Trauma Monthly 2023; 28(5): 907-913

10.30491/tm.2023.382381.1563

Trauma Monthly

Research Article

Outcomes of Blunt Trauma vs. Penetrating Trauma Popliteal Artery Injury

Alireza Azadvar[1], Seyed Masood Mousavi[2], Hossein Minaie Tork[2], Shaghayegh Sherafatmand[3], Hossein Ghaedamini[1*]

[1] Clinical Assistant of General Surgery, Department of Surgery diseases, School of Medicine, Golestan Hospital, Jundishapur University of Medical Sciences, Ahvaz, Iran.
[2] Assistant Professor of Vascular Surgery, Department of General Surgery, School of Medicine Golestan Hospital, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
[3] Assistant Professor of Surgery, Department of General Surgery, School of Medicine, Imam Khomeini Hospital, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
***Corresponding Author**: Hossein Ghaedamini; Clinical Assistant of General Surgery, Department of Surgery diseases, School of Medicine, Golestan Hospital, Jundishapur University of Medical Sciences, Ahvaz, Iran, Tel: +989133886532, Email: Ghaedaminih@gmail.com.

Received 2023-01-22; **Accepted** 2023-09-10; **Online Published** 2023-10-27

Abstract

Introduction: Popliteal artery injuries (PAIs) are among the most severe peripheral vascular injuries; they may lead to movement impairment or amputation. This study aimed to compare the repair results of PAIs following blunt and penetrating trauma in patients referred to our Vascular Surgery Center in southwest Iran.

Methods: In this cross-sectional study, 92 patients with vascular trauma referred to the Southwest Trauma Center of Iran in 2020 were assessed. The sampling method was census. The data collection tool was a checklist containing demographic information, medical information, vascular information, Functional Independence Measure (FIM) Score, Mangled Extremity Severity Score (MESS), and Injury Severity Score (ISS). The chi-square test, Fisher exact test, and independent *t-test* were used to compare categorical and quantitative data between case and control groups. Statistical analyses were conducted using SPSS version 24. The significance level considered was a p-value less than 0.05.

Results: In this study of 92 participants, 63.1% (58) had blunt trauma injuries (case group). The mean age of participants in the case group was 45.37 ± 9.14, and in the control group was 49.43 ± 10.65. The mean GCS of participants in the case group was 10.80 ± 1.30, and in the control group, it was 11.72 ± 0.70, and 10.6% of participants needed limb fasciotomy (1.7% in the case group and 26.3% in the control group). The amputation rate was 12% in the case group and 8.8% in the control group. There was a significant difference between the two groups in terms of organ fasciotomy ($P = 0.035$), type of PAI ($P = 0.018$), and fracture ($P = 0.007$). MESS ($P < 0.001$), FIM Score ($P < 0.001$), ISS ($P = 0.044$), time of discharge ($P < 0.001$), and arterial condition ($P < 0.001$).

Conclusions: The results showed that the complications of penetrating PAI (organ fasciotomy, type of fracture, ISS, MESS, FIM score, time of discharge, and arterial condition were significantly more than in blunt injuries.

Keywords: Blunt Trauma, Penetrating Trauma, Popliteal Artery, Vascular Surgery.

Introduction

Trauma is the first cause of death and one of the main causes of disability and handicap of the active population in developing countries and among the, Vascular trauma is one of the most dangerous types of injuries, requiring a quick and reliable diagnosis[1-3]. The prevalence of vascular trauma is 8%-10% caused by traffic accidents, gunshots, shotguns, and stab wound injuries[4-6]. Immediate surgeries (exploration, anastomosis, ligation, and graft) are the best treatment[2].

Among all lower extremity vascular injuries, popliteal artery injuries (PAI) are one of the most severe peripheral vascular damages that may lead to movement impairment or amputation[7,8]. Acute ischemia is one of the important side effects of PAI, which can lead to amputation or severe long-term complications[7-10]. We have less than 6 hours to prevent ischemia and reestablish blood circulation in the limb to prevent permanent injury. However, it depends on

other factors such as the level of injury, previous arterial disease, soft tissue trauma, and previous history of lower limb surgery[11,12].

The difference in the outcomes of blunt and penetrating popliteal artery traumas is an issue that has always been investigated by vascular surgeries[11-14]. The results of Banion et al. showed that there was no difference between the outcomes of PAIs due to blunt and penetrating traumas[15]. The results of Zhong et al. showed that the technical success rate of endovascular repair of blunt popliteal arterial injuries was 100%[16].

Due to limited studies all over the world about the difference in the outcomes of blunt and penetrating popliteal artery traumas and that no study has been conducted in the southwest of Iran, the present study aimed to compare the outcomes of blunt trauma with penetrating traumatic PAI repair in the southwest of Iran, showing that we can prevent the possible complications of each type of PAIs.

Methods

In this cross-sectional study, the statistical population was all patients with vascular trauma (penetrating and blunt) referred to the Southwest Trauma Center (Golestan Hospital in Ahvaz, affiliated to Jundishapur University of Medical Sciences, a significant Level I Urban Trauma Center) during 2020. The sampling method was census. This study was approved by the Ethics Committee of Jundishapur University of Medical Sciences (IR.AJUMS.HGOLESTAN.REC.1399.087).

Inclusion criteria for the case group were blunt PAIs and the need for emergency surgery, and for the control group, were penetrating PAIs and the need for emergency surgery too, the presence of PAIs was confirmed in the operating room (OR), and vascular surgeons performed all interventions. All cases had Computed Tomography Angiography (CTA) before intervention. The exclusion criteria for the case group were incomplete documents, and the death of patients before surgery, and the control group was undergoing previous surgery of the ipsilateral lower limb arteries and receiving primary surgical treatment before being transferred to our department.

The data collection tool was a checklist containing demographic information (age, gender), systolic blood pressure (SBP), diastolic blood pressure (DBP), Glasgow Coma Scale (GCS), comorbidities (diabetes, hypertension, coronary artery disease, and active smoker), preoperative antiplatelet therapy (aspirin and Plavix), organ fasciotomy, type of PAI, type of fracture, concomitant soft tissue damage, concomitant nerve damage, concomitant venous injury, need for angiography, ischemic time, time of hospitalization, time of intensive care unit (ICU) admission, time of surgery, Functional Independence Measure (FIM) Score, Mangled Extremity Severity Score (MESS), patient status at the time of discharge, arterial condition, and need for amputation.

The long-term consequences of surgery are measured with FIM, degree of disability, and the factors affecting it. FIM is a disability assessment scale for post-discharge victims divided from grade 1 (independent) to grade 4 (complete dependence on companions). In cases where it is greater than or equal to 6, the degree of severe functional disability is considered. In score 1, the patient can walk 150 m independently of others without assistive devices (mild disability). In score 2, the patient can walk independently of others but with the aid of 150 m or more (moderate disability). In score 3, the patient is dependent on the help of others but can walk with the help of others and with aids of 50 m (Moderate disability). In score 4, the patient is dependent on the use of others and cannot walk even 50 m with assistive devices (severe disability). Based on the score, it is decided whether to amputate or keep the limb; a recommendation for amputation at a score above 7[17-19].

MESS is a scoring system for injured organs based on the severity of the shock, blood pressure, type of trauma, degree of injury, age, and symptoms of ischemia. A score above seven needs amputation[20].

The ISS is calculated by taking the sum of the squares of the highest (Abbreviated Injury Scale) AIS from each of the three most severely injured body regions to achieve a score that ranges from 3 (least) to 75 (most) injured. By definition, an unsurvivable injury with an AIS of 6 is automatically given an ISS of 75.[21]

Quantitative and categorical data were expressed as mean (SD) (median, minimum, and maximum) and frequency (percentage), respectively. The chi-square, Fisher exact, and *independent t-tests* were used for categorical and quantitative data. Statistical analyses were conducted using SPSS version 24 (SPSS Inc, Chicago, Ill, USA). Significance level considered p-value less than 0.05.

Results

A total of 92 participants were included in this study, of whom 34 (36.9%) had penetrating trauma. The mean age of participants in the case group was 45.37 ± 9.14, and in the control group was 49.43 ± 10.65. 64.7 % of participants in the case group and 67.2 in the control group were male. The mean GCS of participants in the case group was 10.80 ± 1.30, and in the control group was 11.72 ± 0.70. There was no difference between the two groups in terms of age ($P > 0.05$), SBP ($P > 0.05$), DBP ($P > 0.05$), GCS ($P > 0.05$), comorbidity ($P > 0.05$), and preoperative antiplatelet therapy ($P > 0.05$; Table 1). The most common causes of blunt trauma were fracture (52.9 %) due to traffic accident and fall more than 4 meters, dislocation of the knee (38.5 %) due to traffic accident and fall more than 4 meters, and crushing injury due to traffic accident (8.6 %).

The most common causes of penetrating trauma were gunshot (47 %), shotgun (29.4 %), and stab wounds (23.6 %).

Table 1: Basic Characteristics of Participants.

Variable			Blunt Trauma (n=58)	Penetrating Trauma (n=34)	P value
			Mean ± SD/number (percentage)	Mean ± SD/number (percentage)	
Age (Year)			45.37 ± 9.14 (19-80)	49.43 ± 10.65 (18-77)	0.614
SBP (mm Hg)			11.63 ± 2.9	11.1 ± 3.44	0.361
DBP (mm Hg)			9.34 ± 3.7	9.5 ± 0.9	0.840
BMI (Kg/M^2)			31.23 ± 7.4	29.71 ± 6.1	0.591
GCS			10.8 ± 1.3	11.72 ± 0.7	0.214
Pre-hospital symptoms (Swelling, pain, numbness, mottling, ischemia)			79.3 (46)	82.3 (28)	0.319[a]
Male gender			64.7 (22)	67.2 (39)	0.540[a]
Comorbidity	Diabetes		11.7(4)	5.1(3)	0.251[a]
	Hypertension		20.5(7)	13.7(8)	0.459[a]
	Coronary artery disease		2.9(1)	1.7(1)	-
	Active smoker		41.1 (14)	34.4(20)	0.513[a]
Preoperative antiplatelet therapy	Aspirin		17.6 (6)	18.9 (11)	0.415[a]
	Plavix		5.8 (2)	6.8 (4)	0.187[a]
	None		76.6 (26)	74.3 (43)	0.318[a]
Mechanisms of trauma	Traffic accident	fracture	41.3 (24)	0 (0)	-
		Knee dislocation	32.7 (19)	0 (0)	
		crushing injury	8.6 (5)	0 (0)	
	Fall >4 meters	Fracture	11.6 (6)	0 (0)	
		Knee dislocation	5.8 (4)	0 (0)	
	Penetration	shotgun	0 (0)	29.4 (10)	
		gunshot	0 (0)	47 (16)	
	Stab Injury		0 (0)	23.6 (8)	

SBP, systolic blood pressure; DBP, diastolic blood pressure; GCS, Glasgow Coma Scale.
[a] Chi-squared test

The most common causes of blunt trauma were fracture (52.9 %) due to traffic accident and fall more than 4 meters, dislocation of the knee (38.5 %) due to traffic accident and fall more than 4 meters, and crushing injury due to traffic accident (8.6 %). The most common causes of penetrating trauma were gunshot (47 %), shotgun (29.4 %), and stab wounds (23.6 %). The results showed that 10.6% of participants needed limb fasciotomy (26.3% in the penetrating trauma group vs 1.7% in the blunt trauma group. Therapeutic fasciotomy was performed due to a definitive diagnosis of compartment syndrome by a vascular surgeon, and prophylactic fasciotomy was completed before the onset of the clinical compartment syndrome). The

amputation rate was 8.8% in the penetrating trauma group vs 12% in the blunt trauma group. There was a significant difference between the two groups in terms of organ fasciotomy (P = 0.035), type of PAI (P = 0.018), fracture (P = 0.007), MESS (P < 0.001), FIM Score (P < 0.001), time of discharge (P < 0.001), ISS (P = 0.044), arterial condition (P < 0.001; Table 2).

Five variables were recognized for further analysis with a multivariate logistic regression model, including age, gender, hospitalization time, mechanism of injury, and Type of PAI. By adjusting for those factors, all of them were not considered independent predictors of amputation in logistic regression analysis (P>0.05) (Table 3).

Table 2: Complications of Trauma Injury of Participants.

Variable		Blunt Trauma (n=58)	Penetrating Trauma (n=34)	P value
		n (%)	n (%)	
Organ fasciotomy	No	57 (98.3)	25 (73.7)	0.035[a]
	Primary	0 (0)	2 (5.8)	
	Therapeutic	1 (1.7)	7 (20.5)	
Type of PAI	Proximal	37 (63.9)	18 (53)	0.018[a]
	Middle	3 (5.2)	9 (24.6)	
	Distal	18 (31)	7 (13.2)	
Fracture	Hip	2 (3.4)	0 (0)	0.007[a]
	Tight	5 (8.6)	1 (2.9)	
	Knee	12 (20.6)	0 (0)	
	Calf	27 (46.5)	3 (8.8)	
Concomitant injury	Concomitant soft tissue damage	4 (6.9)	11 (32.3)	0.798[a]
	Concomitant nerve damage	1 (1.7)	3 (8.8)	0.753[a]
	Concomitant venous injury	3 (5.2)	4 (11.7)	0.979[a]
	Thorax injury	1 (1.7)	0 (0)	-
	Traumatic brain injury	2 (3.4)	0 (0)	-
	Basal skull fracture	5 (8.6)	0 (0)	-
	Forearm fractures	2 (3.4)	0 (0)	-
	Clavicular fractures	1 (1.7)	0 (0)	-
	Scapular fracture	1 (1.7)	0 (0)	-
Need for angiography		5 (8.6)	3 (8.8)	0.064[a]
-		Mean ± SD	Mean ± SD	-
Time interval between the trauma and the surgical intervention (hours)		9.45 ± 1.5	8.85 ± 1.3	0.452
Ischemic time (hours)		6.3 ± 2.6	5.7 ± 1.4	0.914
Time of hospitalization (day)		24.9 ± 1.6	22.4 ± 2.3	0.645
Time of ICU admission (day)		15.9 ± 1.4	13.8 ± 2.1	0.427
Time of surgery (hours)		3.7 ± 0.4	3.2 ± 0.9	0.07
MESS		5.3 ± 0.5 (3-9)	6.5 ± 0.7 (6-11)	<0.0001
ISS		14.3 ± 0.3	17.1 ± 0.5	0.044
FIM Score	1	26 (44.9)	13 (38.2)	<0.0001[a]
	2	32 (55.1)	21 (61.8)	
Patient status at the time of discharge	Complete recovery	41 (70.8)	21 (61.8)	<0.0001[a]
	Partial recovery	15 (25.8)	10 (29.4)	
	Expire	2 (3.4)	3 (8.8)	
Arterial condition	Intimal flap	6 (10.3)	1 (2.9)	<0.0001[a]
	Spasm	3 (5.1)	0 (0)	
	Complete cut	14 (24.5)	7 (20.6)	
	Thrombosis	32 (55.1)	24 (70.6)	
	Tearing	3 (5.1)	2 (5.9)	
Surgical Intervention	Saphenous vein graft	46 (79.6)	26 (75.6)	0.317[a]
	Polytetrafluoroethylene graft	10 (17.2)	6 (17.6)	
	Primary Repair	2 (3.4)	2 (5.9)	
Amputation	Minor	2 (3.4)	6 (10.3)	0.451[a]
	Major	1 (2.9)	1 (1.7)	

PAI, popliteal artery injury; ICU, intensive care unit; MESS, Mangled Extremity Severity Score; FIM, Functional Independence Measure. ISS, Injury Severity Score [a]Chi-squared test.

Table 3: Multivariate regression analysis of factors associated with limb loss.

Variable	OR	CI	P
Age	1.02	(94-1.15)	.661[a]
Male Gender	1.43	1.31-152	0.321[a]
Mechanism of injury	1.84	1.80-1.95	0.048[a]
Time of hospitalization	1.31	1.25-1.45	0.014[a]
Type of PAI	1.11	1.08	0.129[a]

Discussion

To our knowledge, this study is the first to investigate the outcome of PAI in the southwest of Iran. PAIs are uncommon, even in busy urban trauma centers, and limited data are available in the southwest of Iran about functional outcomes after it.

PAIs are often seen as fractures, dislocations, or penetrating injuries[4]. Concern for these problems is very important for organ preservation. Also, the time when patients arrive at the hospital can lead to a reduction in injuries. Most blunt popliteal injuries are not easily diagnosed and are dangerous (unlike penetrating injuries).

The mean score of MESS was statistically higher in the penetrating trauma group, which is similar to the results of Assieno et al.[11] (MESS was 5.62 in blunt trauma and 5.86 in penetrating trauma) and against the results of Simons et al.[11] (MESS was 6.52 in blunt trauma and 4.92 in penetrating trauma). The results can differ due to different sample sizes, statistical populations, and inclusion and exclusion criteria. Also, this research was conducted in southeast Iran, where the rate of accidents, crimes, and fights is very high [22].

The study of Simmons et al.[12] showed that MESS more than seven is the best independent prediction of amputation; however, 63% of patients with MESS more than seven did not require amputation. This suggests that MESS is predictive of amputation but should not be the only factor that determines the need for amputation after PAI. However, this issue was not investigated in the present study. We suggest that future studies in the southwest of Iran evaluate the predictivity of MESS for amputation.

The mean score of FIM and ISS was also statistically higher in the penetrating trauma group, which is similar to the study of Nikolaus et al. and against the study of Mulinex et al.[14]. The difference may be related to the limitations of the FIM score (non-trauma–specific design and the effect of preexisting disabilities in the assessment).

There was no significant difference in the amputation rate between the two groups, which is similar to Dua et al., who identified that blunt injury combined with fractures and an Injury Severity Score (ISS) > 9 was associated with the risk of amputation. In contrast, in a military group, penetrating injuries due to explosive devices are associated with worse functional outcomes and higher amputation [24]. Obniaon et al.[15] showed that the amputation risk was higher in blunt popliteal injury compromised with the penetrating group, which is similar to the results of Sciarretta et al. The results showed that multiple risk factors for amputation include MESS < 7, long ischemic time, pulseless distal limb, associated venous injury, severed nerves, open fractures, blunt injury, shock, and advanced age.

The results showed no significant association between the patient's body mass index (BMI) and amputation rate, which is inconsistent with the study of Simmons et al. They showed that BMI was significantly higher in the blunt trauma group than in the penetrating group. The prevalence of obesity is increasing in Iran. Obesity is an independent risk factor in various diseases, especially trauma. The results of Simons et al. showed that a BMI of more than 40 can lead to lower limb amputation [23].

The results showed that there was no difference in the fasciotomy rate between the two groups, which is similar to the effects of Kauvar et al.[25], Mulinex et al.14, and Sciarretta et al.[26]. It can be concluded that performing fasciotomy does not have any association with the type of trauma.

The results showed that there was no difference in the time of hospitalization (day) and ICU admission (day) between the two groups; however, the study of Sciarretta et al.[26] showed that the time of hospitalization and ICU admission were longer in the blunt group.

The results showed no difference in the ischemic time rate between the two groups; however, many studies have shown that maintaining ischemic times as close as 6 hours may lead to improved outcomes for these difficult and rare injuries [11-14].

The results showed that the patient's status at the time of discharge was better in blunt PAI, which is not similar to the results of Cooper et al.[27], Sciarretta et al.[26], Mulinex et al.[14], and Kauvar et al.[25]. They verified that blunt trauma has a significantly worse outcome if compared with penetrating trauma. More studies are needed to confirm these results in the southeast of Iran. It may be because, in the present study, the patients did not only have problems with the popliteal vessels (pure vascular issues) but had more trauma on other parts of their body as well (such as the brain, chest, and abdomen), which affects their prognosis.

The results showed that the rate of fasciotomy was higher in blunt trauma than in penetrating trauma, which is similar to the results of Sciarretta et al.[26].

This study has several limitations, such as a small sample size, inhomogeneous trauma mechanism, different imaging of PAI, and variables such as ISS, dislocation, Limb Salvage Index, initial base deficit, and fasciotomy technique. In this study, we could not evaluate the functional status of extremities after PAI.

Conclusion

Popliteal artery trauma is relatively uncommon. The results showed that the complications of penetrating PAI included organ fasciotomy and type of fracture (P = 0.007). In southwest Iran, MESS, FIM Score, ISS, time of discharge, and arterial condition were significantly more than the blunt type. Our amputation rate was 9.1%, with no significant difference in rates between penetrating and blunt traumas (8.8% vs 12%). More studies are needed with larger sample sizes and extended durations.

Acknowledgments

The authors would like to thank the patients and personnel of Golestan Hospital for their cooperation in performing the present study.

Conflict of Interest Disclosures

The authors declare that they have no competing interests.

Funding Sources

This paper is adapted from a proposal with the same name, which was financially supported by Jundishapur University of Medical Sciences.

Authors' Contributions

M. M. conceived of the present idea. A. A. developed the idea and obtained written informed consent from the patients. H. G. wrote the manuscript. H. M. helped to conduct the literature review, verified the analytical methods, and wrote the manuscript. H. G. also helped to conduct the literature review. M. M. performed the experiments, whereas H. G. contributed to the analysis and wrote the manuscript. A. A. helped with the analyses and wrote the manuscript. All authors reviewed the results and approved the final version of the manuscript.

Ethical Statement

The study protocol was consistent with the ethical principles of Helsinki Declaration. It was approved by Research Ethics Committee of Jundishapur University of Medical Sciences with the Ethical ID IR.AJUMS.HGOLESTAN.REC.1399.087.

Abbreviations

PAI: Popliteal artery injuries
MESS: Mangled Extremity Severity Score
FIM: Functional Independence Measure
ISS: Injury Severity Score
AIS: Abbreviated Injury Scale
SBP: Systolic Blood Pressure
DBP: Diastolic Blood Pressure
GCS: Glasgow Coma Scale
ICU: Intensive Care Unit

References

1- Mohammadi M, Enhesari A, Ghaedamini H, Amirbeigi A, Farahbakhsh S. Investigating the Diagnostic Accuracy of Focused Assessment with Sonography in Trauma (FAST) Compared to CT Scan in Patients with Blunt Abdominal Trauma. J Babol Univ Med Sci 2023; 25 (1) :143-151

2- Aguirre AO, Soliman MA, Azmy S, Khan A, Jowdy PK, et al, Pollina J. Incidence of major and minor vascular injuries during lateral access lumbar interbody fusion procedures: A retrospective comparative study and systematic literature review. Neurosurg Rev. 2021 Dec 1:1-5.

3- Shahien AA, Sullivan M, Firoozabadi R, Lu K, Cannada L, et al. Combined Orthopaedic and Vascular Injuries with Ischemia: A Multicenter Analysis. J Clin Orthop Trauma. 2021 Oct 1;35(10):512-6.

4- Tai NR, Rasmussen TE. Epidemiology of Vascular Injury. InRich's Vascular Trauma. 2016 Jan 1 (pp. 13-20).

5- Georgakarakos E, Efenti GM, Koutsoumpelis A, Veloglou AM, Mechmet B, et al. Five-Year Management of Vascular Injuries of the Extremities in the "Real-World" Setting in Northeastern Greece: The Role of Iatrogenic Traumas. Ann Vasc Surg. 2021 Jul 1; 74:264-70.

6- Bernhoff K, Michaʌlsson K, Bjurck M. Incidence and outcome of popliteal artery injury associated with knee dislocations, ligamentous injuries, and close to knee fractures: a Nationwide Population Based Cohort Study. Eur J Vasc Endovasc Surg. 2021 Feb 1;61(2):297-304.

7- Ramdass MJ, Muddeen A, Harnarayan P, Spence R, Milne D. Risk factors associated with amputation in civilian popliteal artery trauma. Injury. 2018 Jun 1;49(6):1188-92.

8- Futchko J, Parsikia A, Berezin N, Shah A, Stone Jr ME, et al. A propensity-matched analysis of contemporary outcomes of blunt popliteal artery injury. J Vasc Surg. 2020 Jul 1;72(1):189-97.

9- Guice JL, Gifford SM, Hata K, Shi X, Propper BW, et al. Analysis of limb outcomes by management of concomitant vein injury in military popliteal artery trauma. Ann Vasc Surg. 2020 Jan 1; 62:51-6.

10- Grigorian A, Wilson SE, Kabutey NK, Fujitani RM, de Virgilio C, Schubl SD, et al. Decreased national rate of below the knee amputation in patients with popliteal artery injury. Ann Vasc Surg. 2019 May 1; 57:1-9.

11- Asensio JA, Dabestani PJ, Miljkovic SS, Kotaru TR, Kessler JJ, et al. Popliteal artery injuries. Less ischemic time may lead to improved outcomes. Injury. 2020 Nov 1;51(11):2524-31.

12- Simmons JD, Gunter JW, Schmieg RE Jr, Manley JD, Rushton FW Jr, et al. Popliteal artery injuries in an urban trauma center with a rural catchment area: do delays in definitive treatment affect amputation? Am Surg. 2011 Nov;77(11):1521-5. PMID: 22196668.

13- Lang NW, Joestl JB, Platzer P. Characteristics and clinical outcome in patients after popliteal artery injury. J Vasc Surg. 2015 Jun 1;61(6):1495-500.

14- Mullenix PS, Steele SR, Andersen CA, Starnes BW, Salim A, Martin MJ. Limb salvage and outcomes among patients with traumatic popliteal vascular injury: an analysis of the National Trauma Data Bank. J Vasc Surg. 2006 Jul 1;44(1):94-100.

15- O'Banion LA, Dirks R, Saldana-Ruiz N, Farooqui E, Yoon WJ, Pozolo C, et al. Contemporary outcomes of traumatic popliteal artery injury repair from the popliteal scoring assessment for vascular extremity injury in trauma study. J Vasc Surg. 2021 Nov 1;74(5):1573-80.

16- Zhong S, Zhang X, Chen Z, Dong P, Sun Y, Zhu W, et al. Endovascular repair of blunt popliteal arterial injuries. J Korean Soc Radiol. 2016 Oct 1;17(5):789-96.

17- Kameyama Y, Ashizawa R, Honda H, Take K, Yoshizawa K, Yoshimoto Y. Sarcopenia affects Functional Independence Measure motor scores in elderly patients with stroke. J Stroke Cerebrovasc Dis. 2022 Aug 1;31(8):106615.

18- Lee EY, Sohn MK, Lee JM, Kim DY, Shin YI, Oh GJ. Changes in Long-Term Functional Independence in Patients with Moderate and Severe Ischemic Stroke: Comparison of the Responsiveness of the Modified Barthel Index and the Functional Independence Measure. Int J Environ Res Public Health. 2022 Aug 4;19(15):9612.

19- Rabinowitz AR, Chervoneva I, Hart T, O'Neil-Pirozzi TM, Bogner J, Dams-O'Connor K, et al. Influence of prior and intercurrent brain injury on 5-year outcome trajectories after moderate to severe traumatic brain injury. J Head Trauma Rehabil. 2020 Jul 1;35(4): E342-51.

20- Hohenberger GM, Konstantiniuk P, Cambiaso-Daniel J, Matzi V, Schwarz AM, Lumenta DB, et al. The mangled extremity severity score fails to be a good predictor for secondary limb amputation after trauma with vascular injury in Central Europe. World j surg. 2020 Mar;44(3):773-9.

21- Corneille M, Gallup T, Villa C, Richa J, Wolf S, Myers J, et al. Pediatric vascular injuries: acute management and early outcomes. J Trauma,2011: 70:823–8

22- Rakhshani T, Motlagh Z, Hezarvand Zanganeh P, Farsi D, Bizhani B, et al. An Epidemiological Study of Traffic Accidents Leading to Pedestrians' Death in Ahvaz, Iran in 2015-2017. J Health Sci Surveill Syst. 2022 Apr 1;10(2):210-5.

23- Vaisi-Raygani A, Mohammadi M, Jalali R, Ghobadi A, Salari N. The prevalence of obesity in older adults in Iran: a systematic review and meta-analysis. BMC geriatrics. 2019 Dec;19(1):1-9.

24- Dua A, Desai SS, Shah JO, Lasky RE, Charlton-Ouw KM, et al. Outcome predictors of limb salvage in traumatic popliteal artery injury. Ann Vasc Surg. 2014 Jan 1;28(1):108-14.

25- Kauvar D, Sarfati M, Kraiss L. National trauma databank analysis of mortality and limb loss in isolated lower extremity vascular trauma. *J Vasc Surg.* 2011;**53**(6):1598–1603.

26- Sciarretta JD, Macedo FI, Otero CA, Figueroa JN, Pizano LR, Namias N. Management of traumatic popliteal vascular injuries in a level I trauma center: a 6-year experience. Int J Surg. 2015 Jun 1; 18:136-41.

27- O'Banion LA, Dirks R, Saldana-Ruiz N, Farooqui E, Yoon WJ, Pozolo C, et al. Contemporary outcomes of traumatic popliteal artery injury repair from the popliteal scoring assessment for vascular extremity injury in trauma study. J vasc surg. 2021 Nov 1;74(5):1573-80.

28- Cooper N, Roshdy M, Sciarretta J D, Kaufmann C, Duncan S, Davis J. Multidisciplinary team approach in the management of popliteal artery injury. J Multidiscip Health c, 2018: 11:399-403.