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Patterns, Clinical Management, and Outcomes of Acute Limb Ischemia: An Observational Study in Emergency Departments of Government Hospitals in Northern Border, Saudi Arabia

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Abstract **Objectives:** Acute limb ischemia (ALI) is a vascular emergency characterized by a sudden reduction in limb perfusion, threatening limb viability. It affects 10-12 individuals per 100,000 annually in Europe, with common causes including arterial thrombosis, embolism due to cardiac disease, and trauma. Timely intervention typically within 6 to 12 hours is critical to avoid irreversible damage, amputation, or death. The Rutherford Classification system provides a standardized framework to stratify the severity of ALI and guide management. **Objective:** To evaluate the clinical patterns, management strategies, and outcomes of adult patients presenting with acute limb ischemia in government emergency departments in Northern Saudi Arabia from October, 2021 to December, 2024. **Methods:** This observational analytic study was conducted at two tertiary care hospitals North Medical Tower Hospital and Prince Abdulaziz Bin Musaad Hospital. Data were retrospectively collected from medical records of adult patients presenting with post-traumatic or thromboembolic ALI. Variables included demographic details, comorbidities, Injury Severity Score (ISS), transfer timing, Rutherford classification, imaging and intervention details, and clinical outcomes. **Results:** A total of 27 patients with ALI were identified. The majority were males (81.4%), aged 40-60 years (55.5%). Common comorbidities included hypertension (33.3%), smoking (37%), and diabetes (14.8%). Most cases involved the lower limb (85.1%), with trauma and arterial thrombosis being the predominant etiologies. Preoperative CT angiography was performed in 55.5% of cases, particularly in Rutherford Class IIa and IIb patients. Class I (viable) was the most frequent presentation (85.1%), followed by Class IIa (7.4%), IIb (3.7%), and Class III (3.7%). Catheter-directed thrombolysis (48.1%) and surgical embolectomy (40.7%) were the most common interventions. Limb salvage was achieved in 92.5% of patients. Amputation was required in one Class III case, and one mortality occurred in a Class IIb case presenting with atrial fibrillation. **Conclusion:** The Rutherford Classification is a valuable tool for prognostication and decision-making in ALI. Lower limb involvement is more prevalent and associated with poorer outcomes, particularly when referral and intervention are delayed. Early recognition, timely referral to vascular surgery, and appropriate use of thrombolysis or embolectomy are crucial for optimizing limb salvage in resource-limited settings.

Key Words Acute Limb Ischemia (ALI), Rutherford Classification, Limb Salvage, Emergency Care, Northern Saudi Arabia

INTRODUCTION

Acute limb ischemia (ALI) is a vascular emergency characterized by a sudden decrease in limb perfusion that threatens both limb viability and patient survival. Globally, ALI has an estimated annual incidence of 10-12 per 100,000 individuals, as observed in population-based studies from Europe and the United Kingdom [1,2]. Although ALI is more prevalent in older adults due to atherosclerotic and

thromboembolic causes, it may also occur in younger individuals following trauma, including road traffic accidents (RTAs), which are a leading cause of limb injuries in regions like Saudi Arabia [3-5].

The predominant causes of ALI include arterial thrombosis (approximately 60%) and embolism (30%), with the remaining 10% attributed to trauma, dissection, and iatrogenic or rare etiologies [1,6,7]. In thrombotic ALI, an atherosclerotic plaque ruptures and precipitates thrombus formation, while embolic events often originate from cardiac sources such as atrial fibrillation, prosthetic valves, or myocardial infarction [8-10]. Trauma-related ALI, including blunt injuries and fractures, can compromise limb circulation via arterial rupture, systemic hypotension, or compartment syndrome [11-13]. In such cases, the absence of sufficient collateral supply and delayed intervention can rapidly escalate the risk of limb loss.

Clinical manifestations of ALI typically include the six classic "P's": pain, pallor, pulselessness, paresthesia, paralysis, and poikilothermia [14]. Irreversible muscle damage can begin within three hours of ischemia onset and becomes nearly complete by six hours due to microvascular collapse and anoxic injury [15,16]. Delayed diagnosis or referral beyond this critical window may result in permanent disability, gangrene, amputation, or even death.

In emergency settings, ALI evaluation relies on clinical assessment supported by diagnostic tools such as handheld Doppler ultrasound, duplex scans, and intraoperative angiography the latter being considered the gold standard [17-19]. Investigations such as serum lactate, creatine kinase, coagulation profile, renal function tests, and electrocardiography (ECG) are essential, especially to evaluate systemic impact and identify cardiac embolic sources [20,21]. The Ankle-Brachial Pressure Index (ABPI) may assist in diagnosis, although false positives can occur in calcified vessels [22]. Pulse oximetry is often a reliable adjunct for assessing distal perfusion [23].

The Rutherford classification remains the most widely accepted system for stratifying ALI severity, based on motor and sensory deficits, arterial and venous flow, and limb viability. It categorizes patients into Class I (viable), Class IIa/IIb (marginally to immediately threatened), and Class III (irreversible ischemia) [24]. This classification helps guide urgent clinical decisions and predict outcomes.

Management strategies range from systemic anticoagulation with heparin to catheter-directed thrombolysis, surgical embolectomy, bypass grafting, and fasciotomy when compartment syndrome is suspected [25-29]. Heparin is the first-line anticoagulant unless contraindicated and should be administered promptly to prevent thrombus propagation [30]. Surgical revascularization using Fogarty catheter embolectomy or vein bypass remains the standard for large artery occlusions, while thrombolytics like tissue plasminogen activator (tPA), streptokinase, or urokinase are considered for distal or microvascular obstructions [27,31]. In select cases, advanced limb salvage procedures such as local or free flap rotation may be viable alternatives to primary amputation [29].

Reperfusion injury, a major complication of delayed treatment, can result in systemic inflammatory responses, hyperkalemia, metabolic acidosis, acute renal failure, and multiorgan dysfunction syndrome (MODS) [32-34]. Compartment syndrome may accompany or follow revascularization and must be treated proactively with fasciotomy to prevent irreversible neurovascular damage [35].

Despite significant advances in vascular surgery and trauma protocols such as the Advanced Trauma Life Support (ATLS) algorithm, delayed diagnosis and referral remain critical barriers, especially in resource-limited settings [36-39]. This is particularly relevant in Northern Saudi Arabia, where vast geographic coverage and inconsistent access to vascular expertise contribute to treatment delays.

Objective

The present study aims to evaluate the patterns, clinical severity, interventions, and outcomes of acute limb ischemia in adult patients presenting to the emergency departments of government hospitals in the Northern Border Province of Saudi Arabia from October, 2021 to December, 2024.

MATERIALS AND METHODS

Study Design and Setting

This was a retrospective observational study conducted from October, 2021 to December, 2024 at the Accident and Emergency (A&E) Departments of two tertiary care government teaching hospitals in the Northern Border Province of Saudi Arabia: North Medical Tower Hospital and Prince Abdulaziz Bin Musaad Hospital, Arar. The study aimed to evaluate the clinical presentation, management, and outcomes of adult patients diagnosed with acute limb ischemia (ALI) of thromboembolic or traumatic origin.

Study Population

All adult patients (≥18 years of age) who presented to the emergency departments with a clinical diagnosis of acute limb ischemia between from October, 2021 to December, 2024 were considered for inclusion.

Inclusion Criteria

- Adults (≥18 years) with a confirmed diagnosis of ALI.
- ALI secondary to trauma**,** arterial thrombosis, or thromboembolism
- Patients who underwent any intervention or surgical evaluation for ALI

Exclusion Criteria

- Patients under 18 years of age.
- Patients with chronic limb ischemia, including diabetic foot or advanced peripheral arterial disease.
- History of prior lower limb revascularization (angioplasty, stenting, or bypass surgery).

- Known congenital cardiac or neurologic disorders.
- Incomplete medical records or undocumented outcomes.

Sampling and Recruitment Process

All cases of ALI presenting to the two participating hospitals during the defined one-year period were included without any sampling method. Data were collected retrospectively by reviewing hospital admission logs, vascular surgery records, and operating room reports. This approach ensured complete inclusion of eligible cases within the study timeframe, from October, 2021 to December, 2024. No recruitment or consent was required, given the retrospective nature of the data collection.

Data Collection Procedure

Data were retrospectively extracted from electronic medical records, operating room (OR) logs, and the hospital's digital archival system using a standardized data abstraction form. Two independent reviewers cross-verified the entries to minimize transcription errors and ensure consistency.

The following variables were recorded:

- **Demographics**: age, gender, comorbidities (e.g., hypertension, diabetes, smoking history, atrial fibrillation).
- **Clinical Presentation**: cause of ALI (trauma vs. thromboembolism), limb involved (upper vs. lower), Rutherford classification, Injury Severity Score (ISS).
- **Transfer Details**: referring hospital status, time from symptom onset to hospital arrival.
- **Diagnostic Workup**: imaging modalities (e.g., CT angiography), preoperative evaluations.
- **Management**: type and timing of interventions (e.g., thromboembolectomy, catheter-directed thrombolysis, bypass, fasciotomy).
- **Outcomes**: time to operating room, limb salvage, amputation, in-hospital mortality, and functional limb outcomes.

Statistical Analysis

Data were entered and analyzed using SPSS software version 16.0 (SPSS Inc., Chicago, IL, USA). Categorical variables were expressed as frequencies and percentages. No inferential or multivariate statistical models were applied due to the limited sample size; the analysis was limited to descriptive statistics.

Ethical Considerations

This study was approved by the local committee for bio ethics (LCBE), deanship of researches, Northern border university Arar and Institutional Review Board (IRB) of North Medical Tower Hospital. As the research was retrospective in nature and based on anonymized medical records, the requirement for informed patient consent was waived. All data were handled confidentially, and patient identifiers were removed during the extraction process. Ethical standards consistent with the Declaration of Helsinki were maintained throughout the conduct of the study.

RESULTS

A total of 27 patients diagnosed with acute limb ischemia (ALI) were identified over a one-year period. Most patients were male (81.4%) and between the ages of 40 and 60 years (55.5%). The most common comorbid conditions were hypertension (33.3%), a history of smoking (37%), and diabetes mellitus (14.8%). Atrial fibrillation was documented in one patient (3.7%) and was notably associated with an embolic event leading to irreversible ischemia and eventual limb amputation. Most patients presented with mild injury severity, defined as an Injury Severity Score (ISS) less than 9, which accounted for 85.8% of cases. Moderate and severe injuries were observed in 4.7% of patients each.

More than half of the patients (55.5%) were transferred from other hospitals, with 81.5% of these transfers occurring within two hours. A notable exception involved a single case that was referred after a delay of more than 12 hours, which resulted in primary amputation due to Class III (irreversible) ischemia. The majority of patients (85.1%) were taken to the operating room within six hours of arrival. Preoperative CT angiography was performed in 55.5% of cases and was more commonly used in Rutherford Class IIa and IIb presentations. One trauma-induced lower limb ischemia case (3.7%) also exhibited an associated venous injury.

Table 1 presents the demographic and clinical characteristics of the patient cohort. Lower limb involvement was predominant, accounting for 85.1% of cases (23 patients), while upper limb ischemia was seen in only 14.8% (4 patients). According to the Rutherford classification, Class I (viable) was the most common category, comprising 85.1% of cases. This was followed by Class IIa (7.4%), Class IIb (3.7%), and Class III (3.7%). The only case of primary amputation occurred in the patient with Class III ischemia, while the Class IIb patient succumbed to cardiac complications, resulting in a single in-hospital death.

Table 2 outlines the types of procedures performed and patient outcomes according to limb involvement. Catheter-directed thrombolysis (CDT) was the most frequently performed intervention, used in 48.1% of patients. It was particularly common among Class IIa and IIb cases and was utilized in nine lower limb and two upper limb cases. Surgical embolectomy was performed in 40.7% of patients and was predominantly applied in lower limb cases. One patient underwent bypass surgery due to extensive arterial occlusion. Amputation was performed in one patient who presented late with a degloving injury, and two patients were managed conservatively after receiving fasciotomy prior to hospital arrival.

In terms of outcomes, limb salvage was achieved in 92.5% of patients (25 out of 27). The remaining two cases included one amputation in a patient with Class III ischemia and one mortality in a patient with Class IIb ischemia. These findings support the association between timely intervention and positive limb salvage outcomes.

Table 1: Demographics and Pattern of Acute Limb Injuries Presenting to ER

Parameter	Number of Patients n = 27	Percentage
Age Distribution		
< 40 years	3	11.1%
40-60 years	15	55.5%
> 60 years	9	33.3%
Gender		
Male	22	81.4%
Female	5	18.5%
Co-morbidities		
Hypertension	9	(33.3%)
Diabetes Mellitus	4	(14.81%)
Smoking history	10	(37%)
Atrial fibrillation	1	(3.7%)
Injury Severity Score (ISS)		
Mild (ISS < 9)	23	85.82%
Moderate (ISS 9-15)	2	4.7%
Severe (ISS > 15)	2	4.7%
Transferred from another hospital		
Yes	15	55.5%
No	12	44.4%
Transfer Time (hours)		
< 2hrs	22	81.5%
2-6 hrs	4	14.8%
> 6hrs	1	3.7%
Time to OR (hours)		
< 6hrs	23	85.1%
6-12 hrs	3	11.1%
> 12 hrs	1	3.7%
Preoperative CT Angiography		
Yes	15	55.5%
No	12	44.4%
Rutherford Classification		
Class I (Viable)	23	85.1%
Class IIa (Marginally Threatened)	2	7.4%
Class IIb (Immediately threatened)	1	3.7%
Class III (Irreversible)	1	3.7%
Associated Venous Injury		
Yes	1	3.7%
No	26	96.2%
Overall Ischemic Limb Involvement		
Upper Limb	4	14.8%
Lower Limb	23	85.1%

Table 2: Type of Procedure, and Patient Outcomes in Upper and Lower Limb Acute Vascular Injuries

Parameter	Number of Patients n = 27 (%)	Upper Limb	Lower Limb
Type of Procedure			
Catheter Directed Thrombolysis (CDT)[26]	13 (48.1%)	2	9
Surgical Embolectomy	11 (40.7%)	1	8
Bypass Surgery	1 (3.7%)	0	1
Amputation (Primary)	1 (3.7%)	0	1
Conservative Management after fasciotomy (done before arrival)	2 (7.4%)	1	1
Patient Outcome			
Limb Salvage (Successful Revascularization)	25 (92.5%)	4	21
Amputation	1 (3.7%)	0	1
Mortality	1 (3.7%)	0	1

Table 3: Rutherford Classification and Patient Outcomes

Rutherford Classification	Number of Patients (n=27)	Limb Salvage	Amputation	Mortality
Class I (Viable)	23(85.15%)	23(85.15%)	0 (0%)	0 (0%)
Class IIa (Marginally Threatened)	2 (7.4%)	2 (7.4%)	0(0%)	0 (0%)
Class IIb (Immediately threatened)	1(3.7%)	0(0%)	0(0%)	1(3.7%)
Class III (Irreversible)	1 (3.7%)	0 (0%)	1 (3.7%)	0 (0%)

Table 3 summarizes the relationship between Rutherford classification and patient outcomes. All 23 patients classified as Class I achieved full limb salvage. The two patients in Class IIa also had successful outcomes. The patient in Class IIb died due to cardiac complications, and the patient in Class III required amputation following delayed referral. These results demonstrate a clear correlation between the severity of ischemia and clinical outcomes, with advanced Rutherford stages significantly increasing the risk of amputation and mortality, especially when accompanied by delayed intervention.

DISCUSSION

This study highlights important epidemiological and clinical characteristics of acute limb ischemia (ALI) in a resource-limited region of Northern Saudi Arabia. The findings align closely with international and regional literature, especially regarding the demographic profile, risk factors, and treatment outcomes associated with ALI.

Consistent with previous studies, the majority of patients were middle-aged to elderly males, with 81.4% being male and 55.5% between the ages of 40 and 60 years. This demographic pattern reflects known trends in trauma epidemiology and vascular disease, where males are more likely to be involved in road traffic accidents and outdoor activities, predisposing them to traumatic ALI [1-3]. Notably, all amputations in this cohort occurred in patients over 40 years of age, while patients under 40 years demonstrated a 100% limb salvage rate, reinforcing the association between younger age and favorable outcomes.

Hypertension (33.3%), smoking (37%), and diabetes mellitus (14.8%) emerged as the most prevalent comorbidities, particularly among patients with lower limb ischemia. These risk factors are well-documented in the literature as contributors to both thrombotic ALI and poorer prognoses [4-6]. A US-based population study similarly found that comorbidities and socioeconomic factors particularly in women and Black patients were associated with higher amputation and mortality rates [7]. In our cohort, one patient with atrial fibrillation (3.7%) experienced thromboembolic ALI resulting in amputation. Though infrequent in this study, atrial fibrillation is a critical risk factor, and its presence warrants urgent vascular evaluation, as supported by global and regional data [8-10].

Delay in treatment was a significant predictor of adverse outcomes. In our study, 55.5% of patients were referred from other facilities, with 81.5% arriving within two hours. However, a single case of delayed referral beyond 12 hours resulted in irreversible ischemia and amputation. This finding aligns with existing evidence indicating that delays beyond the critical 6-hour window are strongly associated with limb loss and mortality, especially in Rutherford Class IIb and III presentations [11-13]. These observations emphasize the need for timely triage, effective referral systems, and early intervention to optimize limb salvage.

The pattern of ischemic involvement mirrored global trends, with lower limb ALI accounting for 85.1% of cases. This distribution is consistent with reports from both high-income and resource-limited countries, including studies from the United States and Yemen, which documented similar rates of lower extremity involvement [7,14]. The disproportionate burden of lower limb ischemia reflects higher exposure to trauma and chronic vascular disease in these regions.

Rutherford classification proved to be a reliable predictor of outcomes. Class I cases, which represented 85.1% of the study population, had a 100% limb salvage rate. In contrast, Class IIb and III cases were associated with poor outcomes, including one death and one amputation, respectively. These results are consistent with findings from large multicenter studies in Japan and the United States, where Class IIb lesions were associated with significantly higher risks of in-hospital mortality and major amputation [13,15,16].

Injury severity score (ISS) also correlated with outcomes. Patients with mild ISS (<9) had favorable prognoses and accounted for the majority of limb salvage cases. In contrast, severe ISS cases, though few, had poor outcomes. These findings support the utility of injury severity scoring in early risk stratification, as previously described in trauma-focused studies [2,3].

Regarding management, catheter-directed thrombolysis (CDT) was the most frequently used intervention (48.1%) and showed high success in patients with Class I and IIa ischemia. This mirrors findings from other studies, which support the use of thrombolytics in select cases of ALI, especially where surgical options are limited or where vessels are too small for embolectomy [17,18]. Open surgical revascularization (OSR), including thromboembolectomy, was performed in 40.7% of patients and contributed to a limb salvage rate of 92.5%. This is comparable to the 76.9% amputation-free survival reported in a Yemeni study evaluating OSR in similar resource-constrained environments [14,18]. Moreover, a Japanese multicenter study found OSR to be more effective than endovascular therapy (EVT) in patients without pre-existing peripheral artery disease [15].

Venous injury, though uncommon, was identified in one case and resulted in a poor outcome. Literature suggests that combined arterial and venous injuries, particularly in high-energy trauma such as degloving or crush injuries, significantly increase the risk of amputation [19,20]. This further underscores the importance of addressing both inflow and outflow pathways during limb salvage efforts.

Finally, disparities in access to vascular expertise and delayed recognition of ischemic limbs remain pressing issues in rural and peripheral settings. The majority of patients in this study were referred from facilities lacking vascular surgery services. This delay, even when limited to a few hours, can result in progression from viable to irreversible ischemia. The declining incidence of ALI in high-income countries due to preventive measures and early detection contrasts sharply with the ongoing burden in underserved regions, highlighting the need for system-level reforms, awareness campaigns, and improved triage pathways [7,14,21].

This study reinforces that early identification, rapid referral, and timely intervention are essential for successful management of ALI. Public health measures targeting modifiable risk factors such as smoking and hypertension, coupled with improved access to vascular care, are vital for reducing the burden of ALI and its associated morbidity.

Limitations

This study had several limitations. The retrospective design carries inherent risks of selection bias, incomplete documentation, and variability in record-keeping across departments. The small sample size of 27 patients limits the generalizability of the findings and restricts statistical analysis to descriptive methods. Furthermore, the absence of a comparator group makes it difficult to draw definitive conclusions about the effectiveness of specific interventions. Delay in treatment could not always be quantified precisely due to incomplete documentation of symptom onset. Socioeconomic and geographic factors, which are likely to influence treatment delays and access to care, were not captured in this study and should be considered in future research.

CONCLUSIONS

The Rutherford classification proved to be a strong predictor of clinical outcomes in this study. Patients presenting with Class I and IIa acute limb ischemia (ALI) had excellent limb salvage rates, while those with Class IIb and III had significantly worse outcomes, including amputation and mortality. These findings reinforce the utility of this classification in guiding early triage, treatment decisions, and prognostication, particularly in emergency and resource-limited settings.

Lower limb ischemia was more common than upper limb involvement, consistent with global epidemiological data. Poor outcomes, including amputation, were associated with delayed referral beyond six hours, severe ischemic classification, and the presence of comorbid conditions such as hypertension, diabetes mellitus, and smoking. Younger patients, particularly those under 40 years of age, had higher rates of limb salvage, likely due to better vascular reserve and fewer comorbidities.

The application of ankle-brachial pressure index (ABPI) in lower limb ischemia can be limited due to arterial wall calcification, leading to false-positive readings. In such cases, toe pressure measurements offer a more accurate alternative. Compartment syndrome presents diagnostic difficulties, particularly when clinical signs are subtle or when patients are unconscious or heavily sedated. The lack of compartment pressure monitoring devices further complicates diagnosis. In such cases, early fasciotomy, based on clinical suspicion, remains critical to limb preservation.

Timely intervention remains a cornerstone of successful ALI management. Delays in referral from peripheral centers were associated with irreversible ischemia and limb loss. Most patients in this study were referred from rural areas lacking vascular surgical services, underscoring the need for streamlined referral pathways and better-equipped emergency departments. Awareness and education programs for frontline healthcare providers are crucial to improving early recognition and referral practices.

Future Directions

Future research should focus on optimizing standardized limb salvage protocols, especially for complex trauma-related ALI cases. Techniques such as local or free flap reconstruction may offer viable options for salvaging severely injured limbs, including those with degloving injuries. These cases, once deemed unsalvageable, may benefit from timely revascularization and innovative soft tissue coverage if referred within the salvageable window.

Delayed diagnosis and late referral were among the most important contributing factors to amputation in this cohort. There is a compelling need for regional awareness campaigns, clinical decision support tools, and institutional triage protocols to reduce preventable limb loss and improve survival in ALI patients.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to the conduct or publication of this study.

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