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Management of traumatic extremity arterial injuries in a tertiary care center: A report with 197 cases

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ABSTRACT

Objectives: This study aims to analyze patients' characteristics, treatments applied, and treatment outcomes following traumatic extremity arterial injuries (TEAIs) in a tertiary care center.

Patients and methods: A total of 197 patients (185 males, 12 females; mean age: 32.5±10.1 years; range, 13 to 67 years) who underwent emergency operation due to a TEAI in our center between January 2013 and March 2020 were retrospectively analyzed. Data including sex, age, body mass index (BMI), admission time to hospital, side of injury, injured artery or arteries, cause of injury, and associated injuries were noted. Treatments applied, length of hospital and intensive care unit (ICU) stay, and the mortality rate were recorded.

Results: Penetrating injuries and gunshot wounds were found in 81 (41.1%) and 68 (34.5%) patients, respectively. Bone fractures and nerve injuries were accompanied by a TEAI in 38 (19.3%) and 11 (5.6%) patients. Superficial femoral artery (SFA) was the most frequently injured artery (56%). Bypass with saphenous vein was the most utilized management modality in 89 (45.2%) patients, while primary repair was performed in 64 (32.5%) patients. Infection developed in nine (4.6%) patients. Fasciotomy was required due to compartment syndrome in 17 (8.6%) patients. Extremity amputation was performed in three (1.5%) patients and mortality was seen in three (1.5%) patients.

Conclusion: Our study results suggest that penetrating traumas are the most common cause of TEAI, and that SFA is the most commonly injured artery. Primary repair and bypass with saphenous vein are the most utilized techniques in the management of TEAIs.

Keywords: Amputation, extremity artery injury, fasciotomy, primary repair, saphenous vein graft, vascular injury.

Traumatic extremity arterial injuries (TEAIs) are rare entities due to the elastic nature of vessels and presence of protective tissues around them. Previous reports have demonstrated that TEAI is seen in 2 to 3% of all traumatic injuries.[1] However, Khan et al.[2] reported that the incidence of TEAI was relatively higher in developing countries due to more frequent traffic accidents, violent crimes, and industrial injuries. Although relatively rare, TEAIs may be associated with serious consequences, including function loss, extremity amputation, and even death.[3]

Early diagnosis, systemic approach, and rapid intervention are critical to prevent morbidity and mortality due to TEAIs. Feliciano et al.[4] reported that examination of the peripheral artery was essential for all trauma patients, even in those with stable hemodynamic status. Additionally, appropriate imaging modalities such as Doppler ultrasonography, computed tomography angiography (CTA), or conventional angiography should be performed for diagnosis and appropriate treatment decisions.[5] In patients with a unstable hemodynamic condition, external pressure and/or tourniquet should be applied before the emergency intervention. In cases with unstoppable and/or life-threatening bleeding, the emergency operation room treatment options are primary repair, ligation of vessel, autologous graft

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interposition or synthetic graft placement and, in some cases, amputation of extremity.[6]

Although previous studies have investigated patients' characteristics, treatment options and outcomes following TEAIs, there are conflicting results and no consensus on standardization of procedures in the literature. In the present study, we aimed to analyze patients' characteristics, treatments applied, and treatment outcomes following TEAI in a tertiary care center and to help to fill the gap in the literature on this subject.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Health Science University, Şişli Hamidiye Etfal Training and Research Hospital, Department of Cardiovascular Surgery between January 2013 and March 2020. A total of 197 patients (185 males, 12 females; mean age: 32.5±10.1 years; range, 13 to 67 years) who underwent emergency operation due to a TEAI in our center were retrospectively analyzed. Preoperative data including age, sex, body mass index, arrival time to hospital, injured limb, side, cause of injury, and presence of bone and nerve injuries were recorded. Only the patients who had a TEAI and salvageable extremity with or without orthopedic, neurological and/or soft tissue injuries were included in this study. Those who required urgent attention to abdomen and/or head injuries, had extremities with no signs of viability or a non-salvageable extremity due to TEAI, and had a Glasgow Coma Score of ≤3 were excluded. Other exclusion criteria were blunt traumas, including traffic and work accidents, bomb blast injuries, and falls from height. A written informed consent was obtained from each patient. The study protocol was approved by the Health Science University, Şişli Hamidiye Etfal Research and Training Hospital Ethics Committee (02.02.2021/3118). The study was conducted in accordance with the principles of the Declaration of Helsinki.

All patients admitted to the emergency service with the suspicion of a TEAI were evaluated according to the American College of Surgeons Guidelines for Advanced Trauma and Life Support.[7] The diagnosis of TEAI was made based on physical examination and/or imaging modalities (Doppler ultrasonography, CTA, or conventional angiography). The followings were considered the signs of a TEAI: presence of active bleeding, expanding hematoma, cold and pale extremity, absent or weak artery pulses and pronounced neurological deficit. In patients with a stable condition, the imaging modalities were used to identify the location and severity of the injury and to tailor the treatment plan. Patients in critical condition with impaired vital signs were immediately operated without any further diagnostic evaluation.

In all patients, operations were performed under general anesthesia or dissociative anesthesia. In cases of bone fracture, if the patient was hemodynamically instable, vascular surgery was performed first; otherwise, bone fixation was initially applied. Any nerve injuries detected were repaired by a plastic surgeon. If possible, primary repair of artery was performed, but if not, one of the following treatment modalities was performed: coil embolization, arterial ligation, arterial bypass with a prosthetic graft or saphenous vein, thrombectomy or extremity amputation. Prosthetic graft was carried out only in patients with multiple artery injuries or where there was not sufficient time for saphenous vein harvesting. Fasciotomy was only performed in the following cases: suspected or proven compartment syndrome, ischemia of at least 6 h, and for any neurological deficit. In patients with severe soft tissue injury, all dead tissues and foreign bodies were removed, and the injury site was cleaned with isotonic saline solution. Operations were considered successful, if the extremity pulse returned. For all patients, antibiotic prophylaxis was given on Days 3 to 5 in the postoperative period. In patients with severe soft tissue loss and presence of infection, the antibiotic regimen was prolonged. Additionally, low-molecular-weight heparin was given for five to seven days in the postoperative period, and antiaggregant (acetylsalicylic acid or clopidogrel) treatment was continued for four weeks after surgery. The length of hospital and intensive care unit (ICU) stay, complications and mortality rate were recorded.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation, median (min-max) or number and frequency.

RESULTS

The mean age and the mean BMI were 32.5±10.1 years and 26.8±5.1 kg/m^2, respectively. Of the patients, 118 had upper extremity artery injuries, 64 had lower extremity artery injuries, and 15 had both upper and

Table 1. Baseline demographic and clinical data of patients (n=197)

	n	%	Mean±SD
Age (year)			32.5±10.1
Sex			
Male	185	94.0	
Body mass index (kg/m^2)			26.8±5.2
Arrival time to the hospital (min)			23.5±12.8
Injured limb			
Lower limb	118	59.9	
Upper limb	64	32.5	
Lower + upper limb	15	7.6	
Side			
Right	94	47.7	
Left	81	41.1	
Bilateral	22	11.2	
Cause of injury			
Penetrating injury	81	41.1	
Gunshot wound	68	34.5	
Blunt trauma	48	24.4	
Number of patients receiving imaging	132	67.0	
Bone fracture	38	19.3	
Nerve injury	11	5.6	

SD: Standard deviation.

Table 2. Location of arterial injuries (n=197)

	n	%
Axillary artery	12	6.1
Brachial artery	38	19.3
Common femoral artery	9	4.6
Deep femoral artery	13	6.6
Popliteal artery	27	13.7
Superficial femoral artery	56	28.4
Trifurcation arteries	17	8.6
Ulnar artery	6	3.1
Multiple arteries	19	9.6

lower extremity arterial injuries. Penetrating injuries and gunshot wounds were observed in 81 (41.1%) and 68 (34.5%) patients, respectively. Bone fracture and nerve injury were accompanied by TEAI in 38 (19.3%) and 11 (5.6%) patients, respectively. Baseline demographic and clinical characteristics of the patients are summarized in Table 1.

In the present study, superficial femoral artery (SFA) was the most frequently injured artery in 53 (56%) patients, followed by brachial artery (19.3%) and popliteal artery (13.7%). Other injured arteries were deep femoral artery (DFA) in 13, trifurcation arteries in 17, axillary artery in 12, common femoral artery (CFA) in nine, and ulnar artery in six patients. Multiple artery injuries occurred in 19 patients (Table 2).

Table 3. Treatment modalities (n=197)

	n	%
Coil embolization	2	1.0
Ligation	26	13.2
Primary repair	64	32.5
Bypass with prosthetic graft	6	3.0
Bypass with saphenous vein	89	45.2
Thromboectomy	7	3.6
Amputation	3	1.5

Table 4. Complications and postoperative follow-up outcomes

	n	%	Mean±SD
Complications	32	16.2	
Infection	9	4.6	
Compartment syndrome	17	8.6	
Amputation	3	1.5	
Death	3	1.5	
Hospitalization period (days)			16.7±11.8
Length of stay in the ICU (days)			6.3±4.2

SD: Standard deviation; ICU: Intensive care unit.

Bypass with the saphenous vein was the most often utilized management modality in almost half of the patients (n=89, 45.2%). Primary repair was performed in 64 (32.5%), ligation in 26 (13.2%), bypass with a prosthetic graft in six (3.0%) and thrombectomy in seven (3.6%), and coil embolization, in two (1.0%) patients (Table 3).

In this study, the mean length of hospital stay was 16.7±11.8 days and the mean length of ICU stay was 6.3±4.2 days. Infection developed in nine patients (4.6%) and fasciotomy was required due to compartment syndrome in 17 (8.6%) patients. Extremity amputation was performed in three (1.5%) patients and mortality was seen in three (1.5%) patients (Table 4).

DISCUSSION

Trauma is still one of the major causes of death, and extremity arterial vascular injuries significantly increase the morbidity and mortality rates. Although TEAI is rare entity, Gurkan et al.[7] reported an increase in vascular injuries over the past decade. In a study by Khan et al.,[2] the nature of TEAI was found to vary between countries, and treatment approaches varied between the Western and Eastern hemispheres.

Thus, the present study conducted in a tertiary care center of a developing country and investigating characteristics and treatment outcomes of TEAIs has the potential to contribute to the literature.

Arterial injuries have many different causes including penetrating traumas, gunshot injuries, and blunt traumas. Penetrating and gunshot injuries have been shown to be the most common causes of extremity vascular injuries in many studies. Ünlü et al.[8] reported that penetrating traumas and gunshot injuries were the most common causes of upper extremity vascular injuries. Becit et al.[9] found penetrating and gunshot injuries to be the cause of 80.2% of vascular injuries. In contrast, for lower extremity vascular injuries, Sciarretta et al.[10] found blunt traumas to be the most common cause. Consistent with the literature, in our series, penetrating and gunshot injuries were found to be the most common causes.

The type of vessel injured plays an important role in the treatment decision and in determining the patient's chances of survival. Halıcı et al.[11] showed that radial artery and popliteal arteries were most commonly injured arteries in the upper and lower extremity, respectively. However, Khan et al.[2] found popliteal artery to be the most commonly injured lower extremity artery, while they found brachial artery was the most common injured in the upper extremity. We believe that three factors may account for the differences in the most frequently injured arteries between the studies: the country, the data collection procedures implemented, and the definition of anatomical features. In the present study, SFA and brachial artery were found to be the most commonly injured.

Management of TEAIs requires an appropriate surgical intervention under emergency conditions. In a study analyzing lower extremity arterial injuries, repair with the saphenous vein graft (SFG) was the most common technique.[10] Ekim and Tuncer[12] performed end-to-end anastomosis in 28 of 49 cases in the management of brachial artery injuries. This technique was also the most preferred treatment option in the management of traumatic vascular injuries by Halıcı et al.[11] In parallel with the literature, in present study, SFG and primary repair were the most frequently performed methods for TEAI.

Surgeons should be aware of the dangers of non-vascular pathologies accompanying arterial injuries. Bishara et al.[13] reported that bone dislocations and fractures were commonly associated with vascular injuries, and increased the mortality rate by 10%. In another study, extremity bone pathologies increased the amputation rate by up to 40%.[14] Ekim et al.[12] also found that, of 49 patients diagnosed with vascular injuries, 13 had orthopedic pathologies and 11 had nerve injuries. In the present study, 19.3% of the patients had a bone fracture and 5.6% had a nerve injury.

Compartment syndrome is a condition in which the increased pressure in the anatomical compartments of the body results in insufficient blood flow to tissue.[15] Sciarretta et al.[10] performed fasciotomy in 19 of 26 (73.1%) patients with blunt trauma and 16 of 21 (76.2%) patients with penetrating trauma.[10] Fasciotomy was not a routine procedure in our study and was only performed in 8.6% of the patients. A possible explanation for this difference is that fasciotomy is usually applied only to the cases with prolonged extremity ischemia and, in the present study, the mean patient arrival time to the hospital was only 23.5±12.8 min.

Amputation and death are most undesirable results of TEAI, and previous studies have shown varying rates for these outcomes. Burma et al.[16] found that, following peripheral vascular injuries, the rates for amputation and death ranged from 1-10% to 1-5%, respectively. In another study analyzing the data of 123 patients with vascular injuries, Salimi et al.[17] found 11.4% amputation rate and 4% mortality rate. In contrast, Becit et al.[9] reported amputation and death rates as 3.9% and 6.1%, respectively. Additionally, Akça[18] reported 8.3% amputation rate following war-related injuries, whereas Hanedan et al.[19] performed leg amputation in two of 28 patients in civil war-related injuries. In the present study, there were three extremity amputations (1.5%) and three deaths (1.5%). We found our amputation rates to be lower than other studies, which may be due to the fact that other studies particularly examined war injuries.

Nonetheless, there are some limitations to this study. First, it has a retrospective nature with a relatively small sample size. Second, operations were performed by a single cardiovascular surgery team, but by different cardiovascular surgeons. This may have influenced treatment decision and outcomes; however, all surgeons completed standardized education in the management of TEAIs. Third, patients' initial hemodynamic parameters at the time of admission, patients' life quality, and cost-efficacy analysis of the procedures were not considered in the present study,

but may be the focus of further studies. Forth, we focused characteristics, management, and postoperative outcomes of TEAI, while long-term outcomes were beyond the scope of the study. Finally, we only investigated the cardiovascular aspect of TEAI due to the lack of data and we believe that further studies evaluating the multidisciplinary approach on TEAI would clarify this issue.

In conclusion, our study results suggest that penetrating traumas are the most common cause of TEAIs, and that SFA and brachial arteries are the most commonly injured arteries. Additionally, primary repair and bypass with the saphenous vein are the most utilized techniques with low amputation and complication rates in specialized centers implementing systemic approach, early diagnosis and treatment with advanced diagnostic tools. Further multi-center studies including the secondary care centers with reliable data could also identify the differences between centers and emerge appropriate management modality in these patients.

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