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Evaluation of traumatic extremity vascular injuries in surviving and non-surviving patients

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ABSTRACT

Objectives: This study aims to investigate surgical outcomes of traumatic extremity vascular injuries.

Patients and methods: A total of 98 patients (89 males, 9 females; mean age 30.7±12.9 years; range, 4 to 68 years) who were operated for vascular injury due to extremity trauma in our clinic between October 2013 and October 2018 were retrospectively analyzed. Demographic data, type of damage, repair methods, and results of the patients were recorded from the hospital records.

Results: Of the patients, 16 (16.3%) presented with hypotensive hemodynamic shock. The mean Mangled Extremity Severity Score (MESS) of the patients were 3.2±1.8. Injury etiologies were mostly gunshot injuries (57%). Femoral artery was the most common affected artery in 32.3% of cases. Primary repair was the most common repair in 47.3% of cases. Advanced age, higher MESS scores, and increased blood transfusion were found to be most effective factors for mortality ($p<0.001$).

Conclusion: Based on our study results, we suggest that the success rate of treatment increases, if blood loss is reduced and the patient is taken to rapid surgery with effective intervention during patient transfer.

Keywords: Extremity trauma, mangled extremity severity score, vascular injury, vascular surgery.

Trauma-induced injuries are the third most common cause of death in individuals aged 1 to 44 years and about 1 to 3% of all traumas are vascular injuries.[1] Isolated vascular injuries may occur not only in extremity traumas, but also in bone, nerve, and muscle tissue injuries. When the limb trauma results in fractures and bone dislocations, a risk of amputation may increase up to 40%. In addition, possible excessive blood loss and extensive tissue damage can be the cause of mortality.[2,3] Also, increased blood transfusion is associated with increased mortality. Early intervention is, therefore, of utmost importance in extremity traumas with peripheral vascular injury. In case of negative clinical conditions such as active bleeding, ischemia and hypotensive shock, a decision should be based on physical examination findings without losing time with diagnostic methods. Thus, possible bleeding from the extremity would be lower and the possible ischemia time would be shorter. Diagnostic methods such as computed tomography angiography (CTA), Doppler ultrasonography (DUSG), and conventional angiography can be used in hemodynamically stable patients.[4]

In developing countries including Turkey, the frequency of these injuries has been increasing in recent. Successful treatment of these injuries would increase with the help of multidisciplinary approach, increasing experience and sharing knowledge. In the present study, we report our surgical experience and outcomes in patients with vascular injury due to extremity trauma in the light of the literature.

PATIENTS AND METHODS

A total of 98 patients (89 males, 9 females; mean age 30.7±12.9 years; range, 4 to 68 years) who were operated for vascular injury due to extremity

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Table 1. Mangled extremity severity score

Variable	Score
Skeletal/soft tissue injury	
Low energy (stab; simple fracture; pistol gunshot wound)	1
Medium energy (open or multiple fractures, dislocation)	2
High energy (high speed motor vehicle accident, rifle gunshot wound)	3
Very high energy (high speed trauma + gross contamination)	4
Limb ischemia (score doubled for ischemia >6 hours)	
Pulse reduced or absent but normal perfusion	1
Pulseless; paresthesias, diminished capillary refill	2
Cool, paralyzed, insensate, numb	3
Shock	
Systolic blood pressure always >90 mmHg	0
Hypotensive transiently	1
Persistent hypotension	2
Age (years)	
<30	0
30-50	1
>50	2

trauma in our clinic between October 2013 and October 2018 were retrospectively analyzed. Patients who were not revascularized and those with other major systemic injuries were excluded. Data including demographic data, type and location of injury, and surgical methods and postoperative results were retrieved from the surgery registration form and hospital database. A written informed consent was obtained from each patient. The study protocol was approved by the institutional Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Doppler ultrasonography and/or contrast-enhanced CTA were used as the main diagnostic methods in hemodynamically stable patients. However, hemodynamically unstable patients, those with active pulsatile hemorrhage, and pulseless patients were immediately taken to the operating room. The Mangled Extremity Severity Score (MESS) were recorded at the time of admission (Table 1). In the majority of cases, general anesthesia was used, while local anesthesia was used only in isolated radial, ulnar artery, and anterior/posterior tibial artery injuries.

During the operation, direct repair of vascular injury was preferred. In cases in whom repair was not possible, autogenous saphenous vein grafts were used. When the saphenous vein grafts were ineligible, synthetic grafts were used. Patients with tendon, bone, and nerve injuries were evaluated by the specialist physicians intraoperatively. The patients were treated with low molecular weight heparin (LMWH), aspirin, and appropriate antibiotherapy postoperatively.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were expressed in mean ± standard deviation (SD), while nominal variables were expressed in number and frequency. The Kolmogorov-Smirnov and Shapiro-Wilk tests of normality were used to identify distribution of variables. The Student's t-test was used to compare two groups for continuous variables with normal distribution. The chi-square

Table 2. Demographic and clinic characteristics of patients

	Survivors (n=89)			Non-survivors (n=9)			Total (n=98)			
	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			27.4±8.9			59.4±7.2			30.7 ±12.9	<0.001
Gender										
Male	82	92.1		8	88.8		90	91.8		0.735
MESS score ≥6	8	8.9		6	66.6		14	14.3		<0.001
MESS score			2.8±1.1			7.1±2.6			3.2±1.8	0.001
Tobacco use	39	43.8		5	55.5		44	44.9		0.5
Diabetes mellitus	5	5.6		2	22.2		7	7.1		0.065
Hypovolemic shock	9	10.1		7	77.7		16	16.3		<0.001
Heart rate (bpm)			93.3±7.8			103.8±9.5			94.3 ±8.5	0.002
Hematocrit			44±3.7			40±6.4			43.6 ±4.1	0.091
Platelet (10^3/μL)			244.2±48.5			270.1±55.4			246.6 ±48.9	0.331
Bone fracture	15	16.8		4	44.4		19	19.4		0.068
Hospital arrival time >6 hours	7	7.1		7	77.7		14	14.2		<0.001
Body mass index >30	16	17.9		4	44.4		20	20.4		0.060
Injured extremity >1	3	3.3		1	11.1		4	4.1		0.263

SD: Standard deviation; MESS: Mangled extremity severity score.

Table 3. Mechanism of vascular injuries and injured vessels

	n	%
Mechanism of vascular injury (n=98)		
Blunt trauma	10	10.2
Stab	32	32.6
Weapon/Handgun	32	32.6
Rifle gunshot	24	24.4
Injured vessel (n=114)		
Femoral artery/femoral vein	30/7	26.3/6.1
Popliteal artery/popliteal vein	26/5	22.8/4.3
Tibioperoneal trunk and distal branching	14	12.2
Axillary artery	3	2.6
Brachial artery	4	3.5
Radial artery	15	13.1
Ulnar artery	10	8.7

test was used to compare two groups for nominal variables. The Mann-Whitney U test was used to compare two groups for continuous variables without normal distribution. A p value of <0.05 was considered statistically significant.

RESULTS

At the time of admission, the mean hematocrit value was 43.6±4.1%, the mean platelet count was 246.6±48.9×10^3/µL, and the mean heart rate was 94.3±8.5 bpm. There were 44 patients (44.9%) having smoking habit, seven patients (7.1%) with diabetes mellitus, 20 patients (20.4%) with a body mass index of higher than 30 kg/m^2, and 16 patients (16.3%) presented with hypotensive hemodynamic shock. The number of patients with multiple extremity injuries was four (4.1%). The mean MESS score of the patients was 3.2±1.8. Fourteen patients (14.3%) had a MESS score of ≥6 (Table 2). In addition, CTA was performed in 50 patients (51%), diagnostic exploration in 20 patients (20.4%), DUSG in 18 patients (18.3%), and DUSG combined with CTA in 10 patients (10.2%).

Table 4. Surgical repair of vascular injuries

	n	%
Primary repair (n=114)	54	47.3
Vein graft interposition	32	28
PTFE graft interposition	13	11.4
Primary venous repair	3	2.6
Vein graft interposition (vein-to-vein)	5	4.3
Ligation of artery	3	2.6
Ligation of major vein	4	3.5

PTFE: Polytetrafluoroethylene.

Injury etiologies were gunshot injuries in 32 patients (32.6%), as stab injuries in 32 patients (32.6%), as rifle gunshot injuries in 24 patients (24.4%), and as blunt trauma in 10 patients (10.2%) (Table 3). Fourteen patients with lower extremity injuries and five patients with upper extremity injuries had associated bone fractures.

Femoral artery was the most common affected artery in 32.3% of cases and femoral vein was the most common affected vein (minor and superficial vessel injuries were excluded). The arterial injuries were seen in 26 patients (22.8%) with the popliteal artery and in 13 patients (13.1%) with the radial artery. The details of the injured vessels are given in Table 3.

In 98 patients, 114 vascular repair surgeries were performed in a total of 102 extremities. Primary repair was performed in 54 patients (47.3%). Bypass with the saphenous vein was performed in 37 patients (32.3%) and bypass with the polytetrafluoroethylene (PTFE) graft in 13 patients (11.4%). Except for the popliteal vein and femoral vein, veins accompanying the arteries and superficial vessel injuries were ligated. In 12 patients (12.2%) with a major vessel injury, repair was planned. Three of seven patients with femoral vein injury and two of five patients with popliteal vein injury were bypassed with the saphenous vein. Popliteal vein in two patients and femoral vein in two patients were ligated. Primary

Table 5. Intraoperative and postoperative characteristics of patients

	Survivors (n=89)			Non-survivors (n=9)			
	n	%	Mean±SD	n	%	Mean±SD	p
Intensive care unit stay (days)			1±0.2			2.6±1.5	<0.001
Total hostipal stay (days)			3.2±1.1			2.6±1.5	0.141
Wound infection	6	6.7		1	11.1		0.628
Packed red cell units			1.6±1.4			10.4±2.2	<0.001
Neurological deficit	5	5.6		0	0		0.465
Fasciotomy	11	12.3		3	33.3		0.087
PTFE use	11	12.3		2	22.2		0.406

SD: Standard deviation; PTFE: Polytetrafluoroethylene.

repair was performed in the remaining patients (Table 4).

Fasciotomy due to compartment syndrome was performed in 14 patients (15.7%). Two of these patients required amputation due to infection and recurrent thrombosis. All patients with compartment syndrome had lower extremity injury. Among these patients, there were four patients with blunt trauma, four patients having rifle gunshot injury, and three patients with gunshot injury.

In-hospital mortality was observed in nine patients (9.1%) and amputation was required in two patients (2%). When the preoperative factors affecting the mortality were examined, it was found that advanced age and increased MESS scores, hypovolemic shock, and hospitalization time longer than ≥6 hours were found to be the most effective factors for mortality (*p* values <0.001, =0.001, <0.001 and <0.001, respectively). When the intraoperative and postoperative factors affecting the mortality were examined, duration of stay in the intensive care unit and an increased amount of blood product transfusion were found to be statistically significant (p<0.001).

DISCUSSION

The type of injury and early surgical intervention are the main factors affecting mortality and morbidity in vascular injuries after extremity traumas.[5] In Turkey, vascular injuries often occur with penetrating traumas, followed by gunshot injuries and blunt traumas.[6] However, the frequency of gunshot injuries is high in this region.

Physical examination is critical in the diagnosis of patients with suspected vascular injuries. An emergent operation without advanced imaging may be considered in a patient with trauma who has active pulsatile hemorrhage, hemodynamic shock or whose pulses are absent. It has been also shown in large series that the Ankle-Brachial Index can be used for the diagnosis of arterial injuries.[7] Doppler ultrasonography, CTA, and conventional angiography can be used as the diagnostic methods in hemodynamically stable patients.[8] In our study, CTA was used in 50 patients (51%), diagnostic exploration in 20 patients (20.4%), DUSG in 18 patients (18.3%), and DUSG combined with CTA in 10 patients (10.2%). In the Prospective Observational Vascular Injury Treatment (PROOVIT) study, diagnostic exploration (28.8%), CTA (38.9%), DUSG (3.1%), and angiography (10.7%) were used for the diagnosis of vascular injury.[9]

Peripheral vascular injuries often affect male population and lower extremities are more frequently injured.[10] In our series, 90 patients (91.8%) were male, and 70 patients (71.4%) were admitted with lower extremity traumas. In addition, a study by Kayalar et al.[11] showed that upper extremity injuries were seen in 49.1% and lower extremity injuries were seen in 41% of patients.

In trauma patients with vascular injury, the time from the event to surgery is of utmost importance. Possible delays may increase blood loss and prolong ischemia time.[12] Similarly, in our study, 14 patients (14.2%) whose admission time was longer than six hours were found to have an increased mortality rate (p<0.001).

The MESS is a scoring system used to predict the success of treatment in trauma patients at the time of admission and in the decision of possible amputation. These values were identified according to the findings of the patients at the time of admission. In our study, the patients whose MESS scores were higher than 6 had a higher mortality rate (p<0.001). In the study by Rozycki et al.,[13] increased MESS values were found to be closely associated with mortality.

Primary repair is preferred in vascular injuries, where applicable. In cases where primary repair is not possible, autogenous grafts, usually saphenous veins, are used. In our study, primary repair (end-to-end or partial suture) was preferred in 54 (47.3%) vascular injuries. Saphenous vein interposition in 32 (28%) injuries and PTFE graft interposition in 13 (11.4%) injuries were also performed. Popliteal veins in two patients, femoral veins in two patients, and radial arteries in three patients were ligated. Repair of major vessel injuries is still controversial. They can be ligated according to the patient's risk status. In a prospective study, it has been shown that they can be safely ligated.[14]

In other studies, primary repair rates were found to be high.[11] This situation is affected by the type of injury. Primary repair may be difficult in blunt traumas and in close-range rifle gunshot injuries accompanied by large tissue defects. Accordingly, in a study by Agrawal et al.,[15] saphenous vein interposition was the most common surgical procedure with a rate of 56%.

In recent years, endovascular treatments have become prominent in vascular surgery and have been widely used in many clinics. Although it is frequently used in atherosclerotic vascular diseases, its use in vascular injuries has been also reported.[16] Although we did not use endovascular repair in our patient series, we believe that it would be preferred in patients without a common tissue damage.

Amputation is a serious cause of morbidity due to extremity trauma. In large study series, the rate of early amputation was reported as 9.1%, indicating that the incidence of high amputation rates increases with blunt trauma.[17] In our study, amputation was required in two patients (2%). These patients were injured by blunt trauma. We believe that our amputation rate is relatively low, due to low blunt trauma injury rates in our patient series.

Furthermore, mortality and morbidity are main concerns in traumatic injuries. Although mortality is a catastrophic outcome, most of the injuries occur in the young population. Possible limb losses and motor defects are a major cause of morbidity. Mortality rates vary between 5 and 8% in different series. Factors affecting mortality include severity of injury, age, and MESS score.[18,19]

Mortality was observed in nine patients (9.1%). The causes of mortality were disseminated intravascular coagulation in four patients, acute tubular necrosis in three patients, and myocardial infarction in two patients. Two amputations were performed in the postoperative period. Being 50 years of age and over and having a MESS score of ≥6 were found to be statistically significant factors for mortality.

Although we had isolated limb traumas in our study, our mortality rate was found to be high. This can be attributed to the prolonged patient transfer time and increased blood loss. Time for hospital transfer in patients with rifle gunshot injury may extend due to the distance between the rural areas and the hospital in our region. On the other hand, the training of experienced physicians who evaluate these injuries based on physical examination in the emergency unit may prevent the time loss in patients scheduled for urgent surgery. Therefore, prompt evaluation of the patient by the vascular surgeon is critical. We believe that the success rate would increase with increased knowledge sharing, experience, and developing technology.

Nonetheless, there are some limitations to this study. First, it is a retrospective study and our results might have been affected by the treatment methods applied. Second, the sample size is relatively small. Third, the surgical interventions were performed by more than one surgeon which makes the standardization difficult. Finally, in the present study, we evaluated in-hospital mortality and morbidity and, therefore, the mid- and long-term of the operations are not yet known. We recommend further large-scale and long-term studies to confirm these findings.

In conclusion, vascular injuries due to extremity traumas are important causes of mortality and morbidity. Based on our study results, we suggest that the success rate of treatment increases, if blood loss is reduced and the patient is taken to rapid surgery with effective intervention during patient transfer.

Declaration of conflicting interests

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