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Popliteal Artery Injuries: Incidence, Clinical Patterns and Outcomes (A Single Center Study in Yemen)

Nabeel Almadwahi[1], Fahd Ali Alfahd[2], Ali Fadhel[3], Mohamed Alshujaa[4], Abdulhafeedh Al-Habeet[5*], Mohammed S Najran[4], Emad Halbob[4] and Aref Alhashedi[4]

[1]Department of Vascular Surgery, Al-Thawra Modern General Hospital, School of Medicine, Sana'a University of Medical Sciences, Sana'a City, Yemen

[2]Vascular Surgery Unit, General Surgery Department, Al-Thawra Modern General Hospital, Sana'a City, Yemen

[3]Department of Cardio-Pediatric Surgery, Al-Thawra Modern General Hospital, School of Medicine, Sana'a University of Medical Sciences, Sana'a City, Yemen

[4]Department of Vascular Surgery, Al-Thawra Modern General Hospital, School of Medicine, Sana'a University of Medical Sciences, Sana'a City, Yemen

[5]Master of Epidemiology and Biostatistics, District Sales Manager at Shaphaco Pharmaceutical Industries

ABSTRACT

Background: Below the inguinal ligament, popliteal artery injuries are the second most frequent arterial injuries in the world. In order to share our experience with complex traumatic popliteal vascular injuries at Al-Thawra Modern General Hospital in Sana'a City- Yemen, we focus on the incidence, initial presentation, surgical management, and outcomes of popliteal artery injuries.

Patients and Methods: Over the 3-year period from 1 January 2020 to 31 December 2022, all patients with popliteal artery injuries regardless of their other synchronized injuries were included. By contrast, patients who are managed as popliteal artery injuries by a military care giver at battle field were excluded from our analysis. In the diagnosis of popliteal artery injury, we relied on the physical examination. The main outcome was either patients get complete recovery, partial function loss of the limb, or end with amputation.

Results: During study period, an overall incidence of popliteal artery injuries was 0.9%. Of 26 patients with popliteal artery injuries, 25 (96.2%) patients were men, and more than half of our patients (53.8%) were in the age group ≤ 25 years, with an overall mean of age 24.5 ± 5.6 years. The distribution of patients in groups of time delays in treatment of ≤ 6 hours, 6-10 hours and more than 10 hours was 9 (34.6%), 12 (46.2%) and 5 (19.2%) respectively. The mechanisms of injury were penetrating and blunt in 24 (92.3%) and 2 (7.7%) patients respectively. Patients who received a fasciotomy was 25 (96.2%). In our cohort of patients, incidence of amputation was 11.5%, while partial function loss rate was 27%.

Conclusion and Recommendations: In our cohort of patients, incidence of popliteal artery injuries was high. Despite technical improvements in management of popliteal artery injury, a high amputation rate is observed in our study. The need for early diagnosis and early referral to definitive care must be emphasized. One of the most important ways to lower the risk of amputation is to shortening the duration of ischemia.

Corresponding author
Abdulhafeedh Al-Habeet, Master of Epidemiology and Biostatistics, District Sales Manager at Shaphaco Pharmaceutical Industries, Yemen.

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Introduction

The popliteal artery is a major vessel that supplies blood to the lower leg and foot. Injuries to the popliteal artery are relatively rare but can be potentially life-threatening and pose a significant challenge to medical professionals due to the complexity of treatment [1]. Popliteal artery injuries can occur due to traumatic events such as car accidents, falls, and sports injuries. The most common mechanism of injury is blunt trauma to the knee [2]. In some cases, penetrating injuries, such as gunshot wounds or stabbings, can also cause popliteal artery injuries [3].

Treatment of popliteal artery injuries requires prompt and effective action to prevent further damage and potential loss of limb [4]. Diagnosis of popliteal artery injuries involves a thorough physical exam, imaging studies, and assessment of blood flow to the affected area [5].

Surgical intervention is typically required to repair the damaged artery. Depending on the severity of the injury, treatment may involve endovascular procedures, open surgical reconstruction, or a combination of approaches [6].

Popliteal vascular injuries are relatively rare, accounting for approximately 1% to 2% of all vascular injuries. However, they can be associated with significant morbidity and mortality if not

diagnosed and treated promptly. Popliteal artery injuries are more common than popliteal vein injuries, and they are often associated with other injuries such as fractures or dislocations of the knee joint. The most common cause of popliteal vascular injuries is blunt trauma, such as a motor vehicle accident or a fall from a height [7, 8].

A nationwide analysis of popliteal vascular injuries in the United States of America (USA) estimated the national incidence of popliteal vascular injuries was 0.03% of all injured patients in the National Trauma Data Bank for 2013-2016 [9].

Incidence of popliteal artery injuries was 19% of all extremity arterial injuries, in civilian due to blunt mechanisms was from 20% to 75%, 5.6 per 1000 cases of penetrating and 1.6 per 1000 cases of blunt. The 7-year Yemeni conflict, which began on March 25, 2015, has had a significant socioeconomic impact on the populace. In military, incidence of popliteal artery injuries was 20-26% of all extremity arterial injuries [10, 11]. A previous study in Yemen concluded that wartime penetrating popliteal artery injury is a difficult situation and correlated with a high incidence of amputation [12]. During the 1st and 2nd world wars, incidence of amputation due to popliteal artery injuries was 72.5% however this value decreased in Korean and Vietnamese wars to 32.4% and 29.5%, respectively [13-15].

In order to share our experience with complex traumatic popliteal vascular injuries at Al-Thawra Modern General Hospital, our study focuses on the incidence, initial presentation, surgical management, and outcomes. Moreover, our study filled a research gap on this topic as well as encouraging further research in the future in our local area. The findings of our study could also have considerable policy implications for every vascular surgeon in addressing the problems of popliteal artery injuries.

Patients and Methods

Study Design and Population

Over the 3-year period from 1 January 2020 to 31 December 2022, a descriptive study conducted on 26 consecutive patients with popliteal artery injuries who presented to Department of surgery at Al-Thawra Modern General Hospital in Sana'a city- Yemen. We included all patients with popliteal artery injuries regardless of their other synchronized injuries. Patients who are managed as popliteal artery injuries by a military care giver at battle field, as well as patients with irreversible ischemia who referred to primary amputation were excluded from our analysis.

Diagnosis and Surgical Intervention

In the diagnosis of popliteal artery injury, we relied on the physical examination. We also considered presence of clinical evidence of vascular injury with hard signs as an evidence of popliteal artery injury. With therapeutic exploration rates close to 100%, the presence of hard signs during the initial physical examination has demonstrated to be a reliable indicator for prompt exploration [16, 17]. On the other hand, patients presenting with soft signs of vascular injury underwent vascular imaging (CT angiography or color flow duplex scans). All procedures were performed by highly volume skilled and qualified vascular surgeons. Once a popliteal injury has been established, patient expeditious transported to the operating room. A large longitudinal incision between the vastus medialis and sartorius muscles, 1 cm posterior to the distal femur, is made to expose the injured popliteal arteries. We performed one of the both methods of vascular repair, primary with an end-to-end anastomosis or an interposition graft method.

Variables and Data Collection

Operation notes documented immediately after the completion of the operation. Collected data included demographics measures (age, and gender), baseline characteristics (cause, mechanism of trauma, duration of delay between vascular injury and intervention, presence of hard sign, and radiological assessments), operative findings measures (approach, type of injury, fasciotomy, method of repair, presence of associated vein injury, nerve injury, and/or the presence of femur fractures) and main outcome measures (partial function loss, amputation, or complete recovery).

Outcome Measures and Post- Operative Follow-Up

The main outcome was either patients get complete recovery, partial function loss of the limb, or end with amputation. To reduce bias, we used a standard time of follow-up in all of our patients and a two-week period following intervention was used as a duration of follow-up. We did not follow-up our patients after hospital discharge.

Data Processing and Analysis

All collected data were entered into Excel and then exported to the Statistical Package for Social Science analysis (SPSS, Inc., Chicago, Illinois, USA) version 28.0 for analysis. A Shapiro–Wilk test confirmed that continuous data were normally distributed. Therefore, patients' age was expressed as the mean ± standard deviation (SD). Person's x2 test was used to compare between categorical variables; whenever any of the expected values were less than 5, Fisher's exact test was used instead. The results were regarded as significant when the p-value was ≥ 0.05.

Information Disclosure

First of all, our study was conducted in accordance with the Declaration of Helsinki. Moreover, administrations of hospital approved to conduct the study. All participants voluntarily consented to the research after being informed of its objective and methodology, and the patient's confidentiality was secured. Nobody had access to the raw data, and it was not utilized to identify participants. The investigators conducted and oversaw every step of the data collection and compilation process. Strict confidentiality was ensured through the anonymous pre-coding and recording of questionnaires, and then the final master sheets were securely stored.

Results

Characteristics of Patients

All patients arrived with hard signs were immediately transported to the operating room for vascular repair. During study period, a total of 2887 patients were presenting to hospital for vascular repair. Due to the stringent criteria in our study, especially we excluded all patients who are managed as popliteal artery injuries by military caregivers at battle field, only 26 patients were included in our analysis, giving an overall incidence of 0.9% for popliteal artery injuries. Demographic and clinical characteristics of patients were presented in the table 1. In our cohort of patients, 25 (96.2%) patients were men, while only one (3.8%) patient was woman (men to women ratio was 25:1 respectively). More than half of our patients (53.8%) were in the age group $\leq$ 25 years, with a mean of age 24.5 ± 5.6 years (minimum- maximum was 12-34 years). The distribution of patients in groups of time delays in treatment of $\leq$ 6 hours, 6-10 hours and more than 10 hours was 9 (34.6%), 12 (46.2%) and 5 (19.2%) respectively. The mechanisms of injury were penetrating and blunt in 24 (92.3%) and 2 (7.7%) patients respectively. More than half of patients 15 (57.7%) were military, while civilian patients were 11 (42.3%) patients. Patients presenting with hard signs on arrival were 19 (73.1%). Radiological assessment was done in 22 (84.6%) patients.

Table 1: Baseline Characteristics of Patients

Variables	Frequency	%
Gender		
Male	25	96.2
Female	1	3.8
Age, (years)		
≤ 25	14	53.8
> 25	12	46.2
Mean ± SD	24.5 ± 5.6 years	
Delay in treatment (hours)		
≤ 6	9	34.6
6-10	12	46.2
> 10	5	19.2
Mechanism of injury		
Penetrating	24	92.3
Blunt	2	7.7
Cause		
Civilian	11	42.3
Military	15	57.7
Hard signs		
Present	19	73.1
Absent	7	26.9
Radiological assessments		
Yes	22	84.6
No	4	15.4

Operative Findings and Outcome Measures

As shown in the table 2, medial approach of the treatment was in nearly all patients 25 (96.2%), except one patient (3.8%) with posterior approach. Complete injury was in 17 (65.4%) patients. Patients who received a fasciotomy was 25 (96.2%). Regarding to type of repair, 4 (15.4%) patients underwent primary with an end-to-end anastomosis, whereas 22 (84.6%) patients underwent an interposition graft. Patients who presented with arterial injuries combined with venous, nerve injuries and femur fractures were 11 (42.3%), 6 (23.1%) and 14 (53.8%) respectively. In our cohort of patients, incidence of amputation was 11.5%, while partial function loss rate was 27%.

Table 2: Operative Findings and Outcome Measures

Variables	Frequency	%
Treatment approach		
Medial	25	96.2
Posterior	1	3.8
Injury		
Partial	9	34.6
Complete	17	65.4
Fasciotomy		
Yes	25	96.2
No	1	3.8
Type of repair		
Primary	4	15.4
Graft	22	84.6
Combined arterial/venous injury		
Present	11	42.3
Absent	15	57.7
Combined arterial/nerve injury		
Present	6	23.1
Absent	20	76.9
Combined arterial injury/femur fractures		
Present	14	53.8
Absent	12	46.2
Outcome		
Amputation	3	11.5
Partial function loss	7	27
Complete recovery	16	61.5

Discussion

Even in a single crowded urban hospital and despite the war that was going on in Yemen at the time of the study, popliteal artery injuries are still rare. In both the military and the civilian spheres of conflict, popliteal artery injuries result in severe morbidity, including amputations along with long-term disability [1]. Due to their unique anatomy as well as difficult surgical exposure, these injuries present difficult challenge for vascular and trauma surgeons. Moreover, this challenge is made more difficult by the common occurrence of associated popliteal venous injuries, open and closed fractures, as well as significant soft tissue and nerve damage [1, 13-15, 18].

Apparently, our study is the first study that estimated incidence of popliteal artery injuries in Yemen. Therefore, comparison at the local level is difficult. In our cohort of patients, an overall incidence of popliteal artery injuries was 0.9%, a figure that is considerably high in comparison with findings of 0.03% in the USA [9], however our finding is slightly lower than the range of 1-2% that was previously estimated and showcased in [7, 8].

Our patients presented 3.2 years younger than their other Yemeni counterparts, as showcased in a study that was conducted in Taiz governorate-Yemen (24.5 vs. 27.7 years respectively). This age group is the productive age group, therefore disability among them has bad impact on economic situation of the country. The majority of our patients were male, except for one patient (3.8%), a female, who was gunshot in an attempt to commit suicide. Previously in Taiz governorate, Nasr., et al reported that 8.2% were women [12].

Majority of our patients had had penetrating injuries (92.3%). This is inconsistent with what was revealed by a recent nationwide study that attempted to analyze outcomes of popliteal vascular injuries in the USA, as it reported a majority (64.0%) of their patients had blunt injuries [9]. The reasons behind this are well known, as penetrating injuries are results of an object that pierced the body, while stabbings and gunshot wounds are examples of injuries that might result in blunt injuries. Blunt injuries are caused by the impact or other force applied from or with a blunt object. While blunt trauma accounts for the bulk of civilian cases, penetrating trauma mechanism is the main cause of vascular trauma in military cases. Compared to cases who have penetrating trauma, higher amputation rates are observed for individuals who have blunt vascular trauma and these injuries are frequently accompanied by soft tissue and bone injuries [19-25].

In our cohort of patients, a fasciotomy rate was 96.2%, a figure that is considerably high in comparison with Nasr., et al findings of 33% [12]. This indicates an increase in the use of fasciotomy for patients with a popliteal artery injury. According to an American nationwide analysis, fasciotomy rate was 17% [9]. High rate of fasciotomy in our study may be related to high incidence of associated vein injuries along with delay of presentation more than 6 hours was high which was two-thirds of overall cases.

Although, there are several experimental trials done on porcine to estimate ischemia time, the limit for blood flow restoration, perfusion of tissue and survival of limb, that offer valuable data; it must be kept in mind that collateral circulation through the shank vessels frequently lessens the consequences of limb ischemia and reperfusion injury in humans [26-29]. These collaterals do provide collateral circulation and a mechanism of tissue perfusion, despite the fact that they can occasionally be flimsy and quickly disrupted by associated injuries like fractures [1, 27, 28].

Popliteal artery injuries rate differs depending on the warfare areas. Delay in getting war wounded off the battlefield to definitive surgical treatment decreases the likelihood of limb salvage and may result in limb loss [29]. Makins found a 12% incidence of popliteal artery injuries during World War I, with a 43% amputation rate, while during World War II, amputation rate increased to 72% due to treatment by ligation [30, 13]. During Korean and Vietnamese Wars, incidence of amputation was 32.4% and 29.5% respectively [14-18].

According to our study findings, incidence of amputation was 11.5%, a rate that is significantly higher than prior studies' findings of 4.5% and 7% in the USA and Yemen respectively [9, 12]. The high incidence of amputation rates is attributed to the ischemia time, time to blood flow restoration along with the impact of reperfusion injury [29].

Limitations

We acknowledge that our study has many limitations. Our study has an inherent selection bias due to the inclusion of a single public hospital, therefore our results do not reflect the practices that occur in the other public and private hospitals. Given the rarity of the clinical pattern, the provided cohort of 26 individuals with popliteal artery injury can be regarded as considerable; nonetheless, examination of a larger cohort may reveal other predictors of limb salvage or loss. There is no follow-up with our patients after discharge from the hospital, therefore long-term outcome was not established in our study, including vascular complications and limb survival.

Conclusion

In our trauma center, incidence of popliteal artery injuries was high compared to other countries such as USA. Despite technical improvements in management of popliteal artery injury, a high amputation rate is observed in our study. The need for early diagnosis and early referral to definitive care must be emphasized. One of the most important ways to lower the risk of amputation is to shortening the duration of ischemia. It is quite important that revascularization along with soft tissue protection by liberal fasciotomy should always be attempted, as this approach is likely to succeed and increase limb salvage rates.

Acknowledgment

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Conflict of Interest

All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation. All authors have approved the final article. None of the authors have any conflicts of interest to declare.

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