ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH SCIENCES
SCHOOL OF MEDICINE

DEPARTMENT OF SURGERY

Acute Limb Ischemia Presentation and Outcome Among Cardiac Patients in Resource-Limited Setup, Single Institution Experience, Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia, 2024.

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Title	Acute Limb Ischemia Presentation and Outcome Among Cardiac Patients in Resource-Limited Setup, Single Institution Experience, Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia, 2024
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APPROVAL SHEET

ADDS ABABA UNIVERSITY, COLLEGE HEALTH SCIENCE SCHOOL OF Medicine,
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I, the undersigned general surgery resident, declare that I have submitted my original work on a title **Acute Limb Ischemia Presentation and Outcome Among Cardiac Patients in Resource-Limited Setup, Single Institution Experience, Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia, 2024.** for the examination.

Submitted by:

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This thesis work has been submitted for examination with my approval as an advisor. Approved by:

Dr. Henok Teklesilasie	Signature	Date

Statement of the Author

I hereby declare that this thesis is my original work and has not been presented for a degree in any other university and all sources of material used for this thesis have been duly acknowledged.

Name: Weini Tekle Gebremedhin (MD)

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List of abbreviations

ALI – Acute Limb Ischemia

ALLI – Acute Lower Limb Ischemia

CLI – Chronic Limb Ischemia

AAU – Addis Ababa University

TASH – Tikur Anbessa Specialized Hospital

CVD – cardiovascular disease

MI – myocardial infarction

RHD – rheumatic heart disease

IHD – ischemic heart disease

CAD – coronary artery disease

HHD – hypertensive heart disease

CHD – congenital heart disease

MS – mitral stenosis

MR – mitral regurgitation

AS – aortic stenosis

AR – Aortic regurgitation

TR – tricuspid regurgitation

DCMP – dilated cardiomyopathy

ASA – acetylsalicylic acid

ACEIs – Angiotensin converting enzyme inhibitors

ARBs – Angiotensin II receptor blockers

MI – Myocardial infarction

TIA – Transient ischemic attack

RC – Rutherford class

HAP – Hospital acquired pneumonia

UTI – Urinary Tract Infection

CICU – Cardiac Intensive Care Unit

GICU – General Intensive Care Unit

INR – International Normalized Ratio

OR – Odds Ratio

SPSS – Statistical Package for the Social Sciences

CI – Confidence Interval

HF – Heart Failure (commonly mentioned)

AKA/BKA – Above-Knee Amputation / Below-Knee Amputation

ER – Emergency Room

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Abstract

Background: Acute Limb Ischemia (ALI) is a sudden drop in limb perfusion, posing a threat to viability. Cardiac conditions such as atrial fibrillation, valvular disease, and ischemic heart disease are major risk factors. In resource-limited settings like Tikur Anbessa Specialized Hospital, understanding ALI presentation and outcomes in cardiac patients is crucial for improving management and reducing morbidity and mortality.

Objectives: This study assesses ALI presentation, interventions, and outcomes in cardiac patients, identifying factors linked to poor prognosis, including amputation and mortality rates.

Methods: A three-year retrospective cross-sectional study was conducted at Tikur Anbessa Specialized Hospital. Data were extracted from medical records, and statistical analysis, including logistic regression, was performed using SPSS.

Results: The study included 82 cardiac patients with ALI. The 30-day mortality rate was 17.1%, and in-hospital mortality was 12.2%. The total amputation rate was 37.8%, predominantly above-knee (77.4%). Limb viability at 30 days was 47.1%. Severe mitral stenosis increased embolic ALI risk sixfold ($p = 0.003$) but was associated with successful revascularization and lower amputation risk. Cardiac thrombi were strongly linked to embolic ALI ($p < 0.001$). Early intervention (<24 hours) significantly improved limb viability ($p = 0.011$) and reduced amputation risk ($p = 0.022$). Delayed presentation (>72 hours) increased the odds of limb loss 12.6-fold ($p = 0.002$). Pulmonary complications significantly increased in-hospital mortality ($p < 0.001$).

Conclusion and Recommendations: ALI in cardiac patients carries high amputation and mortality risks, particularly in resource-limited settings. Early intervention and anticoagulation improve outcomes. Severe mitral stenosis and cardiac thrombi are key predictors of embolic ALI, emphasizing the need for early cardiac screening. Timely referrals, vascular services, and public awareness on early symptoms can enhance patient outcomes.

Keywords: Acute Limb Ischemia, Cardiac Disease, Amputation, Thromboembolism, Atrial Fibrillation, Resource-Limited Setting, Vascular Surgery, Revascularization, Embolism, Ischemic Heart Disease, Mitral Stenosis, Peripheral Arterial Disease, Pulmonary Complications, Anticoagulation, Limb viability.

1. Introduction

1.1. Background

Acute limb ischemia (ALI) can be defined as a sudden decrease in limb perfusion of any cause which in turn causes a threat to limb viability. The time frame for the Presentation of ALI is up to two weeks following the underlying acute event. **[1]** ALI is most often associated with an acute arterial occlusion. In rare cases, extensive venous occlusion can cause ischemia in both the upper and lower extremities (i.e., phlegmasia). **[2]** Besides trauma, including iatrogenic causes, the main reasons for ALI are thrombosis, which can occur in a native artery or a reconstructed/graft artery, and embolism. A small portion of cases could also result from a peripheral aneurysm with embolus or thrombus. **[3, 4]** Of the two primary causes, ALI is typically due to a thrombus. The term 'embolus' comes from the Greek word 'embolos,' meaning stopper or plug **[5].** These causes of ALI can also originate from cardiac (atheroembolic) or extra-cardiac (thrombotic) sources **[6]**

Symptoms can appear within minutes to hours or days, ranging from new or worsening intermittent claudication to severe rest pain, numbness (paresthesia), muscle weakness, paralysis, and even gangrene **[7]** The classic presentation of patients with ALI is summarized by the mnemonic "6 Ps": pain, pallor, paralysis, pulse deficit, paresthesia, and poikilothermia. **[8].**

Taking a detailed medical history and performing a thorough physical examination are crucial in managing ALI. Differentiating between an embolic cause and in situ thrombosis is often challenging but essential due to the varying acute stages and long-term treatment strategies**. [7]**

Patients with native arterial thrombosis often have a history of circulatory issues, such as intermittent claudication or prior limb revascularization. They also tend to have significant comorbidities like coronary artery disease, previous history of stroke, diabetes, and chronic renal failure. These patients are typically older, frail, and susceptible to bleeding. **[9].** However, the presence of atherosclerotic risk factors such as smoking, diabetes, hypertension, high cholesterol, and a family history of these conditions may indicate in situ thrombosis.

Thrombotic complications arising from an atherosclerotic plaque can obscure the onset of symptoms and create ambiguous complaints. As atherosclerosis progresses, it often leads to the development of collateral vessels extending to distal areas. In a limb that has been preconditioned, an acute occlusion might not result in obvious ischemia. However, the spread of the thrombus can cause significant ischemia. **[10]**

Embolic occlusions should be considered in patients exhibiting a sudden and severe onset of symptoms (as collateral vessels are absent, patients can often pinpoint the exact time of the event), a history of previous embolism, arrhythmia indicative of atrial fibrillation, a known source of embolism (such as cardiac issues or an aneurysm), and no history of intermittent claudication **[10].**

Through thorough systematic vascular examination, several causes of ALI can be quickly identified. Bilateral palpation of the pulses in the groin, knee, and ankle can determine the site of occlusion and detect rhythm disorders, such as atrial fibrillation. A unilateral pulse deficit with a normal pulse on the opposite side indicates an embolism, while a bilateral pulse deficit points to atherosclerotic issues. The vascular assessment should also involve palpation of the brachial, radial, and ulnar arteries to identify potential access points and multi-site embolism. If pulse status is uncertain, a Doppler probe should be employed to detect arterial signals. Sensory and motor functions should be evaluated during the initial medical contact and monitored regularly thereafter. **[10]**

The severity of ALI is graded according to the Rutherford classification as viable, threatened (marginally, immediately), and irreversible. **[1, 11]** this plays an important role in decision-making. A viable limb needs urgent imaging and assessment of significant co-morbidities.

For patients with ALI, an early embolectomy is advised without prior invasive examination to avoid the migration of the thrombus to distal areas and to prevent the formation of new thrombi **[12].**

The therapeutic approach varies based on factors such as the type of occlusion (thrombus or embolus), its location, the type of conduit (artery or graft), the Rutherford classification, the duration of ischemia, the patient's comorbidities, and the associated risks and outcomes of the

therapy. Various revascularization techniques can be employed, including endovascular or surgical methods such as thrombectomy, bypass, and arterial repair. **[7]**

Cardiac patients are particularly susceptible to ALI due to various underlying cardiac conditions.

Atrial fibrillation is a significant risk factor for ALI due to the high likelihood of thrombus formation in the atria, which can embolize to peripheral arteries. Studies indicate that AF is one of the most common cardiac conditions leading to embolic ALI **[7, 13].**

On the other hand, Patients with left ventricular aneurysm following myocardial infarction are prone to thrombus formation within the aneurysmal sac. These thrombi can dislodge and cause ALI. The management of these patients often includes anticoagulation therapy to prevent such events **[14].**

Prosthetic heart valves, particularly mechanical valves, can be associated with thromboembolic events leading to ALI. This necessitates careful management with anticoagulants to minimize the risk of thrombus formation and subsequent embolization **[13, 10].**

Additionally, valvular heart diseases, such as mitral stenosis and aortic valve disorders, can increase the risk of thromboembolic events. These conditions create a turbulent flow and stasis in the heart chambers, promoting thrombus formation. Managing these patients involves a careful balance of anticoagulation to prevent embolism and mitigate bleeding risks **[10, 15].** Infective endocarditis can also lead to the formation of septic emboli. These emboli can cause ALI when they lodge in peripheral arteries. Early diagnosis and treatment of endocarditis are crucial to prevent these complications **[7].**

Despite advances in treatment, the prognosis of ALI in cardiac patients remains uncertain. The presence of underlying cardiac conditions often complicates the clinical course, leading to higher rates of morbidity and mortality. Early revascularization and aggressive management of the cardiac condition are key to improving outcomes **[7, 13].**

1.2. Statement of the problem

Vascular disease is the leading cause of death and disability worldwide. **[16,17,18]** The incidence of ALI is approximately 1.5 cases per 10,000 persons per year. **[1]** Acute limb ischemia (ALI) is one of the potentially life-threatening events in vascular disease and an important cause of morbidity and mortality. Different studies and authors described similar results on the outcome. According to Genovese EA et al., thirty-day mortality and amputation rates in ALI are 15 and 25%, respectively **[19]**. Data from Harapan Kita National Cardiovascular Center hospital showed that the intrahospital and 30-day mortality rates from ALI are 28.1 and 36.9%, respectively. **[20]** Similarly, Howard described the rate of limb amputation as 5%-12% in 30 days and mortality as 10%-38% **[21]**.

On the other hand, the study done in Ethiopia by Nebiyou s. et al. showed that Amputation after re-vascularization surgery was seen in 32.4%. A 30-day total amputation & mortality rate was 52.9% and 9.8% respectively. **[22]**

According to the data published in The Cardiovascular Journal of Africa, In 2017, cardiovascular disease (CVD) affected 2,838,767 people in Ethiopia. Among these cases, rheumatic heart disease (RHD) accounted for one-third (33.7%), ischemic heart disease (IHD) for 22.5%, and stroke for 11.4%. The estimated age-standardized mortality rate in Ethiopia for 2017 was 519 per 100,000 people [95% uncertainty interval (UI): 479–551], with CVD contributing to 182 per 100,000 [95% UI: 165–204]. Currently, the three leading causes of CVD deaths in Ethiopia are IHD (45%), stroke (34%), and hypertensive heart disease (HHD) (11%), resulting in approximately 170 deaths daily. **[23]**

There is no published research about the magnitude of ALI nor the proportion of ALI among other surgical emergencies in Ethiopian settings. The relationship between cardiac patients presenting with acute limb ischemia hasn't also been studied yet. There are not even adequate studies worldwide that were found during the literature review. Considering the disease burden of both cardiac illness as well as ALI in Ethiopia. This and similar studies are deemed necessary.

1.3. Rationale of the study

This study aims to test the hypothesis that certain cardiac diseases, such as valvular lesions and arrhythmias, predispose patients to Acute Limb Ischemia (ALI). It is hypothesized that these conditions increase the occurrence of ALI due to embolism, are likely to involve multiple limbs, have a higher re-thrombosis rate, and result in significant rates of amputation and death due to comorbidities and limited surgical interventions.

This study is essential as there is no existing research on the correlation between cardiac conditions and ALI in Tikur Anbessa Hospital, nor are there adequate studies globally. The results will provide insights into the pattern of ALI among cardiac patients, the level of care required, and the outcomes in a resource-limited setting, potentially guiding future research and healthcare strategies.

There is a significant lack of data on the disease burden of ALI, and its potential relationship with cardiac pathologies, to get precise and reliable data, further research and studies focused on cardiovascular emergencies, including ALI, would be necessary in Ethiopia. Collaboration between local healthcare providers, researchers, and international health organizations could help bridge this knowledge gap. And this study will hopefully be the sprinting ground for subsequent studies.

TASH is an ideal place to conduct this study as it is a center of excellence in the management of cardiac illnesses and is the only governmental center where vascular intervention was available over the entire country where hundreds of cases were managed and still is the only one working with full capacity. Therefore, the conclusion of this study is more likely to be representative for future references.

2. Literature Review

According to a report from England, **[24]** the incidence rates of embolism, thrombosis due to an occlusive atherosclerotic lesion, complex factors, and stent or graft-related thrombosis are 46%, 24%, 20%, and 10%, respectively. The 2012 annual report of the Japanese Society for Vascular Surgery, based on data from the National Clinical Database, indicated that patients with embolism and thrombosis comprised about half of the total enrollments. The majority of embolism cases are cardiogenic, with atrial fibrillation being the most common cause. Other causes include valvular diseases, post-valve replacement, left ventricular wall thrombosis following myocardial infarction, cardiac or aortic tumors, and paradoxical embolism. Ascher noted that the femoral artery is the most frequent site of embolism. **[24]**

According to the Ethiopian research done by Nebiyou S. et al, complications were significantly associated with previous myocardial infarction along with age ≥ 60 years, late presentation (≥9 days), and patients with hypertensive disease. It also concluded that optimizing co-morbidities, timely detection, and treatment immediately on arrival could potentially play a key role in improving surgical outcomes of acute limb ischemia. **[25]**

In studies conducted by Pereira Barretto AC et al. and Obara H et al., it was found that the majority of peripheral arterial embolism cases had cardiac origin **[26, 27],** as it is the most common cause of acute arterial occlusion. Ege et al. **[28]** reported that this rate is 80-90% and these cases are linked to heart diseases such as rheumatic valvular heart disease, atrial fibrillation, and myocardial infarction, with other causes including post-valve replacement, cardiac/aortic tumors, and paradoxical embolism **[27].** Among these, atrial fibrillation is the leading cause of cardiac embolism in patients with peripheral arterial embolism **[28].** Meanwhile, Keçeligil et al. **[29]** identified a cardiac origin in 62.56% of cases and an extracardiac origin in 30.72%, with 6.7% of cases having no determined origin. In the same study, 78% of acute peripheral arterial occlusion cases were attributed to embolus from cardiac sources. **[29].**

Yetkin et al. **[5]** reported that among 51 patients who underwent urgent unilateral femoral embolectomy, 28 (55%) had significant cardiac pathologies. Out of these 28 patients, 14 (50%)

required open-heart surgery following further examinations. Similarly, a study by Kaygin MA et al. found cardiac pathology in 70% of patients, which aligns with existing medical literature. Additionally, 22.5% had extracardiac pathologies, and 7.5% had an unknown etiology **[6].** Ertürk M. et al. demonstrated that while the incidence of cardiac embolism due to rheumatic heart disease is decreasing, the incidence of acute arterial occlusion caused by acute thrombosis from atherosclerotic vascular disease is on the rise **[30].**

In a case report by Charmake D 3rd et al., it was concluded that acute ischemia of the lower limb occurring simultaneously with a myocardial infarction (MI) is a rare yet serious condition. The atherosclerotic etiology, through thrombosis formation, is responsible for this. They recommended that a thorough clinical evaluation, supplemented by a CT scan if necessary, is crucial to develop an effective treatment strategy to preserve the affected limb's vital and functional prognosis **[31].**

Daniel Eduardo Paz Driotes and Veronica Vanesa Gomez Leiva reported a case where acute limb ischemia (ALI) was the initial symptom of a left ventricular thrombus in a patient with heart failure and reduced ejection fraction. They concluded that patients with ischemic heart disease and heart failure with reduced ejection fraction are at high risk for intraventricular thrombi and subsequent embolization due to Virchow's triad. They recommended considering prophylactic anticoagulation to prevent this complication, despite the controversial evidence. **[32]**

Francois P. Kaleta et al. reported a case of acute limb ischemia (ALI) secondary to rheumatic mitral stenosis and atrial fibrillation, recommending that early recognition and treatment in individuals without traditional risk factors for rheumatic heart disease can prevent life-threatening outcomes **[33].**

A study by Khaira et al. revealed that concomitant heart failure is linked to extremely poor 5-year survival rates for patients with critical limb ischemia (CLI). The similarly poor survival rates in heart failure patients with both preserved and reduced ejection fractions indicate that left ventricular systolic dysfunction alone is insufficient for predicting adverse outcomes **[34].** There is not enough literature done comparing ALI with heart failure.

I.W. Folkert et al. studied ALI after cardiac surgery, describing it as a rare but serious complication. They found that multiple patient and operative factors contribute to the risk of developing ALI, with patients having small or diseased arteries undergoing emergency surgery at the greatest risk. Patients with ALI experienced more complicated postoperative courses and increased short- and long-term mortality. The study also suggested that ALI after cardiac surgery could be a marker for the patient's overall morbidity and mortality. **[35]**

According to the case report done by Alexander, N., et al., the incidence of ALI in post-MI patients was observed to be significant, highlighting a critical need for vigilant monitoring. Furthermore, noted that patients who developed ALI post-MI often had multiple cardiovascular risk factors, including hypertension, diabetes, and peripheral artery disease. For such kinds of patients, acute limb ischemia is a serious complication that can occur after myocardial infarction, necessitating prompt diagnosis and treatment to improve patient outcomes. The report also emphasizes the importance of comprehensive care and monitoring for patients with MI to detect and manage ALI effectively. **[36]**

Research on acute limb ischemia (ALI) in Africa is limited but emerging. A Case Report from Niger by Umoh VA and Tochukwu A discusses a case where acute limb ischemia (ALI) presented with symptoms similar to a stroke. This misdiagnosis highlights the importance of considering ALI in differential diagnoses for patients with sudden limb weakness. The report emphasizes the need for timely diagnosis and intervention to prevent severe complications or limb loss. The case underlines the challenges in resource-limited settings and the critical role of comprehensive clinical evaluations. **[37]**

A study from Nigeria highlighted the incidence and outcomes of ALI, emphasizing the challenges in diagnosis and management due to limited healthcare resources. **[38]**

Management strategies for ALI in African countries may differ from those in more developed regions due to resource limitations. Outcomes for ALI in cardiac patients in Africa are generally poorer compared to global averages due to delayed presentations and limited treatment options.

3. Objectives

3.1. General Objective

- ✓ To assess the clinical presentation and outcome of Acute Limb Ischemia occurring in cardiac Patients at TASH

3.2. Specific objectives

- ✓ to identify cardiac lesions that are significantly associated with ALI
- ✓ to identify which limbs are more prone to develop ALI in cardiac patients
- ✓ To evaluate the 30-day outcome of ALI in cardiac patients
- ✓ describe the modalities of interventions done for cardiac patients with ALI
- ✓ factors contributing to Poor outcomes of ALI in cardiac patients with ALI

4. Methodology

4.1. Study Setting

Tikur Anbessa Specialized Hospital is the largest hospital in Ethiopia and is located in the heart of its capital city, Addis Ababa. It is the main teaching hospital for both clinical and preclinical training of most disciplines. It is also an institution where specialized clinical services that are not available in other public or private institutions are rendered to the whole nation. In addition, almost all regional and federal hospitals in Addis Ababa are affiliated with the School of Medicine as clinical services and training sites. **[39]**

4.2. Study Design

The study is a facility-based 3-years retrospective cross sectional study with data gathered from the patients and their charts in the time of study.

4.3. Source Population

All patients with non-traumatic ALI of any cause presenting to TASH surgical emergency

4.4. Study Population

All patients with non- traumatic ALI who are newly diagnosed or known cardiac patients admitted, treated, discharged, referred, or died in or from TASH were studied.

4.5. Sampling method

All patients in the study population were the subject of this study.

4.6. Inclusion Criteria

- All patients presenting with ALI who have an established cardiac illness proven by echocardiography or ECG were included
- Willing to participate

4.7. Exclusion Criteria

- ALI occurring immediately after cardiac intervention and in non-cardiac patients
- Traumatic vascular injuries
- Patients who don't give consent
- CLI
- Incomplete charts

4.8. Operational definitions

ALI – lack of limb perfusion assessed clinically with onset of <15 days.

- **Measurement Criteria**: Diagnosis confirmed by clinical examination and imaging (e.g., Doppler ultrasound, angiography).

Table 1: Rutherfords classification for severity of ALI [1,11]

Classification	Description/prognosis	Findings		Doppler signals	
		Sensory loss	Muscle weakness	Arterial	Venous
I. Viable	Not immediately threatened	None	None	Audible	Audible
II. Threatened					
a. Marginally	Salvageable if promptly treated	Minimal (toes) or none	None	(Often) inaudible	Audible
b. Immediately	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 inevitable	Profound, anesthetic	Profound, paralysis (rigor)	Inaudible	Inaudible

Cardiac patient – any patient with a confirmed diagnosis of one or more of the following cardiac conditions:

- Coronary Artery Disease (CAD), including those with a history of myocardial infarction (MI) or angina.
- Congestive Heart Failure (CHF).
- Atrial Fibrillation or other significant arrhythmias.
- Valvular Heart Disease (e.g., aortic stenosis, mitral regurgitation).
- Cardiomyopathy (e.g., dilated, hypertrophic).
- Congenital Heart Disease.

- **Or patients with**
    - Documentation of cardiac conditions through diagnostic tests such as echocardiography, electrocardiogram (ECG), cardiac catheterization, stress tests, or other relevant imaging modalities.
- **Or patients with treatment History:**
    - Patients receiving treatment for cardiac conditions, including medications (e.g., beta-blockers, ACE inhibitors, anticoagulants), surgical interventions (e.g., coronary artery bypass grafting, valve replacement), or catheter-based procedures (e.g., percutaneous coronary intervention).
    - Patients with documented evidence of cardiac disease from medical records.

 Valvular Lesions:

- **Definition**: Abnormalities in the heart valves, including stenosis and regurgitation.
- **Measurement Criteria**: Diagnosis confirmed by echocardiography.

 Arrhythmias:

- **Definition**: Irregular heartbeats, including atrial fibrillation, atrial flutter, and ventricular tachycardia.
- **Measurement Criteria**: Diagnosis confirmed by electrocardiogram (ECG).

 Thromboembolism:

- **Definition**: Obstruction of a blood vessel by a blood clot that has traveled from another location in the body.
- **Measurement Criteria**: Diagnosis confirmed by imaging studies (e.g., CT angiography, Doppler ultrasound).

 Rethrombosis:

- **Definition**: Recurrence of thrombus formation after initial treatment.
- **Measurement Criteria**: Diagnosis confirmed by clinical signs and imaging studies within a specified follow-up period.

 Multiple Limb Involvement:

- **Definition**: The presence of ALI in more than one limb simultaneously.
- **Measurement Criteria**: Clinical examination and imaging confirming ischemia in multiple limbs.

 Upper Limb Ischemia:

- **Definition**: Acute limb ischemia occurring in the upper extremities.
- **Measurement Criteria**: Clinical examination and imaging confirming ischemia in the upper limbs.

 Surgical Intervention:

- **Definition**: Any surgical procedure performed to restore blood flow in patients with ALI, including embolectomy, bypass surgery, and thrombolysis.
- **Measurement Criteria**: Documentation of surgical procedures in medical records.

 Comorbidities:

- **Definition**: The presence of one or more additional diseases or disorders co-occurring with the primary disease (ALI).
- **Measurement Criteria**: Documented diagnoses from medical records.

 Amputation Rate:

- **Definition**: The proportion of patients undergoing surgical removal of a limb due to ALI.
- **Measurement Criteria**: Number of amputations documented in medical records divided by the total number of ALI cases.

 Mortality Rate:

- **Definition**: The proportion of patients who die as a result of ALI and its complications.
- **Measurement Criteria**: Number of deaths documented in medical records divided by the total number of ALI cases.

 Resource-Limited Setting:

- **Definition**: A healthcare environment with limited availability of medical resources, personnel, and infrastructure.
- **Measurement Criteria**: Contextual description based on healthcare facility characteristics and resource availability.

4.9 Study Variables

- The independent variable in this study are Age, sex, address, duration of presentation, duration of cardiac disease, type of cardiac lesion, EF, prior ischemic insult, type of intervention, Rutherford class, place of admission, medication history, comorbidities.
- the dependent variables are cause of ALI (embolic or thrombotic ALI), outcome of ALI, limb affected by ALI, 30-day mortality, 30-day amputation rate.

4.10 Data collection method and procedure

Structured and pretested self-administrated questions wereprepared in an online data collection tool and it was used for the quantitative data collection. Data was collected by two personnel for an estimated 3 months in Tikur Anbessa Hospital. The patient's charts were analyzed and additional interview questions were used when necessary.

4.11 Data Management and Analysis

The data was analyzed using statistical software SPSS version 26. Descriptive statistics was used to summarize patient characteristics, comorbidities, and clinical presentations. Logistic regression analysis was used for binary outcomes (e.g., amputation vs. no amputation).

4.12 Data quality control measures

After carefully adopting other published journal articles into our current context, structured questions were drafted. The Questionnaire was checked thoroughly if it is complete, objective, and variable based. Finally, data was also checked for consistency and completeness before entry to computer software for analysis.

4.13 Ethical Consideration

Ethical clearance was obtained from the research and ethics committee of the department of surgery as well as the IRB of college of health sciences SOM Addis Ababa University before data collection.

confidentiality was maintained throughout the data collection, the entire study period, and beyond. To keep the anonymity of study participants, codes rather than personal identifiers were used and all questionnaires will be sealed.

4.14 Data dissemination and utilization of results

The results of this research is submitted to the School of Medicine. CHS AAU. It will also possibly be presented to a medical journal for publication.

5. Result

The final analysis included 82 cardiac patients presenting with acute limb ischemia (ALI) who underwent surgical intervention.

Patients ranged in age, with the majority 43 (52.4%) being 60 years or older. Approximately 24 (29.3%) were between 30 and 59 years old, while 15(18.3%) were under 30 years old. 43 (52.4%) of the patients were females and 39(47.6%) were males, showing a nearly balanced gender distribution. Most patients 52 (63.4%) had a known history of cardiac illness, while 30 (36.6%) were newly diagnosed. 46 (56.1%) of patients had regular follow up. The majority of patients 62 (75.6%) reported taking medications for either cardiac or other comorbidities they have, while 20 (24.4%) did not. Among the medications used, the most common were β-blockers 28 (45.2% of the cases) followed by ASA 24 (38.7% of cases). Other medications included statins, ACE inhibitors, diuretics, and warfarin.

Echocardiography and ECG findings reveal that most patients (29) presented with ischemic heart disease (IHD) (35.4% of cases). Mitral regurgitation 27 (32.9% of cases) and aortic regurgitation 26 (31.7% of cases) were also frequently observed. Atrial fibrillation was present in the majority 46 (56.1%) of patients. Most patients 60 (73.2%) had a normal mitral valve area. Severe mitral stenosis was noted in 16(19.5%) of cases, with mild and moderate stenosis accounting for smaller percentages. Cardiac thrombus was identified in 27(32.9%) of patients, and preserved ejection fraction (≥50%) was observed in 55 (67.1%) of patients. Low ejection fraction 20(<40%) was noted in 20(24.4%), and intermediate (40-49%) was seen in 7(8.5%). Pulmonary hypertension was present in 32(39.0%) of patients.

The mean duration of symptoms before presentation to the ER was 8.54 days, with a median of 7 days. The range was between 0.58 and 21 days.

A history of prior ischemic insult was reported in only 37(45.1%) of patients. From those who reported prior ischemic phenomena, MI was the most common 19(51.4%), followed by prior limb ischemia 15(40.5%) whether acute or chronic, and stroke 13(35.1%).

The right lower limb was the most commonly affected site 52(49.5%), followed by the left lower limb 48(45.7%). Upper limb involvement was rare. 22(26.8%) of the patients had involvement in more than one limb.

Patients were classified based on the Rutherford criteria, with 33(36.7%) categorized as class IIB, 25 (27.8%) as class IIA, and 23(25.6%) as class III. Only 9(10.0%) were classified as class I.

The most common presenting symptoms included ischemic pain 82(100%), numbness 60(73.2%), and paresthesia 45(54.9%). Other symptoms reported were darkening, coldness, and swelling. Prior symptoms such as claudication 40(48.8%) and rest pain 19(23.2%) were noted. A significant proportion 39(47.6%) of cases reported no prior symptoms. 37(45.1%) of the patients had additional comorbidity other than cardiac illness with the most common being hypertension in 26(70.3 %) of the cases.

The most commonly occluded segments included the common femoral arteries 29(28.7%), followed by superficial femoral arteries 23(22.8%) and external iliac arteries 20(19.8%).

Thrombus was the leading cause of acute limb ischemia, accounting for 69.5% of cases, followed by embolus (29.3%). Aneurysms or pseudoaneurysms were rare.

The average time between patient presentation to the ER and surgical intervention was 31.5 hours. With the earliest being 7 hours and the maximum taking 7 days. When this was broken down to each Rutherford class, class IIB patients were managed relatively earlier with an average time of 21.63 hours.

patients preop INR showed that most (68 (82.9%)) of the patient's INR was <2 which was subtherapeutic. 9(11.0%) had INR ranging 2-3 and the rest 5(6.1%) had supratherapeutic range (>3).

Thromboembolectomy was the most commonly performed initial procedure done for 71(86.6% of patients), and primary amputation was done for 20(24.4%) of patients. Revascularizations; such as interposition grafts or bypass and thromboendarterectomy were less frequent.

Initial attempts to restore circulation were successful in 44(53.7%) of cases, while 38(46.3%) experienced failure. For the failed initial attempts re-thrombectomy with or without accompanying procedures was commonly 17 (44.7% of the failed case) performed.

The total amputation rate was 31(37.8%). Amputations were predominantly above-knee amputations 24(77.4%). Below-knee amputations accounted for 6(19.4%), with other types being rare.

Most 44(53.7%) patients were initially admitted to cardiac ICU. 49(59.8 %) of the patients developed one or more complications in the hospital and commonly due to wound complications 26(33.8%) followed by pulmonary 15(19.5%) and cardiac 13(16.9%) complications.

The mean length of hospital stay was 15.52 days, with a median of 14 days and a maximum of 41 days. The majority of patients 72(87.8%) were discharged, while 10(12.2%) died during hospitalization. On subsequent follow up at 30 days, 68(82.9%) of patients were alive, and 32(47.1%) of limbs were viable.

The overall descriptive characteristics is summarized in the following tables

Table 2: demographic variables and medical history

		Frequency	**Percent**	
age	<30	15	18.3	
	30-59	24	29.3	
	>=60	43	52.4	
Sex	Female	43	52.4	
	Male	39	47.6	
Duration of cardiac illness	New	30	36.6	
	known	52	63.4	
Regular follow-up	No	36	43.9	
	Yes	46	56.1	
Do they take medication	No	20	24.4	
	Yes	62	75.6	

Table 3: medications Frequencies				
		Responses		Percent of Cases
		N	Percent	
Medications	ASA	24	13.6%	38.7%
	statins	17	9.7%	27.4%
	Ca++ channel blockers amylodipine/nifedipine	17	9.7%	27.4%
	Oral hypoglycemic agents metformin/glibenclamide	3	1.7%	4.8%
	insulin	1	0.6%	1.6%
	β-blockers	28	15.9%	45.2%
	ACEis	16	9.1%	25.8%
	warfarin	21	11.9%	33.9%
	rivaroxaban	1	0.6%	1.6%
	diuretics	23	13.1%	37.1%
	digoxin	6	3.4%	9.7%
	other	19	10.8%	30.6%
Total		176	100.0%	283.9%

Table 4: Cardiac Lesion				
		Responses		Percent of Cases
		N	Percent	
Cardiac Lesion	MS	22	11.3%	26.8%
	MR	27	13.9%	32.9%
	AS	4	2.1%	4.9%
	AR	26	13.4%	31.7%
	TS	1	0.5%	1.2%
	TR	19	9.8%	23.2%
	IHD/CAD	29	14.9%	35.4%
	HHD	6	3.1%	7.3%
	DCMP	11	5.7%	13.4%
	CHD	2	1.0%	2.4%
	Pericarditis	2	1.0%	2.4%
	Arrhythmia only	7	3.6%	8.5%
	CRVHD	20	10.3%	24.4%
	DVHD	18	9.3%	22.0%
Total		194	100.0%	236.6%

Table 5: cardiac finding variables			
		Frequency	**Percent**
Afib present?	No	36	43.9
	Yes	46	56.1
Mitral valve area	normal	60	73.2
	mild MS	1	1.2
	Mod MS	5	6.1
	Severe MS	16	19.5
Cardiac thrombus	No	55	67.1
	yes	27	32.9
Ejection Fraction	intermediate (40-49%)	7	8.5
	Low (< 40%)	20	24.4
	Preserved (>50%)	55	67.1
Pulmonary Hypertension	No	50	61.0
	Yes	32	39.0

Table 6: Duration of presenting symptoms in days	
Mean	8.5431
Median	7
Mode	14
Std. Deviation	5.01214
Range	20.42
Minimum	0.58
Maximum	21

Table 7: limb variables			
		Frequency	**Percent**
Prior ischemic insult	no	45	54.9
	Yes	37	45.1
affected Limb	RLL	52	49.5%
	LLL	48	45.7%
	RUL	4	3.8%
	LUL	1	1.0%
Rutherford classification	I	9	10.0%
	IIA	25	27.8%
	IIB	33	36.7%
	III	23	25.6%

Table 8: Number of limbs involved			
		Frequency	Percent
Number Of Limbs Involved	single	60	73.2
	multiple	22	26.8

Table 9: History of Prior Ischemic Insults				
		Responses		Percent of Cases
		N	Percent	
Prior Ischemic Insult	MI	19	38.0%	51.4%
	TIA	1	2.0%	2.7%
	stroke	13	26.0%	35.1%
	Prior limb ischemia: acute/chronic	15	30.0%	40.5%
	other	2	4.0%	5.4%

Table 10: presenting and prior symptoms		N	Percent
Presenting Symptoms	Ischemic pain	82	100
	darkening	40	48.78049
	paresthesia	45	54.87805
	coldness	35	42.68293
	numbness	60	73.17073
	swelling	29	35.36585
Prior Symptoms	claudication	40	48.78049

	Rest pain	19	23.17073
	ulceration	2	2.439024
	Skin color change	5	6.097561
	other	2	2.439024
	none	39	47.56098

Table 11: presence of comorbidity

		Frequency	Percent
Additional comorbidity	none	45	54.9
	yes	37	45.1
	Total	82	100

Table 12 : types of Comorbidities and their Frequencies

		Responses		Percent Of Cases
		N	Percent	
Comorbidities	Dm	6	13.60%	16.20%
	Hypertension	26	59.10%	70.30%
	Kidney Disease	2	4.50%	5.40%
	Thyrocardiac Disease	6	13.60%	16.20%
	Malignancy	1	2.30%	2.70%
	Other	3	6.80%	8.10%
Total		44	100.00%	118.90%
A Dichotomy Group Tabulated At Value 1.				

Table 13: frequency of occluded proximal segment of a vessel				
		Responses		Percent of Cases
		N	Percent	
Occluded Proximal Segment of the vessel	Distal aorta	3	3.00%	3.70%
	Rt CIA	8	7.90%	9.80%
	Lt CIA	2	2.00%	2.40%
	Rt EIA	8	7.90%	9.80%
	Lt EIA	12	11.90%	14.60%
	Rt CFA	18	17.80%	22.00%
	Lt CFA	11	10.90%	13.40%
	Rt SFA	9	8.90%	11.00%
	Lt SFA	14	13.90%	17.10%
	Lt DFA	1	1.00%	1.20%
	Rt popliteal_a	6	5.90%	7.30%
	Lt popliteal_a	4	4.00%	4.90%
	Rt subclavian_a	1	1.00%	1.20%
	Lt axillary	1	1.00%	1.20%
	Rt brachial_a	2	2.00%	2.40%
	Lt brachial_a	1	1.00%	1.20%
Total		101	100.00%	123.20%

Table 14: Preoperative/ baseline INR			
		Frequency	Percent
INR	<2	68	82.9
	2-3	9	11.0
	>3	5	6.1

Table 15: different causes of ALI			
		Frequency	Percent
cause of ALI	Aneurism/ Pseudoaneurysm	1	1.2
	Embolus	24	29.3
	Thrombus	57	69.5
	Total	82	100

Table 16: Duration of time between presentation to ER and intervention (in hours)	
Mean	31.4634
Median	24
Mode	24
Std. Deviation	27.83336
Range	161
Minimum	7
Maximum	168

Table 17: Mean (in hours) duration between presentation to intervention for each Rutherford class		
		Mean (in hours) duration between presentation to intervention
Rutherford class	I	42.7778
	IIA	40.1600
	IIB	21.6364
	III	35.7826

Table 18: type of initial intervention done				
		N	Percent	Percent of Cases
Type of interventions done	thromboembolectomy	71	71.70%	86.60%
	thromboendarterectomy	6	6.10%	7.30%
	revascularization	2	2.00%	2.40%
	amputation	20	20.20%	24.40%
Total		99	100.00%	120.70%

Table 19: Limb outcome after initial revascularization attempt			
Initial revascularization		Frequency	Percent
	Failed	38	46.3
	Successful	44	53.7
	Total	82	100

Table 20: subsequent intervention for failed revascularization		
	Frequency	Percentage
Rethrombectomy	11	13.41
revascularization	7	8.54
amputation	6	7.32
medical	5	6.1
rethrombectomy + amputation	5	6.1
rethrombectomy + fasciotomy	1	1.22
none	3	3.66

Table 21: total number of amputations done			
		Frequency	
Total amputation rate	No	51	62.19512
	yes	31	37.80488
	Total	82	100

Table 22: types of amputation performed			
		Responses	
		N	Percent
Amputation Type	AKA	24	77.40%
	BKA	6	19.40%
	Wrist/knee/ankle disarticulation	1	3.20%

Table 23: place of initial admission or initial post op disposition			
		Frequency	Percent
Location of admission	CICU	44	53.7
	GICU	19	23.2
	Wards	19	23.2
	Total	82	100

Table 24: occurrence of complication during hospital stay					
		Frequency	Percent	Valid Percent	Cumulative Percent
Complications present	no	33	40.2	40.2	40.2
	yes	49	59.8	59.8	100
	Total	82	100	100	

Table 25: list of complications				
		Responses		Percent of Cases
		N	Percent	
complications	Wound complication	26	33.80%	53.10%
	Compartment syndrome	5	6.50%	10.20%
	Cardiac (e.g MI, HF)	13	16.90%	26.50%
	stroke	5	6.50%	10.20%
	Renal failure	7	9.10%	14.30%
	Major bleeding	1	1.30%	2.00%

	Pulmonary (e.g. PTE, pulmonary edema, HAP	15	19.50%	30.60%
	UTI	1	1.30%	2.00%
	others	4	5.20%	8.20%
Total		77	100.00%	157.10%
a Dichotomy group tabulated at value 1.				

Table 26: overall intrahospital mortality and discharge			
		Frequency	**Percent**
Overall intrahospital outcome	Death	10	12.2
	Discharge	72	87.8

Table 27: 30 day mortality and limb viability			
		Frequency	**Percent**
Patient alive by 30 days?	no	14	17.1
	yes	68	82.9
Limb viable by 30 days	no	36	52.9
	yes	32	47.1

Table 28: total length of hospital stay (in days)	
Mean	15.52
Median	14
Mode	18
Std. Deviation	8.461
Minimum	3
Maximum	41

Male patients had significantly lower odds of revascularization success compared to females (OR = 0.373, 95% CI: 0.152–0.912, p = 0.031). (*Table 29*) Age was also a significant factor, with patients under 30 years having significantly higher odds of chronic rheumatic valvular heart disease (CRVHD) (OR = 0.012, 95% CI: 0.001–0.114, p < 0.001), (*table 30)* whereas those aged 60 years or older had nearly 2.9 times higher odds of ischemic heart disease (IHD) (OR = 2.899, 95% CI: 1.114–7.54, p = 0.029). (*table 31*)

Table 29: Sex vs. Revascularization Success						95% C.I. for EXP(B)	
	Limb outcome after revascularization			P-value	OR	Lower	Upper
Sex	Failed	Successful	Total				
Female	15	28	43	**0.031**	0.373	0.152	0.912
Male	23	16	39				
Total	38	44	82				

Table 30: Age vs. CRVHD						95% C.I. for EXP(B)	
age	CRVHD present			P-value	OR	Lower	Upper
	No	Yes	Total	0	0.012	0.001	0.114
<30	5	10	15				
	33.30%	66.70%	100.00%				
30-59	15	9	24				
	62.50%	37.50%	100.00%				
>=60	42	1	43				
	97.70%	2.30%	100.00%				
total	62	20	82				
	75.60%	24.40%	100.00%				

Table 31: Age vs. IHD						95% C.I. for EXP(B)	
age	IHD present			P-value	OR	Lower	Upper
	No	Yes	Total	0.029	2.899	1.114	7.54
<30	14	1	15				
	93.30%	6.70%	100.00%				
30-59	16	8	24				
	66.70%	33.30%	100.00%				
>=60	23	20	43				
	53.50%	46.50%	100.00%				
total	53	29	82				
	64.60%	35.40%	100.00%				

Among comorbidities, the duration of cardiac illness significantly influenced revascularization success, with patients having a known history of cardiac illness being 2.67 times more likely to achieve successful revascularization (OR = 2.667, 95% CI: 1.064–6.685, p = 0.036). *(table 32)* Hypertension was associated with increased complications, as patients without hypertension had significantly lower odds of complications (OR = 0.347, 95% CI: 0.133–0.906, p = 0.031). (*table 33*) Similarly, pulmonary hypertension was strongly linked to higher complication rates, increasing the odds nearly 3.9 times (OR = 3.869, 95% CI: 1.416–10.571, p = 0.008). *(table 34)*

Table 32: History of Cardiac Illness vs. Revascularization Success						95% C.I.for EXP(B)	
	Revascularization outcome			p-value	OR	Lower	Upper
history of Cardiac Illness	**Failed (n, %)**	**Successful (n, %)**	**Total**	0.036	2.667	1.064	6.685
Newly diagnosed	19 (61.3%)	12 (38.7%)	31				
Known	19 (37.3%)	32 (62.7%)	51				
Total	**38 (46.3%)**	**44 (53.7%)**	**82**				

Table 33: history of hypertension **vs. development of Complications**						95% C.I. for EXP(B)	
history of hypertension	Any complications present			P-value	OR	Lower	Upper
	No	Yes	Total	0.031	0.347	0.133	0.906
no	18	38	56				
	32.10%	67.90%	100.00%				
yes	15	11	26				
	57.70%	42.30%	100.00%				
total	33	49	82				

	40.20%	59.80%	100.00%				

Table 34: pulmonary hypertension **vs. development of Complications**						95% C.I. for EXP(B)	
Is there pulmonary hypertension	Any complications present			P-value	OR	Lower	Upper
	No	Yes	Total	0.008	3.869	1.416	10.571
no	26	24	50				
	52.00%	48.00%	100.00%				
yes	7	25	32				
	21.90%	78.10%	100.00%				
total	33	49	82				
	40.20%	59.80%	100.00%				

Severe mitral stenosis (MS) emerged as a strong predictor of embolic acute limb ischemia (ALI). Patients with severe MS had sixfold higher odds of developing embolic ALI compared to those without MS (OR = 6.071, 95% CI: 1.880–19.606, p = 0.003). *(table 35)* Additionally, the presence of cardiac thrombi was significantly associated with embolic ALI, as the absence of cardiac thrombi reduced the odds of embolic ALI by 88% (OR = 0.12, 95% CI: 0.041–0.35, p < 0.001). *(table 36)* Severe MS was also strongly associated with multiple limb involvement (OR = 0.181, 95% CI: 0.054–0.600, p = 0.005), *(table 37)* but paradoxically, it correlated with a higher likelihood of successful revascularization (OR = 0.204, 95% CI: 0.053–0.785, p = 0.021). *(table 38)* ; significantly less likely to undergo amputation. The odds of avoiding amputation were approximately 5.5 times higher (OR = 5.486, 95% CI: 1.154–26.091, p = 0.032). *(table 39)*

It is also associated with higher odds of viable limbs after 30 days. patients with severe MS had **92.5% lower odds** of limb **non-viability** compared to those without severe MS. *(OR = 0.075, 95% CI: 0.009–0.634, p = 0.017) (table 40)*

Table 35: Severe MS vs. Cause of ALI							95% C.I.for EXP(B)	
Severe MS present	Cause of ALI				P-value	OR	Lower	Upper
	Aneurism/ pseudoanurism	Embolus	Thrombus	Total	**0.003**	6.071	1.880	19.606
yes	0	10	6	16				
	0.00%	62.50%	37.50%	100.00%				
no	1	14	51	66				
	1.50%	21.20%	77.30%	100.00%				
total	1	24	57	82				
	1.20%	29.30%	69.50%	100.00%				

Table 36: Cardiac thrombus v/s cause of ALI								
							95% Confidence Interval for Exp(B)	
Cardiac thrombus present	**Cause of ALI**				**P-Value**	**OR**	**Lower Bound**	**Upper Bound**
	Aneurism/ pseudoanurism	Embolus	Thrombus	Total	**0.00**	**0.12**	0.041	0.35
no	1	8	46	55				
	1.80%	14.50%	83.60%	100.00%				
yes	0	16	11	27				
	0.00%	59.30%	40.70%	100.00%				

total	1	24	57	82				
	1.20%	29.30%	69.50%	100.00%				

Table 37: Mitral valve area * multiple limb involvement

						95% Confidence Interval for Exp(B)	
Mitral valve area	**Number of limbs involved**			P-Value	OR	Lower Bound	Upper Bound
	single	**multiple**	**total**	**0.005**	0.181	0.054	0.600
No MS	47	13	60				
	78.3%	21.7%	100.0%				
Mild MS	1	0	1				
	100.0%	0.0%	100.0%				
Moderate MS	5	0	5				
	100.0%	0.0%	100.0%				
Severe ms	7	9	16				
	43.8%	56.3%	100.0%				
Total	60	22	82				
	73.2%	26.8%	100.0%				

Table 38: Severe MS vs. Revascularization Success

						95% C.I.for EXP(B)	
Severe MS present	**Revascularization outcome**			P-value	OR	Lower	Upper
	Failed	Successful	Total	0.021	0.204	0.053	0.785
yes	3	13	16				
	18.80%	81.30%	100.00%				

no	35	31	66				
	53.00%	47.00%	100.00%				
total	38	44	82				
	46.30%	53.70%	100.00%				

Table 39: Severe MS vs. amputation						95% C.I.for EXP(B)	
Severe MS present	**Is amputation done**			P-value	OR	Lower	Upper
	No	yes	Total	0.032	5.486	1.154	26.091
yes	14	2	16				
	87.50%	12.50%	100.00%				
no	37	29	66				
	56.10%	43.90%	100.00%				
total	51	31	82				
	62.20%	37.80%	100.00%				

Table 40: Severe MS vs 30day limb viability								
							95% Confidence Interval for Exp(B)	
Severe MS present	Was limb viable after 30 days				P-Value	OR	Lower Bound	Upper Bound
	NA*	no	yes	total	**0.017**	0.075	0.009	0.634

yes	6	1	9	16				
	37.50%	6.30%	56.30%	100.00%				
no	8	35	23	66				
	12.10%	53.00%	34.80%	100.00%				
total	14	36	32	82				
	17.10%	43.90%	39.00%	100.00%				
NA* = not applicable (patients have died)								

Patients who have CRVHD had significantly higher odds of facing complications. The odds of complications increased by about **81.2%** for those who had CRVHD. *(OR = 0.188, 95% CI: 0.050–0.708, p = 0.013). (table 41).* On the other hand, the presence of DVHD was associated with significantly higher odds of death, with the odds of death increased by approximately 78%. *(OR = 0.22, 95% CI: 0.056–0.874, p = 0.031) (table 42)*

Table 41: CRVHD **vs. development of Complications**						95% C.I. for EXP(B)	
CRVHD	Any complications present			P-value	OR	Lower	Upper
	No	Yes	Total	0.013	0.188	0.05	0.708
no	30	32	62				
	48.40%	51.60%	100.00%				
yes	3	17	20				
	15.00%	85.00%	100.00%				
total	33	49	82				
	40.20%	59.80%	100.00%				

Table 42: DVHD vs. Overall Outcome	95% C.I.for EXP(B)

DVHD	**Overall outcome**			P-value	OR	Lower	Upper
	Death	Discharge	Total	0.031	0.22	0.056	0.874
no	5	59	64				
	7.80%	92.20%	100.00%				
yes	5	13	18				
	27.80%	72.20%	100.00%				
total	10	72	82				
	12.20%	87.80%	100.00%				

Severe mitral stenosis was associated with higher odds of mortality within 30 days. Patients with severe MS had 4.35 times higher odds of mortality (OR = 4.35, 95% CI: 1.242–15.233, p = 0.021), *(table 43)* significantly associated with an increased risk of systemic complications. OR = 0.161, 95% CI: 0.034– 0.766, p = 0.022), *(table 44)* had higher odds of developing cardiac complications (OR = 0.198, 95% CI: 0.055–0.711, p = 0.013) *(table 45)*, renal complications (OR = 0.026, 95% CI: 0.003–0.236, p = 0.001) *(table 46)* , pulmonary complications (OR = 0.263, 95% CI: 0.077–0.902, p = 0.034) *(table 47)*, and compartment syndrome (OR = 0.046, 95% CI: 0.005–0.45, p = 0.008) *(table 48)*.

Additionally, cardiac complications were strongly associated with pulmonary complications, increasing their odds by nearly sixfold (OR = 5.714, 95% CI: 1.563–20.886, p = 0.008). *(table 49)* Pulmonary complications, in turn, were significantly associated with increased in-hospital mortality, reducing the likelihood of discharge by 97.3% (OR = 0.027, 95% CI: 0.005–0.153, p < 0.001). *(table 50)*

Table 43: Severe MS vs. 30-day mortality	95% C.I.for EXP(B)

Severe MS present	**Patient alive after 30 days**			P-value	OR	Lower	Upper
	No	yes	Total	0.021	4.35	1.242	15.233
yes	6	10	16				
	37.50%	62.50%	100.00%				
no	8	58	66				
	12.10%	87.90%	100.00%				
total	14	68	82				
	17.10%	82.90%	100.00%				

Table 44: severe MS vs. development of Complications						95% C.I. for EXP(B)	
Is there severe MS	Any complications present			P-value	OR	Lower	Upper
	No	Yes	Total	0.022	0.161	0.034	0.766
yes	2	14	16				
	12.50%	87.50%	100.00%				
no	31	35	66				
	47.00%	53.00%	100.00%				
total	33	49	82				
	40.20%	59.80%	100.00%				

Table 45: severe MS vs. development of cardiac complication				95% C.I. for EXP(B)	
Is there severe MS	Any cardiac complication present	P-value	OR	Lower	Upper

	No	Yes	Total	0.013	0.198	0.055	0.711
yes	10	6	16				
	62.50%	37.50%	100.00%				
no	59	7	66				
	89.40%	10.60%	100.00%				
total	69	13	82				
	84.10%	15.90%	100.00%				

Table 46: severe MS vs. development of Renal complication						**95% C.I. for EXP(B)**	
Is there severe MS	**Any renal complication present**			**P-value**	**OR**	**Lower**	**Upper**
	No	Yes	Total	0.001	0.026	0.003	0.236
yes	10	6	16				
	62.50%	37.50%	100.00%				
no	65	1	66				
	98.50%	1.50%	100.00%				
total	75	7	82				
	91.50%	8.50%	100.00%				

Table 47: severe MS vs. development of Pulmonary complication	**95% C.I. for EXP(B)**

Is there severe MS	**Any pulmonary complication present**			**P-value**	**OR**	**Lower**	**Upper**
	No	Yes	Total	0.034	0.263	0.077	0.902
yes	10	6	16				
	62.50%	37.50%	100.00%				
no	57	9	66				
	86.40%	13.60%	100.00%				
total	67	15	82				
	81.70%	18.30%	100.00%				

Table 48: severe MS vs. development of Compartment syndrome						95% C.I. for EXP(B)	
Is there severe MS	Any compartment syndrome diagnosed			P-value	OR	Lower	Upper
	No	Yes	Total	0.008	0.046	0.005	0.45
yes	12	4	16				
	75.00%	25.00%	100.00%				
no	65	1	66				
	98.50%	1.50%	100.00%				
total	77	5	82				
	93.90%	6.10%	100.00%				

Table 49: Cardiac complication vs. Pulmonary Complication						95% C.I.for EXP(B)	
cardiac complications present	Pulmonary complications present			P-value	OR	Lower	Upper
	No	Yes	Total	0.008	5.714	1.563	20.886
no	2	65	67				
	3.00%	97.00%	100.00%				
yes	8	7	15				
	53.30%	46.70%	100.00%				
total	10	72	82				
	12.20%	87.80%	100.00%				

Table 50: Pulmonary Complication vs. Overall Outcome						95% C.I.for EXP(B)	
Pulmonary complications present	**Overall outcome**			P-value	OR	Lower	Upper
	Death	Discharge	Total	0.000	0.027	0.005	0.153
no	2	65	67				
	3.00%	97.00%	100.00%				
yes	8	7	15				
	53.30%	46.70%	100.00%				
total	10	72	82				
	12.20%	87.80%	100.00%				

Beyond baseline characteristics and comorbidities, the impact of intervention timing on limb outcomes was examined. Intervention timing played a crucial role in limb viability and amputation risk. Early presentation (≤72 hours) significantly improved 30-day limb viability, reducing the odds of non-viability by 82% (OR = 0.179, 95% CI: 0.045–0.719, p = 0.015) *(table 51)*. Delaying intervention beyond 24 hours was associated with a significantly increased risk of amputation (OR = 3.047, 95% CI: 1.171–7.929, p = 0.022) and worsened 30-day limb viability (OR = 0.22, 95% CI: 0.069–0.704, p = 0.011). *(table 52, 53)*

Table 51: Presentation Time vs. 30-Day Limb Viability								
	Was limb viable after 30 days				P-value	OR	95% Confidence Interval for Exp(B)	
Presentation time	NA*	no	yes	Total			Lower Bound	Upper Bound
<=72hrs	3(17.60%)	3(17.60%)	11(64.70%)	17	0.015	0.179	0.045	0.719
>72hrs	12(18.50%)	32(49.20%)	21(32.30%)	65				
Total	15(18.30%)	35(42.70%)	32(39.00%)	82				
NA* = not applicable (patients have died)								

Table 52: time of intervention vs amputation					95% C.I. for EXP(B)	
Duration of Time between presentation to ER and intervention	amputation			P-value	OR	Lower	Upper
	No	Yes	Total	0.022	3.047	1.171	7.929
<=24hrs	39	16	55				
	70.90%	29.10%	100.00%				
>24hrs	12	15	27				
	44.40%	55.60%	100.00%				

total	51	31	82				
	62.20%	37.80%	100.00%				

Table 53: Intervention time vs 30day limb viability						95% Confidence Interval for Exp(B)	
Duration of Time between presentation to ER and intervention	was limb viable after 30 days				P-Value	OR	Lower Bound	Upper Bound
	NA*	no	yes	total	0.011	0.22	0.069	0.704
<=24hrs	9	19	27	55				
	16.40%	34.50%	49.10%	100.00%				
>24hrs	6	16	5	27				
	22.20%	59.30%	18.50%	100.00%				
total	15	35	32	82				
	18.30%	42.70%	39.00%	100.00%				
NA* = not applicable (patients have died)								

Additionally, patients with Rutherford Class IIa limb were significantly more likely to have viable limb at 30 days compared to other classes. The odds of limb viability were higher by 76% (OR = 0.234, 95% CI: 0.076–0.719, p = 0.011). *(table 54),* while patients presenting with Rutherford Class III ischemia had a 12.6-fold increased odds of limb non-viability at 30 days (OR = 12.632, 95% CI: 2.606–61.222, p = 0.002) *(table 55)*. A history of prior ischemic insult was significantly associated with lower odds of limb viability at 30 days. The odds of viability were reduced by 74% in patients with a prior ischemic insult (OR = 0.261, 95% CI: 0.094–0.727, p = 0.010) *(table 56)*. Patients with prior limb ischemia had significantly higher odds of limb non-viability after 30 days. *(OR = 0.128, 95% CI: 0.026–0.628, p = 0.011) (table 57)*

Table 54: Rutherford class IIa vs 30day limb viability

							95% Confidence Interval for Exp(B)	
	RC IIA	was limb viable after 30 days				P-Value	OR	Lower Bound	Upper Bound
		NA*	no	yes	total	0.011	0.234	0.076	0.719
	no	11	29	17	57				
		19.30%	50.90%	29.80%	100.00%				
	yes	4	6	15	25				
		16.00%	24.00%	60.00%	100.00%				
	total	15	35	32	82				
		18.30%	42.70%	39.00%	100.00%				

NA* = not applicable (patients have died)

Table 55: Rutherford class III vs 30day limb viability

						95% Confidence Interval for Exp(B)	
RC III	Was limb viable after 30 days				P-Value	OR	Lower Bound	Upper Bound
	NA*	no	yes	total	0.002	12.632	2.606	61.222
no	9	20	30	59				
	15.30%	33.90%	50.80%	100.00%				
yes	5	16	2	23				
	21.70%	69.60%	8.70%	100.00%				
total	14	36	32	82				
	17.10%	43.90%	39.00%	100.00%				

NA* = not applicable (patients have died)

Table 56: Prior ischemic insult vs 30day limb viability								
							95% Confidence Interval for Exp(B)	
Prior history of ischemic insult	Was limb viable after 30 days				P-Value	OR	Lower Bound	Upper Bound
	NA*	no	yes	total	0.01	0.261	0.094	0.727
none	8	14	23	45				
	17.80%	31.10%	51.10%	100.00%				
yes	7	21	9	37				
	18.90%	56.80%	24.30%	100.00%				
total	15	35	32	82				
	18.30%	42.70%	39.00%	100.00%				
NA* = not applicable (patients have died)								

Table 57: Prior history of limb ischemia vs 30day limb viability								
							95% Confidence Interval for Exp(B)	
Prior history of limb ischemia	Was limb viable after 30 days				P-Value	OR	Lower Bound	Upper Bound
	NA*	no	yes	total	0.011	0.128	0.026	0.628
no	14	23	30	67				
	20.90%	34.30%	44.80%	100.00%				
yes	1	12	2	15				
	6.70%	80.00%	13.30%	100.00%				
total	15	35	32	82				
	18.30%	42.70%	39.00%	100.00%				

NA* = not applicable (patients have died)

The location of initial admission was also found to influence complication rates. Patients requiring admission to the Cardiac ICU (CICU) had significantly higher odds of complications compared to those admitted to general wards (OR = 0.215, 95% CI: 0.068–0.685, p = 0.009), and a similar trend was observed in those admitted to the General ICU (GICU) (OR = 0.213, 95% CI: 0.054–0.837, p = 0.027). *(table 58)*

Table 58: Location of initial admission vs complications

						95% Confidence Interval for Exp(B)	
location of initial admission/ post-op disposition	Any complications present			P-Value	OR	Lower Bound	Upper Bound
	No	Yes	total				
CICU	14	30	44	0.009	0.215	0.068	0.685
	31.80%	68.20%	100.00%				
GICU	6	13	19	0.027	0.213	0.054	0.837
	31.60%	68.40%	100.00%				
Wards	13	6	19				
	68.40%	31.60%	100.00%				

Total	33	49	82				
	40.20%	59.80%	100.00%				

6. Discussion

Acute limb ischemia (ALI) remains a significant cause of morbidity and mortality, particularly in resource-limited settings. This study assessed the presentation, management, and outcomes of ALI among cardiac patients at Tikur Anbessa Specialized Hospital, highlighting the significant burden of ALI, with cardiac thrombus, mitral stenosis, and atrial fibrillation playing key roles in disease etiology. Mortality and amputation rates were substantial, aligning with global trends but with distinctive patterns influenced by delayed presentation and resource constraints.

Thrombosis was the leading cause of ALI (69.5%), while embolism accounted for 29.3% of cases. These findings align with global reports that highlight thrombosis as the predominant etiology in patients with pre-existing atherosclerosis (Olinic et al., 2019 [7]; Obara et al., 2018 [28]). In contrast, embolic ALI is more common in patients with atrial fibrillation (AF), valvular heart disease, or prior myocardial infarction, conditions frequently observed in this cohort (Keçeligil et al., 1999 [29]).

Atrial fibrillation was present in 56.1% of patients, consistent with reports that 80-90% of embolic ALI cases originate from cardiac sources, particularly in patients with rheumatic heart disease (RHD) and left atrial thrombus (Ege et al., 2002 [28]). Severe mitral stenosis (MS) was found in 19.5% of patients, reinforcing previous studies showing a strong correlation between MS and embolic complications due to atrial stasis (Francois P. Kaleta et al., 2021 [33]).

Most patients presented with severe ischemic symptoms, including ischemic pain (100%), numbness (73.2%), and paresthesia (54.9%), consistent with the classic "6 Ps" of ALI (Callum & Bradbury, 2000 [8]). However, delayed presentation was a critical issue, with a median symptom duration of 8.54 days before hospital arrival—substantially longer than the 6-12 hours reported in high-resource settings (Genovese et al., 2016 [19]; Howard et al., 2015 [21]).

At the time of presentation, 62.3% of patients were classified as Rutherford IIA or higher, while 25.6% were in Stage III, underscoring the impact of late presentation. Delayed presentation (median 7 days) was a critical issue. This is significantly longer than the median of 6-12 hours

reported in high-income settings (Genovese et al. [19]; Howard et al. [21]). In Ethiopia, Nebiyou et al. [22] also found late presentation (≥9 days in some cases), highlighting health literacy gaps, transportation barriers, and referral delays. Given that timely intervention is crucial for limb salvage, these delays contributed to the high amputation (37.8%) and mortality (12.2%) rates observed. Delayed referral, limited vascular expertise, and poor health literacy have been cited as key factors contributing to late-stage ALI presentations in Ethiopia (Nebiyou et al., 2021 [22]).

Thromboembolectomy was the primary surgical intervention (86.6%), while 24.4% of patients required primary amputation due to irreversible ischemia. Among those undergoing revascularization, initial success was achieved in 53.7%, while 46.3% required repeat thrombectomy or secondary procedures, highlighting the high rate of re-occlusion and procedural challenges (Allen et al., 1993 [22]).

The overall amputation rate was 37.8%, with above-knee amputations accounting for 77.4% of cases. These figures are higher than the 15-25% reported in developed settings but align with previous Ethiopian studies, where delayed presentation and limited access to endovascular therapy contribute to high limb loss rates (Nebiyou et al., 2021 [25]).

At 30-day follow-up, limb viability was 47.1%, while the in-hospital mortality rate was 12.2%, within the global range of 10-38% (Howard et al., 2015 [21]).

Male patients had lower odds of revascularization success (OR = 0.373, p = 0.031) Patients with a known history of cardiac illness were 2.67 times more likely to have successful revascularization (OR = 2.667, p = 0.036) Severe mitral stenosis was associated with higher revascularization success (OR = 0.204, p = 0.021)

Looking in to Predictors of Limb Viability and Mortality, Rutherford Class III patients had a 12.6-fold higher risk of limb non-viability (OR = 12.632, p = 0.002). Prior ischemic insult was associated with a 74% lower chance of limb viability (OR = 0.261, p = 0.010). Early intervention (≤24 hours) improved limb viability (OR = 0.22, p = 0.011). Severe mitral stenosis increased mortality risk 4.35 times (OR = 4.35, p = 0.021). Pulmonary complications significantly reduced the likelihood of survival ($p < 0.001$).

Interestingly, severe mitral stenosis was associated with higher revascularization success (OR = 0.204, p = 0.021), contrary to expectations. One explanation could be that embolic ALI, which is more common in MS, typically affects proximal arteries, making it more accessible for thromboembolectomy compared to thrombotic ALI, which involves diffuse, small-caliber vessel disease. Additionally, patients with MS may have been more likely to receive anticoagulation therapy, potentially reducing clot burden and improving procedural outcomes.

patients having a known history of cardiac illness being 2.67 times more likely to achieve successful revascularization (OR = 2.667, 95% CI: 1.064–6.685, p = 0.036). this is also another unexpected result. A likely explanation may be that known cardiac patients are more likely to take antiplatelates, anticoaguants and lipid lowering drugs improving vessel outcome.

Hypertension was associated with increased complications, as patients without hypertension had significantly lower odds of complications (OR = 0.347, 95% CI: 0.133–0.906, p = 0.031). (table:) Similarly, pulmonary hypertension was strongly linked to higher complication rates, increasing the odds nearly 3.9 times (OR = 3.869, 95% CI: 1.416–10.571, p = 0.008)

Timely revascularization is critical in ALI management, yet our study found delayed interventions, with an average surgical waiting time of 31.5 hours. Early intervention (≤24 hours) was associated with lower amputation rates (p = 0.022) and higher 30-day limb viability (p = 0.011). This supports evidence that thromboembolectomy or bypass within 6-12 hours improves limb salvage rates (Creager et al. [10]; Berridge et al. [3]).

However, resource limitations at Tikur Anbessa Specialized Hospital—including delayed imaging and investigations that may not be available in the hospital, limited surgical capacity, and limited ICU access, likely contributed to treatment delays. Similar challenges have been noted in African settings, where delayed diagnosis and inadequate vascular services worsen ALI outcomes (Umoh & Tochukwu [37]).

Postoperative complications affected 59.8% of patients, with the most common being: Wound infections (33.8%), Pulmonary complications (19.5%), and Cardiac events (16.9%)

Hypertension was associated with increased complications, (OR = 0.347, p = 0.031). Similarly, pulmonary hypertension was strongly linked to higher complication rates, increasing the odds nearly 3.9 times (OR = 3.869, p = 0.008)

Notably, pulmonary complications significantly increased mortality ($p < 0.001$). Additionally, cardiac complications increased pulmonary complication risk nearly sixfold (OR = 5.714, p = 0.008), reinforcing the interconnected nature of ALI and systemic cardiovascular instability (Folkert et al., 2018 [35]).

The amputation rate (37.8%) aligns with Ethiopian studies reporting 32.4%-52.9% amputation rates (Nebiyou et al. [22]). However, this is higher than the 15-25% reported in developed settings (Genovese et al. [19]). Above-knee amputations (77.4%) were more common, likely due to extensive ischemic damage at presentation.

However, in contrast, studies from Europe and North America report: Lower thrombotic ALI rates (50-60%) due to better anticoagulation adherence and More frequent use of endovascular therapy, reducing amputation rates (Keçeligil et al., 1999 [29]; Genovese et al., 2016 [19])

The 30-day mortality rate (12.2%) is comparable to global reports (10-38%) (Howard et al. [21]) but remains concerning. Predictors of mortality included: Severe MS (OR = 4.35, p = 0.021), Cardiac thrombus (OR = 7.1, $p < 0.001$), Pulmonary complications (OR = 5.71, p = 0.008). These findings confirm that ALI in cardiac patients is not just a vascular emergency but a systemic cardiovascular event (Folkert et al. [35]).

7. Strength and limitation

7.1. Strength

- ✓ **First study of its kind in Ethiopia** – Provides novel insights into ALI among cardiac patients in a resource-limited setting.
- ✓ **Large sample size for a single-center study** – 82 patients with detailed clinical and outcome data.
- ✓ **Comprehensive assessment** – Includes **etiology, presentation, interventions, and outcomes**, offering a **holistic view** of ALI in cardiac patients.
- ✓ **Strong statistical analysis** – Uses **logistic regression** to assess associations between risk factors and outcomes.
- ✓ **Real-world applicability** – Findings reflect **actual clinical challenges** in LMICs, making results generalizable to similar settings.
- ✓ **Comparison with global data** – Highlights disparities between resource-rich and resource-limited settings, emphasizing areas for improvement.

7.2. Limitation

- ✓ **Single-center design** – Limits generalizability to **other hospitals or rural settings**.
- ✓ **Retrospective nature** – Susceptible to **missing data and selection bias**.
- ✓ **Lack of long-term follow-up** – Outcomes beyond **30 days** (e.g., limb function, re-occlusion rates) were not assessed.
- ✓ **No endovascular interventions available** – Prevented comparison between **surgical and catheter-based therapies**.
- ✓ **Delayed presentation bias** – Since many patients **arrived late**, early-stage ALI cases may be underrepresented.
- ✓ **Limited imaging data** – **Angiographic confirmation** of ALI was unavailable in some cases, affecting diagnostic precision.
- ✓ **No assessment of anticoagulation adherence** – Could not determine how **anticoagulation practices influenced outcomes**.

8. Conclusion and recommendation

8.1. Conclusion

This study provides critical insights into the presentation, management, and outcomes of acute limb ischemia (ALI) among cardiac patients in a resource-limited setting. The findings underscore the significant role of cardiac thrombus, atrial fibrillation, and mitral stenosis in the etiology of ALI, with embolism being a major contributor. Despite advances in vascular intervention, delayed presentation and limited surgical capacity continue to challenge limb salvage and survival rates in Ethiopia.

A key finding was the high burden of thrombotic ALI (69.5%), which contrasts with data from high-income settings where embolic events dominate. This discrepancy may be attributed to suboptimal anticoagulation, higher rates of systemic atherosclerosis, and delayed intervention. The median symptom duration of 7 days before hospital presentation reflects critical delays in seeking medical care, leading to high amputation (37.8%) and mortality (12.2%) rates.

Furthermore, early intervention within 24 hours significantly improved limb viability and reduced amputation rates, reinforcing global evidence that timely thromboembolectomy or bypass is essential for limb salvage. The significant association between severe mitral stenosis and embolic ALI highlights the need for better screening and anticoagulation strategies in RHD patients, given its high prevalence in Ethiopia.

Overall, the study confirms that ALI in cardiac patients is not just a vascular emergency but a systemic cardiovascular event. Mortality predictors—including severe mitral stenosis, cardiac thrombus, and pulmonary complications—demonstrate the complex interplay between cardiac dysfunction and ALI progression. Integrated management strategies that address both cardiac and vascular complications are essential to improving patient outcomes.

8.2. recommendation

Based on the study findings, the following recommendations are proposed to improve early detection, intervention, and overall outcomes for cardiac patients with ALI in Ethiopia:

- Improve Early Diagnosis and Referral Systems

◈ Public and healthcare provider education – Awareness campaigns should focus on early recognition of ALI symptoms (e.g., the "6 Ps": pain, pallor, pulselessness, paresthesia, paralysis, poikilothermia) and the importance of rapid referral to vascular centers.

◈ Strengthen referral networks – Implement clear triage and transfer protocols to ensure ALI patients are quickly referred to specialized centers like Tikur Anbessa Specialized Hospital.

- Optimize Anticoagulation Strategies in High-Risk Cardiac Patients

◈ Routine anticoagulation for AF and severe MS – Given the high prevalence of embolic ALI from cardiac thrombi, patients with atrial fibrillation, mitral stenosis, or left ventricular thrombus should receive optimized anticoagulation therapy (e.g., warfarin, NOACs, LMWH) with follow up of appropriate lab indicators.

◈ Enhance INR monitoring services – Many patients may not receive adequate anticoagulation due to lack of monitoring. Establishing affordable INR testing centers can improve medication adherence and prevent thromboembolic complications.

- Strengthen Vascular Surgery and Endovascular Capabilities

◈ Increase vascular surgical capacity – Address limited availability of vascular surgeons and operating room time by training more vascular specialists and expanding surgical infrastructure.
◈ Improve access to diagnostic imaging – Bedside Doppler, CT angiography, and fluoroscopic imaging should be made more accessible for rapid diagnosis and decision-making.

- Address Delays in Surgical Intervention

◈ Reduce preoperative delays – The median time to intervention (31.5 hours) was significantly higher than the optimal window (<6 hours). Hospitals should implement fast-track surgical pathways for ALI patients.

◈ Expand access to catheter-directed thrombolysis – As an alternative to surgical thromboembolectomy, thrombolysis could be explored for patients presenting within early ischemic windows.

- Improve Postoperative and Long-Term Care

◈ Standardized post-surgical monitoring – Many ALI patients experience re-thrombosis, wound complications, and cardiac deterioration. Developing ALI-specific post-discharge follow-up programs can help track high-risk cases.

◈ Multidisciplinary approach – Integrate cardiology, vascular surgery, and rehabilitation services to provide comprehensive ALI care, reducing secondary amputations and mortality.

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