an open embolectomy is required (17).

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