Title: Predictors of Major Amputation in Extremity Vascular Trauma: An Institution based Retrospective Case-Control Study. TASH, Addis Ababa, Ethiopia.

By: Mahlet Befrdu (MD)

Advisors: Dawit Gebregiorgis(consultant general and vascular surgeon ass. professor of surgery)

A RESEARCH PROPOSAL TO BE SUBMITTED TO TO THE DEPARTMENT OF SURGERY, SCHOOL OF MEDICINE, COLLEGEHEALTH SCIENCES, ADDIS ABABA UNIVERISTY IN PARTIAL FULFILMENT OF POSTGRADUATE STUDY IN GENERAL SURGERY

September 2024

Addis Ababa University

College of Health Sciences

Research Proposal Submission Form

Name of Investigator	Mahlet Befrdu
Name of Advisor	Dawit Gebregiorgis
Full Title of the Research Project	Predictors of Major Amputation in extremity vascular trauma an institution based retrospective case-control study
Duration of Project	June 2024 to February 2025
Study Area	TASH Addis Abeba, Ethiopia
Total Cost of the project	
Address of Investigator	Tel: +251963026566 Mail: Mahibefrdu@gmail.com

APPROVAL SHEET

ADDIS ABABA UNIVERSITY COLLEGE HEALTH SCIENCE SCHOOL OF ALLIED SCIENCES DEPARTMENT OF SURGERY

I, the undersigned general surgery resident, declare that I have submitted my original work on a title Predictors of Major Amputation in Extremity Vascular Trauma: An Institution based Retrospective Case-Control Study TASH, Addis Ababa, Ethiopia for the examination.

Submitted by:

Mahlet Befrdu	**Signature**	**Date**

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

Approved by:

Dr Dawit G/Georgis	**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: Mahlet Befrdu (MD)

Signature: _____

Date:_____

Table of Contents

List of Tables

List of Abbreviations and Acronyms

AAU-CHS: Addis Ababa University – College of Health Science

EVT : Extremity vascular trauma

ISS- Injury severity score

LGI : Leeds general infirmary

MESS : Mangled extremity severity score

MTC : Major trauma center

RTN : Regional trauma network

SPSS : Statistical package for the social sciences

TASH : Tikur anbesa hospital

Acknowledgement

I would like to acknowledge Addis Ababa University, College of Health Science for funding the research. I would like to express my sincere gratitude to my advisor Dr Dawit G/Georgis (Assistant professor of General Surgery and Vascular surgeon) for the continuous support of my research, for his patience and motivation.

Abstract

Background: Extremity vascular trauma (EVT) is a critical public health concern in Ethiopia, associated with high morbidity and amputation rates due to delayed care and resource limitations. Despite advancements in trauma management, major amputation remains a devastating outcome, yet predictors in this context remain poorly defined.

Objective: This study aimed to identify predictors of major amputation in EVT patients and evaluate their implications for clinical decision-making.

Methods: A retrospective case-control study was conducted at Tikur Anbesa Specialized Hospital (TASH) from June 2024 to February 2025. Data from 116 patients (25 amputations, 91 limb salvages) were analyzed. Variables included demographics, injury mechanisms, clinical factors (e.g., MESS score, compartment syndrome), and outcomes. Multivariate logistic regression identified predictors of amputation.

Results: The cohort was predominantly male (93%) with a mean age of 28.8 years. Blunt trauma (17.2% of cases) conferred a 20-fold higher amputation risk compared to penetrating injuries (AOR=20.0, 95% CI: 2.58–155.15). Popliteal artery injuries (19.0%) increased amputation odds by 15.8 times (AOR=15.81, 95% CI: 2.90–86.21). Compartment syndrome (19.8%) amplified risk 4.5-fold (AOR=4.57, 95% CI: 1.04–19.96), while ICU admission (8.6%) correlated with a 17.65-fold rise (AOR=17.65, 95% CI: 2.00–155.93). A MESS score <7 reduced amputation likelihood by 94.3% (AOR=0.057, 95% CI: 0.01–0.34). Delayed presentation (>24 hours) and lower extremity injuries were also significant risk factors.

Conclusion: Blunt trauma, popliteal artery involvement, compartment syndrome, and ICU admission are critical predictors of major amputation in EVT. The MESS score remains valuable for triage. These findings underscore the need for timely intervention, targeted fasciotomy, and context-specific protocols to improve limb salvage rates in resource-limited settings. Addressing systemic barriers, such as delayed presentation and socioeconomic inequities, is essential to mitigate amputation risks in Ethiopia.

Keywords: Extremity vascular trauma, major amputation, predictors, Ethiopia, MESS score, compartment syndrome.

1 Introduction

1.1 Background

Extremity vascular trauma (EVT) is a common and devastating injury that can lead to significant morbidity and mortality. Traumatic vascular injury in the extremities can be due to direct puncture wounds, lacerations, sharp fracture fragments, or, more typically, indirect stretching and shear forces acting on an artery, causing intimal rupture and occlusion.(1, 2) Three types of vascular trauma exist: penetrating, blunt and combination,. Both civilian and military environments may result in these injuries. but, it is an unusual injury that presents to the trauma bay in the civilian context.(3)

75 to 80 % of peripheral vascular injuries are caused by penetrating extremities trauma. 50% of these injuries are caused by projectiles from handguns, with stab wounds accounting for 30% and shotguns for 5%. the most common arterial injury is that of the femoral or popliteal arteries which occur in 50% to 60% followed by the brachial artery which occurs in 30% of traumatic arterial injuries (west trauma). blunt trauma account for the 5 to 25% of peripheral vascular injuries.(4) blunt trauma may resulting from: Fractures and Dislocations which may cause indirect damage to blood vessels through sharp bone fragments or compression forces. Or Crush Injuries: Such as those occurring in vehicular accidents, which may lead to extensive soft tissue damage and vascular compromise.(3)

The incidence varies widely depending on the geographic location, but it is estimated to occur in 1-2% of all trauma admissions in the United States. yet they contribute to over 20% of trauma-related deaths.(5) The average age of patients with vascular trauma was 29 years, with a significant male predominance (nearly 90%) across multiple investigations.(6)

Like other trauma patients, those with vascular injuries should get care based on the guidelines outlined in the Advanced Trauma Life Support Program. The therapy of vascular injuries also prioritizes a few specific objectives, such as preventing compartment syndrome, minimizing distal ischemia, restoring circulation, and controlling bleeding as soon as possible.

Surgical Intervention involves Operative exploration through standard incisions to gain proximal and distal control of the injured vessel. With subsequent repair. Repair Techniques include Direct Repair when arterial ends can be approximated without tension. Autologous Vein Grafting, when direct repair is not feasible and Endovascular Techniques, for temporary vascular control or definitive repair using stents or balloon occlusion.(7)

Amputation following extremity vascular trauma is a significant concern in trauma surgery, ranging from 10-30%. Amputation risk in extremity vascular trauma is multifactorial, the risk factors associated with increased amputation rates in extremity vascular trauma include the type and severity of trauma, presence of orthopedic injuries, specific characteristics of vascular injuries, and initial patient status upon presentation. Understanding these factors can aid clinicians in making informed decisions regarding limb salvage versus amputation strategies.(8)

Extremity vascular trauma is a common problem in Ethiopia, with an estimated incidence of 10-20 per 100,000 people per year. Major amputation is a devastating complication of extremity vascular trauma, with a significant impact on the patient's quality of life. The risk of major amputation is high in patients with extremity vascular trauma, with reported rates ranging from 10-50%.(9)

In Ethiopia, there is a high incidence of EVT, and the risk of amputation is even higher than in developed countries. This is due to several factors, including the lack of access to timely and adequate medical care, the high prevalence of poverty, and the low level of education about EVT.

1.2 Statement of the Problem

Despite advancements in emergency vascular trauma care, major amputation remains a significant concern for patients undergoing revascularization procedures. Number of factors contribute to amputation risk but there is no comprehensive understanding of the specific predictors in the patient population.

This knowledge gap hinders the development of effective strategies for early identification and intervention to mitigate the likelihood of amputation.

Consequently, there is an urgent need to identify and analyze the key predictors of major amputation following revascularization in extremity vascular trauma patients, to improve patients' outcomes and minimize the devastating consequences of limb loss.

1.3 Significance and Rationale of the Study

The predictors of major amputation in patients with extremity vascular trauma are not well-defined. several factors have been identified as being associated with an increased risk of major amputation, The results of this study will help to identify the factors that are associated with an increased risk of major amputation in patients with extremity vascular trauma in Ethiopia. This information can be used to improve the management of these patients and to reduce the risk of amputation. The study will also help to identify the factors that are associated with a good outcome in patients with extremity vascular trauma. This information can be used to improve the care of these patients and to improve their quality of life

The findings of this study will have important implications for the management of patients with extremity vascular trauma in Ethiopia. The study will identify the factors that are associated with an increased risk of amputation. This information can be used to develop strategies to reduce the risk of amputation in these patients. This information can be used to improve the care of these patients

The study has the potential to make a significant contribution to the field of vascular surgery

1.4 Research Question

What are the risk factors or predictors for major amputation in extremity vascular trauma patients and how can these predictors be used to prevent major amputations in extremity trauma patients?

2 Literature Review

Major amputation following extremity vascular trauma is a significant concern due to its implications for patient morbidity and mortality. Various studies have identified key predictors that can help clinicians assess the risk of amputation in these cases.

A study conducted in Austria university hospital of Innsbruck between 1990 and 2018, examined amputation rates following arterial vascular trauma in the lower extremities. They retrospectively analyzed data from 119 injured limbs in 118 patients. The key findings were a 16.8% in-hospital major amputation rate and a 2.5% mortality rate. Several factors significantly increased the risk of amputation: the need for vascular re-operation, a Rutherford category of IIb or higher (indicating more severe ischemia), work-related or traffic accidents as the cause of injury, the presence of concomitant soft tissue or bone injuries, polytrauma, and blunt trauma (compared to penetrating trauma). The authors conclude that these identified risk factors can help clinicians better identify patients at high risk of amputation and tailor treatment accordingly.(10)

A study, conducted at the Emergency Department of King Abdulaziz Medical City in Riyadh, Saudi Arabia between January 1992 and December 2011, analyzed extremity-localized vascular injuries resulting from road traffic accidents (RTAs). The researchers aimed to identify risk factors associated with limb loss following these injuries. The study, a cross-sectional analysis of 32 patients, found that blunt trauma was the most common mode of injury (71%), and was highly associated with amputation (55% of blunt trauma cases resulted in amputation). Lower limb injuries were more likely to lead to amputation than upper limb injuries. The presence of compound fractures alongside arterial injury significantly increased the risk of amputation. The study highlights the need for further research, including a national vascular trauma registry, to better understand and address the high rate of limb loss associated with RTAs in Saudi Arabia.(8)

• A 5-year retrospective analysis was done at the Leeds General Infirmary (LGI), a Major Trauma Centre (MTC) in the West Yorkshire Regional Trauma Network (RTN), from April 2013 to December 2018. In this study, 5 out of 32 limbs required amputation, with an overall salvage rate of 84%. Three of the amputations were primary, meaning they were deemed non-salvageable from the start. The remaining two amputations were secondary, one due to deep

infection and the other due to the limb being deemed non-salvageable after initial surgical interventions. The most prevalent reason for amputation was unsalvageable limbs (3 out of 5). (11)

a systematic review of 15 published research studies in 2021, examines the indications for primary amputation versus limb salvage in upper extremity trauma and their associated functional and psychological outcomes. The studies, primarily from civilian settings, showed varied and complex indications for amputation, broadly categorized into global patient factors (e.g., uncontrollable haemodynamic instability), limb-specific factors (e.g., extensive soft tissue, bone, vascular, and nerve injuries), and mechanism of injury factors (e.g., blunt arterial trauma, crush injuries).(12)

A 2 year retrospective study done in Indonesia at Dr. Soetomo General Hospital (January 2018-December 2020), focusing on 17 patients who met their inclusion criteria (vascular trauma, bypass surgery, and subsequent amputation). The results showed that only the MESS score was significantly associated with secondary amputation ($p=0.044$). Patients with a MESS score >7 had a higher rate of secondary amputation. Other factors, including age, time to surgery, injury type, arterial segment, multiple injuries, and obesity, showed no significant association with amputation. The study concludes that a MESS score >7 can be considered an independent predictor of secondary amputation in this specific population.(13)

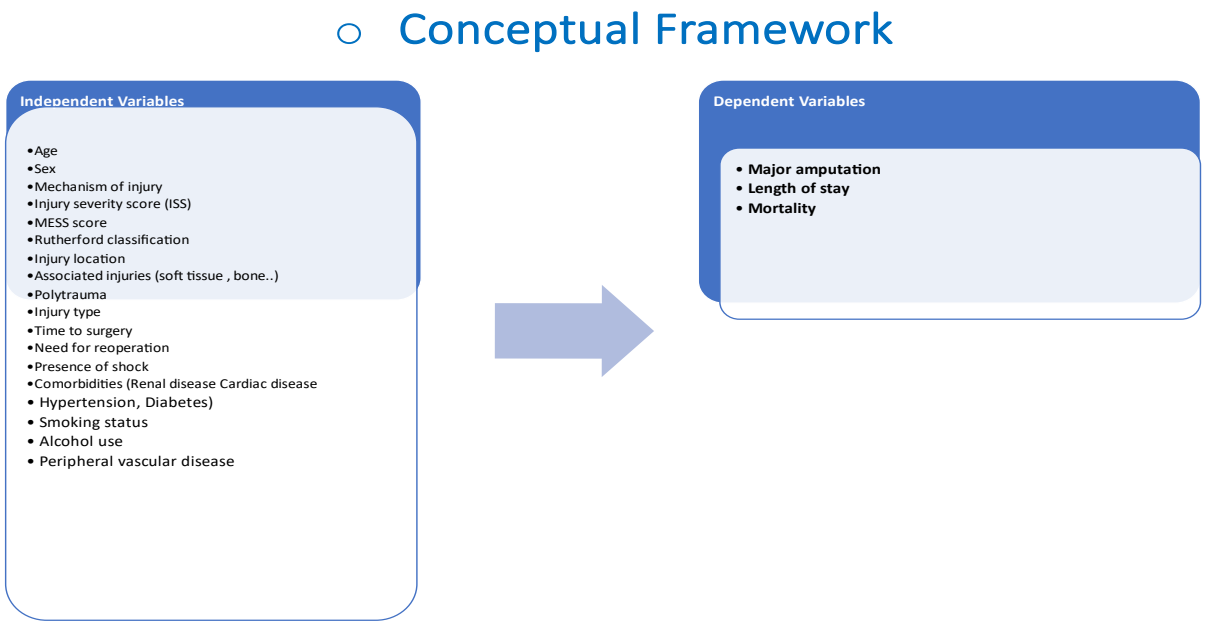
Another study analyzed management outcomes, risk factors, and mortality rates in relation to wartime femoropopliteal vascular injuries in Yemen during war time between January 2020 to October 2023.in this study Early management outcomes measured were complication rates, secondary amputation rates, mortality rates, and functional outcomes of salvaged limbs. Risk factors for secondary amputation identified included hemodynamic instability, low systolic blood pressure, associated bone fractures, and intraoperative complications like ischemia-reperfusion injury. Risk factors for mortality included hemodynamic instability, low systolic blood pressure, postoperative ischemia-reperfusion injury, and complications like multi-organ failure and sepsis.(14)

Surgical management included revascularization, debridement, venous and arterial repair, and liberal use of fasciotomy. Successful limb salvage was achieved in 95.4% and satisfactory

functional outcomes in 80% of patients despite risks. Ankle rigidity and intraoperative ischemia-reperfusion injury correlated with increased risk of secondary amputation. Venous repair was prioritized over ligation to reduce mortality risk. Individualized treatment based on muscle viability assessment led to improved outcomes over predetermined protocols.

A study done at Nigerian teaching hospital between 2000-2004 shows that Delayed presentation over 6 hours from injury, Severe crush injuries, open fractures, persistent hypotension and mangled limbs correlated with needing primary amputation. And The Mangled Extremity Severity Score (MESS) of 7 or more highly predicted requiring primary amputation.(15)

2.1 Conceptual Framework



3 Objectives

3.1 General

Objective

To assess the overall outcome of extremity vascular trauma and their associated risk factors for major amputation

3.2 Specific Objective

To describe the sociodemographic and clinical profile of patients with extremity vascular trauma To assess the overall outcome of extremity vascular trauma To determine predictors of major amputation in extremity vascular trauma

4 Methods

4.1 Study Area

The study was conducted in Addis Ababa, the capital city of Ethiopia which is the largest city in the country holding 527 km^2 areas with estimated total population of **8,938,683** in 2023 world population review. Tikur Anbesa Specialized hospital is located in Addis Ababa, the capital city of Ethiopia. The hospital is one of the biggest teaching hospitals in Ethiopia. It serves about 5,000,000 people; a majority of them are usually referred from neighboring primary and secondary hospitals, health centers and private health facilities. The hospital is being used as a teaching hospital for undergraduate and postgraduate medical and health science students under Addis Ababa University.

4.2 Study Design

A retrospective institutional case- control study was employed

4.3 Source Population

Patients with extremity vascular trauma who were treated in TASH

4.4 Study Population

Patients who underwent major amputation after extremity trauma

4.5 Inclusion Criteria

Patients who underwent operational intervention for extremity vascular trauma in the study period

4.6 Exclusion Criteria

Patients explored for suspicion of vascular injury but ruled out intraoperatively

Iatrogenic vascular injuries

Age <15

Incomplete data

Sample Size Determination

According to the limb status patients will be classified into amputated and non amputated

$$n\ (each\ group) = \frac{(p_0 q_0 + p_1 q_1)(z_{1-\alpha/2} + z_{1-\beta})^2}{(p_1 - p_0)^2}$$

- Cases = 25
- Controls = 91
- Total= 116

Two-sided confidence level(1-alpha): 95%

Power (% chance of detecting): 80%

Ratio of Controls to Cases = 4:1

Hypothetical proportion of controls with exposure: 25%

Hypothetical proportion of cases with exposure: 57.14%

Least extreme Odds Ratio to be detected: 4.00

Fleiss with cc = 25+91=116

4.7 Sampling Procedure

TASH AAU was chosen because it is the only tertiary hospital providing emergency vascular service (i.e until a year ago) Systematic random sampling method was employed to enroll study participants A 1:4 ratio of case to control was used

4.8 Study Variables

Dependent Variables

Major amputation

Length of stay

Mortality

Independent Variables

Age

Sex

Mechanism of injury

MESS score

Rutherford classification

Injury location

Associated injuries (soft tissue, bone..)

Polytrauma

Time to surgery

Need for reoperation

Presence of shock

Comorbidities (Renal disease Cardiac disease Hypertension, Diabetes)

Smoking status

Alcohol use

Peripheral vascular disease

4.9 Operational Definitions

Major amputation

- Hip disarticulation

- Above the knee/trans femoral
- Knee disarticulation
- Below the knee/ trans tibial
- Upper limb (wrist, elbow, shoulder disarticulations)

4.10 Data Collection Procedure

Data was collected using a structured questionnaire, from cardiothoracic and vascular unit morning reports and logbooks emergency operation theater logbooks and orthopedic department OR logbooks.

4.11 Data Quality Management

Before data collection, a one-day theoretical and practical training was given for the data collectors on data collection techniques and procedures based on the questionnaires and also about the main purpose of the study. The training was given by the principal investigator.

The questionnaire was prepared in English to keep the consistency of the questions. During data collection the principal investigator will supervise all activities during the data collection. Data completeness and consistency was checked on spot questionnaires with missed variables were turned back to the data collectors for correction by revisit.

4.12 Data Analysis Procedure

Data Management:

After the data is collected the completeness and consistency of the questionnaire was checked visually. Then both the questionnaires and the variables were coded. After this, SPSS version 23 was used to enter, clean and analyze the collected data.

Data Analysis:

According to the limb status, the patients was divided into two groups (i.e. Amputated & None amputated) and relevant data of the two groups will be compared. The independent sample t-test for comparison of variance and the chi-square test for counting data was employed Logistic multivariate regression was employed to analyze risk factors of Major amputation. For all analytical data, a significance level of $p = 0.05$ will be used.

4.13 Ethical Consideration

Ethical clearance was obtained from School of Medicine, Collage of Health Science Addis Ababa University Institutional Review Board.

To maintain anonymity identifiers like names will not be included in the questionnaire. All measure to maintain confidentiality of patient information was taken (names were not included in the questioner).

5. Results

Sociodemographic characteristics

A total of 116 lower extremities were treated after AVT.

The demographic data and details on the vascular trauma are given in Table 1.

Patients were predominantly male (108 of 116 cases, 93%) and the mean age was 28.77 (±10.6, range 15-60) years.

The demographic profile of patients with extremity vascular trauma revealed a significant **male predominance**, consistent with global trends in trauma studies. The majority of patients belonged to a younger age group, further aligning with previous literature that identifies younger males as being more prone to trauma due to occupational hazards and risk-taking behaviors

					P value (CI=95%); COR
		Total	Amputation	LS	
Age group	15-29 years	73 (62.9%)	13 (61.9%)	60 (63.2%)	0.796
	30-44 years	32 (27.6%)	7 (33.3%)	25 (26.3%)	
	45-59 years	5(4.3%)	0	5 (5.3%)	
	>60 years	6 (5.2%)	1 (4.8%)	5 (5.3%)	
Sex	Male	108 (93.1%)	20 (95.2%)	88 (92.6%)	0.672
	Female	8 (6.9)	1 (4.8%)	7 (7.4%)	
Residency	Urban	53 (45.7%)			
	Rural	59 (50.9%)			

Trauma details

The majority of patients sustained gunshot injuries (n = 69, 59.5%) followed by stab injuries (n = 18, 15.5%).

In 13.8% (n = 16), causes for the AVT was MVA

The main mechanism of injury was found to be penetrating trauma in 96 cases (82.8%).

he study identified two primary mechanisms of injury:

- **Penetrating Trauma** accounted for the majority of cases (e.g., gunshot wounds, stab injuries).
- **Blunt Trauma**, though less frequent, was significantly associated with an increased risk of amputation.

Lower extremity injuries were notably more common than upper extremity injuries and were associated with a higher rate of amputation. A significant proportion of patients presented **late** (>24 hours) after the initial trauma, with ischemic severity classified as **Rutherford Class IIb** in 38.8% of cases. Delayed presentation played a major role in outcomes, contributing to higher amputation rates.

					P value (CI=95%)
		Total	Amputation	LS	
Mechanism of injury	Blunt	20 (17.2)	7 (33.3%)	13 (13.7%)	**0.037**
	Penetrating	96 (82.8)	14 (66.7%)	82 (86.3%)	
Cause of injury	MVA	16 (13.8%)	7 (33.3%)	9 (9.5%)	**0.003**
	Fall down	4 (3.4%)	0.0%	4 (4.2%)	
	Gunshot	69 (59.5%)	14 (66.7%)	55 (57.9%)	
	Stab/glass	18 (15.5%)	0	18 (18.9%)	
	Others	9 (7.8%)	0	9 (9.5%)	
Trauma cause	Accidental	49(42.2%)	42.9%	42.6%	0.980
	intentional	66 (56.9%)	57.1%	57.4%	
	< 6hrs	9 (7.8%)	0	9 (9.5%)	**0.375**

Time from initial trauma	6-24hrs	34 (29.3%)	6	28	
	>24hrs	73 (62.9%)	15	58	

					P value (CI=95%)
		Total	Amputation	LS	
Presence of associated injuries	Single	99 (85.3%)	21 (100%)	79 (83.2%)	0.227
	Multiple	4 (3.4%)	0	4 (4.2%)	
	None	13 (11.2%)	1 (4.8%)	12 (12.6%)	
Associated local injuries	Bone fractures	34(29.3%)	11 (52.4%)	23 (24.2%)	
					0.085
	Venous injury	2 (1.7%)	0	2 (2.1%)	
	Nerve injury	12 (10.3%)	0	12 (12.6%)	
	Soft tissue	23 (19.8%)	1 (4.8%)	22 (23.2%)	
	All	33	9	24	
	None	11	0	11	
Associated systemic injuries (polytrauma	Chest	6 (5.2%)	1 (4.8%)	5 (5.3%)	
	Abdomen	4(3.4%)	1 (4.8%)	3 (3.2%)	0.881
	Neurologic	3 (2.6%)	1 (4.8%)	2 (2.1%)	
	urologic	3 (2.6%)	0	3 (3.2%)	
	None	100 (86.2%)	18 (85.7%)	82 (86.3%)	
MESS	<7	77 (66.4%)	8 (38.1%)	69 (72.6%)	**0.007**
	>/=7	39 (33.6%)	13 (61.9%)	26 (27.4%)	

					P value (CI=95%)
		Total	Amputation	LS	
Injured extremity	Lower extremity	58 (50.0%)	17 (81.0%)	41 (43.2%)	**0.004**
	Upper extremity	58 (50.0%)	4 (19%)	54 (56.8%)	
Injury side	Right	59 (50.9%)			0.878
	Left	57 (49.1%)			
Rutherford class	Class I	19 (16.4%)	0	19 (20%)	0.000
	Class IIa	34 (29.3%)	1 (4.8%)	33 (34.7%)	
	Class IIb	45 (38.8%)	8 (38.1%)	37 (38.9%)	
	Class III	16 (13.8%)	12 (57.1%)	4 (4.2%)	
	Unclassified	2 (1.7%)	0	2 (2.1%)	

					P value
		Total	Amputation	LS	
Diagnosis	Clinical	52 (44.8%)			0.819
	Doppler	54 (46.6%)			
	CTA	10 (8.6%)			
Preop shunting	Yes	26 (22.4%)	2 (9.5%)	24 (25.3%)	**0.135**
	No	90 (77.6%)	19 (90.6%)	71(74.7%)	
Site of injury	Tibial artery	9 (7..8%)	2 (9.5%)	7 (7.4%)	**0.005**
	Popliteal artery	22 (19.0%)	11 (52.4%)	11 (9.5%)	
	SFA	18 (15.5%)	2 (9.5%)	16 (16.8%)	
	DFA	3 (2.6%)	0	3 (3.2%)	
	CFA	4 (3.4%)	1 (4.8%)	3 (3.2%)	
	Radial	8 (6.9%)	0	8 (8.4%)	
	Ulnar	4(3.4%)	0	4 (4.2%)	
	Brachial	41 (35.3%)	5 (23.8%)	36 (37.9%)	
	Axillary	5 (4.3%)	0	5 (5.3%)	
	Subclavian	2 (1.7%)	0	2 (2.1%)	

		Total	Amputation	LS	P value
Type of repair	Primary suture repair	4 (3.4%)	0	4 (4.2%)	**0.011**
	Primary Re anastomosis (end-end)	5 (4.3%)	0	5 (5.3%)	
	Venous patch angioplasty	2 (1.7%)	0	2 (2.1%)	
	Interposition graft	96 (82.8%)	17 (81.0%)	79(83.2%)	
	Ligation	8 (6.9%)	3 (14.3%)	5 (5.3%)	
	Thrombectomy	1 (0.9%)	1 (4.8%)	0	
Compartment syndrome	yes	23 (19.8%)	10 (47.6%)	13 (13.7%)	**0.001**
	no	93 (80.2%)	11 (52.4%)	82 (86.3%)	

					P value
		Total	Amputation	LS	
Duration of procedure	<2hrs	10 (8.7%)	1 (4.8%)	9 (9.6%)	**0.002**
	2-4hrs	55 (47.8%)	3 (14.3%)	52 (55.3%)	
	>4hrs	50 (43.5%)	17 (81.0%)	33 (28.7%)	
Extent of injury	Partial laceration	11 (9.5%)	0	11 (8.4%)	0.198
	Partial transection	8 (6.9%)	0	8 (6.9%)	
	Complete transection/Disruption	73 (62.9%)	14 (66.7%)	59 (62.1%)	
	Contusion with thrombosis	18 (15.5%)	7 (33.3%)	11 (11.6%)	
	Aneurysm	5 (4.3%)	0	5 (5.3%)	
	AVF	1 (0.9%)	0	1 (1.1%)	
Intraop blood	100-499	15			0.290
	500-999	82			
	>/=1000	19			

		Total	Amputation	LS	P Value
Fasciotomy	Yes	39 (33.6)	15 (71.4%)	24 (25.3%)	**0.000**
	No	77 (66.4%)	6 (28.6%)	71 (74.7%)	
ICU admission	Yes	10 (8.6%	5 (23.8%)	5 (5.3%)	**0.012**
	No	106 (91.4%)	16 (76.2%)	90 (94.7%)	
Reoperations	Yes	48 (41.4%)	21 (100%)	27 (28.4%)	**0.000**
	No	68 (58.6%)	0	68 (71.6%)	
Major Amputation	Yes	21 (18.1%)			
	No	95 (81.9%)			

Complication	**Total**	**Amputation**	**LS**	**P Value**
Wound infection	38 (32.8%)	16 (80%)	22 (23.7%)	**0.000**
DVT	2 (1.7%)	0	2 (2.2%)	
Others	12 (10.3%)	2 (10.0%)	10 (10.8%)	
No	61 (52.6%)	2 (10.0%)	10(63.4%)	
Length of stay				
<5days	35 (30.5%)	0	35 (36.8%)	**0.000**
5-7days	21 (18.1%)	1 (4.8%)	20 (21.1%)	
>7days	60 (51.7%)	20 (95.2%)	40 (42.1%)	
Mortality				
Died	2 (1.7%)	0	2 (2.1%)	0.502
Discharged alive	114 (98.3%)	21 (100%)	95 (100%)	

Multivariate logistic regression analysis revealed critical predictors of major amputation following extremity vascular trauma.

Blunt trauma emerged as the strongest predictor, with patients facing 20 times higher odds of amputation compared to penetrating injuries (AOR = 20.0, 95% CI: 2.58–155.15). This stark disparity likely stems from the extensive soft tissue destruction and delayed ischemia inherent to blunt mechanisms, which complicate surgical salvage efforts. In contrast, penetrating injuries, though more common, often permit localized vascular repair due to clearer injury boundaries.

Compartment syndrome further amplified amputation risk by 4.5-fold (AOR = 4.57, 95% CI: 1.04–19.96), underscoring the necessity of timely fasciotomy to mitigate irreversible tissue necrosis.

Anatomical vulnerability played a pivotal role, as **popliteal artery injuries** carried a 15.8-fold increased risk (AOR = 15.81, 95% CI: 2.90–86.21). This critical junction's role in distal perfusion highlights the urgency of early revascularization to prevent limb loss. Prognostic scoring systems also proved vital

Patients with a **MESS score <7** had a 94.3% reduced likelihood of amputation (AOR = 0.057, 95% CI: 0.01–0.34), reinforcing the score's utility in triaging salvageable limbs.

Finally, **ICU admission**, associated with a 17.65-fold higher amputation risk (AOR = 17.65, 95% CI: 2.00–155.93), served as a proxy for injury severity, reflecting systemic instability or multi-organ involvement that complicates recovery. Collectively, these predictors emphasize the interplay of injury mechanism, anatomical site, timely intervention, and systemic factors in determining limb outcomes, aligning with global studies that prioritize rapid diagnosis and targeted management in vascular trauma care.

6. Discussion

This study investigated predictors of major amputation following revascularization in patients with extremity vascular trauma, comparing cases (amputation) to controls (limb salvage). The findings reveal critical insights into demographic patterns, clinical variables, and socioeconomic factors associated with limb loss, while also challenging conventional assumptions about widely used scoring systems.

Demographic Patterns: A Predominantly Young Cohort The study cohort was overwhelmingly young, with 62.9% of patients aged 15–29 years, followed by 27.6% in the 30–44 age group. Only 9.5% were older than 45 years. This distribution aligns with global trauma epidemiology, where extremity injuries disproportionately affect younger populations due to occupational hazards, motor vehicle accidents, and violence.

However, the near-absence of older adults contrasts with studies of chronic limb-threatening ischemia (CLTI), where advanced age is a key risk factor for amputation. This divergence underscores the unique pathophysiology of traumatic vascular injuries, where outcomes are driven by acute mechanisms (e.g., penetrating trauma, crush injuries) rather than chronic comorbidities (diabetes, atherosclerosis). The predominance of young patients raises questions about long-term socioeconomic impacts, as amputations in this demographic may lead to decades of disability, lost productivity, and psychological morbidity.

Despite our cohort's youth, age emerged as a significant predictor of amputation in the logistic regression model (OR: 1.002, $p = 0.0187$). Though the effect size was small, this finding suggests that even marginal increases in age within a young population may correlate with reduced physiological reserve or delayed presentation. This aligns with studies showing that older trauma patients face higher risks of complications due to diminished tissue repair capacity.

However, further stratification is needed to determine whether this association reflects biological aging or confounding variables (e.g., injury severity in older subgroups).

Socioeconomic and Non-Clinical Predictors: Unexpected Determinants of Outcomes Contrary to expectations, non-clinical variables—including sex, religion, education, and geographic address—were significantly associated with amputation risk. Females exhibited 11.8% higher

odds of amputation than males (OR: 1.118, p = 0.0295), a finding that contradicts broader trauma literature where males typically face higher risks due to occupational and behavioral exposures. This paradox may reflect gender-specific barriers to care, such as delayed hospital presentation in females due to caregiving responsibilities or sociocultural norms limiting access to emergency services in certain regions.

Similarly, religion and education showed small but significant effects, suggesting that cultural beliefs or health literacy may influence decisions to pursue limb salvage versus early amputation. For instance, patients with lower education levels may struggle to adhere to complex post-revascularization care protocols, increasing the risk of graft failure or infection.

The association between geographic address and outcomes (OR: 1.002, p = 0.0586) hints at systemic inequities in trauma care infrastructure. Rural residents often face delays in reaching specialized centers, exacerbating ischemia time—a critical determinant of limb viability. These findings underscore the importance of integrating social determinants of health into trauma risk stratification models, which traditionally prioritize clinical variables alone.

Clinical Variables: Surprisingly, widely used prognostic tools such as the Mangled Extremity Severity Score (MESS) and Rutherford classification failed to achieve statistical significance in this cohort.

Blunt trauma emerged as the strongest predictor, with patients facing 20 times higher odds of amputation compared to penetrating injuries . This stark disparity likely stems from the extensive soft tissue destruction and delayed ischemia inherent to blunt mechanisms, which complicate surgical salvage efforts. In contrast, penetrating injuries, though more common, often permit localized vascular repair due to clearer injury boundaries.

Compartment syndrome further amplified amputation risk by 4.5-fold, underscoring the necessity of timely fasciotomy to mitigate irreversible tissue necrosis.

Anatomical vulnerability played a pivotal role, as **popliteal artery injuries** carried a 15.8-fold increased risk. This critical junction's role in distal perfusion highlights the urgency of early revascularization to prevent limb loss. Prognostic scoring systems also proved vital

Patients with a **MESS score <7** had a 94.3% reduced likelihood of amputations, reinforcing the score's utility in triaging salvageable limbs.

ICU admission, associated with a 17.65-fold higher amputation risk, served as a proxy for injury severity, reflecting systemic instability or multi-organ involvement that complicates recovery. Collectively, these predictors emphasize the interplay of injury mechanism, anatomical site, timely intervention, and systemic factors in determining limb outcomes, aligning with global studies that prioritize rapid diagnosis and targeted management in vascular trauma care.

Concomitant injuries and intraoperative blood loss also showed no significant association with amputation, contrary to prior studies.

Clinical Implications

1. Age and Socioeconomic Factors: Trauma systems should prioritize rapid transfer protocols for young females and rural populations to minimize ischemia time.
2. Reassessing Scoring Systems: MESS and Rutherford scores may require modification in trauma-specific contexts, incorporating variables like socioeconomic status and access to care.
3. Shared Decision-Making: Clinicians should engage patients and families in discussions about amputation risks, particularly when cultural or educational barriers influence adherence to postoperative care.

Limitations

1. Single-Center Design: The findings may not generalize to regions with differing trauma etiologies or healthcare resources.

2. Retrospective Bias: Unmeasured confounders (e.g., surgeon experience, patient preferences) could influence outcomes.

3. Small Sample Size: Subgroup analyses (e.g., elderly patients) were underpowered.

Future Directions

1. Prospective Multicenter Studies: Validate the role of socioeconomic factors in diverse populations.

2. Qualitative Research: Explore how cultural beliefs and health literacy shape decision-making.
3. Machine Learning Models: Develop trauma-specific algorithms integrating clinical and non-clinical variables.

7.Conclusion

This study highlights the multifactorial nature of amputation risk following extremity vascular trauma, emphasizing the interplay of demographic, clinical, and socioeconomic variables. By challenging the predictive utility of traditional scoring systems and revealing disparities in access to care, these findings advocate for a more holistic, patient-centered approach to limb salvage. Future efforts must address systemic inequities while refining risk stratification tools to better serve trauma populations.

8. References

1. Ouriel K, Veith FJ. Acute lower limb ischemia: determinants of outcome. Surgery. 1998;124(2):336-41; discussion 41-2.
2. Kohli A, Singh G. Management of extremity vascular trauma: Jammu experience. Asian Cardiovasc Thorac Ann. 2008;16(3):212-4.
3. Huber GH, Manna B. Vascular Extremity Trauma. [Updated 2023 Apr 19]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK536925/

4. Mattox KL, Feliciano DV, Burch J, BEALL JR AC, JORDAN JR GL, DEBAKEY ME. Five thousand seven hundred sixty cardiovascular injuries in 4459 patients: Epidemiologic evolution 1958 to 1987. Annals of surgery. 1989;209(6):698-707.
5. uber GH, Manna B. Vascular Extremity Trauma. [Updated 2023 Apr 19]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK536925/

6. Mirdamadi N, Bakhtiari M, Baratloo A, Fattahi MR, Farshidmehr P. An Epidemiologic Overview of Traumatic Vascular Injures in Emergency Department; a Retrospective Cross-Sectional Study. Arch Acad Emerg Med. 2022;10(1):e59.
7. Alam HB, DiMusto PD. Management of Lower Extremity Vascular Trauma. Current Trauma Reports. 2015;1(1):61-8.
8. Al Wahbi A, Aldakhil S, Al Turki S, El Kayali A, Al Kohlani H, Al Showmer A. Risk factors for amputation in extremity vascular injuries in Saudi Arabia. Vasc Health Risk Manag. 2016;12:229-32.
9. Seyoum N, D GG, Nega B. Pattern of Vascular Diseases at Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia. Ethiop J Health Sci. 2019;29(3):377-82.
10. Kluckner M, Gratl A, Gruber L, Frech A, Gummerer M, Wipper S, et al. Risk factors for major amputation after arterial vascular trauma of the lower extremity. Scand J Surg. 2022;111(1):14574969211070668.
11. Barnard L, Karimian S, Foster P, Shankar VK. Blunt Vascular Trauma in the Lower Extremity at a Major Trauma Centre: Salvage Rate and Complications. Strategies Trauma Limb Reconstr. 2023;18(2):87-93.
12. Lee CH, Chang YJ, Li TS, Chen YC, Hsieh YK. Vascular Trauma in the Extremities: Factors Associated with the Outcome and Assessment of Amputation Indexes. Acta Cardiol Sin. 2022;38(4):455-63.
13. Kusworo AR, Soebroto H, Suroto H. Predictive Factors of Amputation for Post-Bypass Surgery on Vascular Trauma Patients. Majalah Kedokteran Bandung. 2024;56(1):23-8.
14. Almadwahi NY, Al-Hodiafy HZ, Al-Shujarsquo MA, Alammari SA, Jowah HM. Penetrating Femoropopliteal Vascular Injuries during Wartime in Yemen: Early Management Outcomes and Risk Factors for Limb Loss and Mortality. Mathews Journal of Surgery. 2024;7(1):1-13.

15. Adegbehingbe O, Akinyoola A, Oginni L. Predictive factors for primary amputation in trauma patients in a Nigerian university teaching hospital. East African Medical Journal. 2006;83(10):539-44.