



## Overview of Treatment Methods in Peripheral Major Vascular Injuries: A Retrospective Study

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### ABSTRACT

**Objective:** Vascular injuries are observed in 0.2–4% of all traumas and can be life-threatening or difficult when not properly treated. In this study, we aimed to present our experience in the treated vascular injury cases.

**Materials and Methods:** This retrospective and descriptive study covered the period between May 2014 and December 2018. Medical records of patients with vascular injuries were evaluated concerning demographic and trauma-related parameters.

**Results:** In this study, 73.1% of 93 patients were male, and the average age was 27.44±6.70 years. In the majority of the patients, it was observed that vascular injuries occurred as a result of penetrating traumas, and mainly radial and superficial femoral arteries were affected. Nerve injuries were found to be accompanied in 16.1% of the patients. The concomitant nerve injuries were also present in 16.1% of the patients. End-to-end anastomosis was used in 73.3% of the injuries. Mortality and amputation rates were 1.1% and 3.2%, respectively.

**Conclusion:** Demographic and clinical parameters in vascular injury cases were found to be compatible with the previous studies. By collecting the correct data obtained from this study and the other studies, the medical needs of patients with vascular injuries could be better evaluated and clinical services could be planned in advance by conducting a medical approach accordingly.

**Keywords:** Artery, vein, vascular injuries, vascular trauma, amputation

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### INTRODUCTION

Trauma is the fourth leading cause of death and vascular trauma is estimated to be approximately 0.2–4% of all traumatic injuries worldwide (1). Although vascular injuries are occasionally life-threatening, the risks posed by vascular injuries on the viability of the extremities are overall greater. Using modern diagnostic tools and surgical techniques, modern emergency services and advanced management strategies have dramatically changed the mortality rates due to vascular injuries. The morbidity rates that are especially estimated by the number of amputation requiring vascular trauma patients also decreased to 5–15% from 40–72% of the World War II era (2).

Vascular trauma is generally classified according to its formation mechanism, such as blunt and penetrating injury. The etiology of the vascular trauma is further subdivided into high/low velocity injuries as in gunshot and stab wounds. Blunt injuries involve bone fractures, joint displacements, contusions as mostly seen in vehicle accidents (3). The vascular injuries due to blunt mechanisms often have concomitant trauma of the surrounding neuromusculoskeletal tissue. Therefore, the morbidity rates are higher in the vascular injuries caused by blunt trauma (2).

There are differences in the etiology of vascular injuries in civilian and military settings. It is ordinarily accepted that vascular injuries due to blunt and penetrating trauma are more common in civilian and military settings, respectively (4). Moreover, increasing rates of violence in civilian populations lead to increased vascular injuries associated with penetration trauma, and the overall etiology difference between civilian and military settings is gradually decreasing. Although the incidence and etiology of vascular injuries differ greatly due to the geographical and socioeconomical factors, the anatomical location of the vessels more frequently injured as a result of penetrating or blunt trauma shows similar distribution in epidemiologic studies (3). In general, blunt trauma-related vascular injuries mostly involves the upper extremities, while penetrating trauma the comprises lower extremities.

The management approaches used for vascular trauma patients usually follow the algorithms set forth by leading associations of surgeons. However, the surgical technique is tailored according to the etiology and type of the vascular trauma, and to the concomitant injuries (4, 5).

Our hospital, is located in Kayseri, serves approximately 5 million people living both in the city and in the neighbouring suburban regions. It is also one of the major transit crossroads for emergency vehicles. A significant number of patients with vascular injuries are treated annually. Owing to its experienced team of physicians and medical

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facilities of advanced technology, our hospital's trauma center represents one of the well-known of its kind in the whole country. In this study, we aimed to share our experience on patients with vascular trauma by presenting demographic factors, the etiology and localization of the vascular injuries, as well as concomitant injuries, surgical treatment techniques, and the outcomes of patients, who were treated in our hospital over period of four years.

## MATERIALS and METHODS

This study was designed as a retrospective descriptive study. We used the observational analysis method. Ethical approval was obtained from the ethics committee of Erciyes University Faculty of Medicine (Date: 06.02.2019; Decision nr.: 2019/104).

For the data acquisition, the hospital archives data of Cardiovascular Surgery Clinic at Kayseri City Hospital and Department of Cardiovascular Surgery, in the Faculty of Medicine at Erciyes University were used. Patient files were evaluated for the period between May 2014 and December 2018, and documents with vascular trauma were recorded.

This study included patients that applied to our hospital for trauma and underwent surgery for vascular injuries. The patients were divided into three age groups: <25 years, 25–35 years and >35 years. The exclusion criteria consisted of the pediatric age group and patients with the vascular injuries that were secondary to surgical intervention or any iatrogenic development such as a pseudoaneurysm.

The vascular injuries were grouped as blunt or penetrating trauma according to their etiology. The upper extremity vascular injuries observed in this study involved brachial artery, axillary artery, radial artery, ulnar artery, and subclavian vein. The lower extremity vascular injuries covered commonly femoral artery, superficial femoral artery, profunda femoral artery, popliteal artery, tibialis anterior artery, tibialis posterior artery, profunda femoral vein, superficial femoral vein and popliteal vein. A patient with vena cava inferior injury and four patients with aortic injuries that met the criteria were also included in our study.

After the selection of files was completed, the enrolled patients in this study were classified by demographic data that consisted of age and gender. The medical files were further evaluated for parameters related to the vascular injury that included the etiology of the injury, localization of the involved vessel(s), and concomitant neuromusculoskeletal injuries. The surgical technique(s) used for the treatment and outcome of the patients were recorded.

### Statistical Analysis

SPSS 22.0 program (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. All data collected in the study were statistically analyzed using a chi-square test. Numerical data were expressed by a mean value and standard deviation, whereas the categorical data were expressed as frequency (n) and percent ratio (%).

## RESULTS

The number of patients in the current study was 93. The documentation of the gender revealed that the majority of the patients were male (n: 68, 73.1%). The age of patients ranged from 17 to

**Table 1.** The age and gender frequencies of the study group

Age	Gender						p
	Male		Female		Total		
	n	%	n	%	n	%	
<25	28	30.1	10	10.8	38	40.9	0.922
25–35	30	32.3	12	12.9	42	45.2	
35<	10	11.1	3	3.2	13	14	
Total	68	73.1	25	26.9	93	100	

**Table 2.** The classification of the etiology of vascular injuries

Etiology	Gender						p
	Male		Female		Total		
	n	%	n	%	n	%	
Penetrating							0.741
Sharp instrument	46	49.5	16	17.2	62	66.7	
Gunshot	16	17.2	2	2.2	18	19.4	
Blunt							
Car Accident	3	3.2	2	2.2	5	5.4	
Other incident	3	3.2	5	5.4	8	8.6	
Total	68	73.1	25	26.9	93	100	

48 years old, and mean age was  $27.44 \pm 6.70$  years. There was no difference concerning gender distribution according to age categories of the patients ( $\chi^2$ : 0.163, p: 0.922). The age and gender distribution are presented in Table 1.

The most common etiology (n: 62), which was mainly due to stabbing wounds or glass cuts, was penetrating trauma by sharp instruments. Penetrating trauma due to gunshot wounds (n:18) consisted of the second-largest etiological group. In the current study, we observed that blunt trauma-related vascular injuries were the result of car accidents and other incidents like fallen down. The etiological distribution of vascular injuries between men and women is summarized in Table 2.

We determined 121 vascular injuries in our 93-patient study group. The vascular injuries in 65 patients (69.9%) involved a single vessel. The remaining patients (30.2%) had multiple vascular injuries. The localization of the vascular injuries were classified according to their respective anatomical region. The number of upper and lower extremity injuries observed was 52 (55.9%) and 37 (39.9%), respectively. One patient had both upper and lower extremity injuries. The distribution of the vascular injuries regarding their anatomical locations is presented in Table 3.

We found that 15 patients (16.1%) had concomitant nerve injury. Seven patients had single vessel injury in the upper extremities. Radial, ulnar and brachial artery injuries were present in three, two, and two patients with concomitant nerve injuries, respectively. One patient had a single vessel injury in the superficial femoral artery of lower extremity. Seven patients had more than one vessel injury, and four of them had the combined radial and ulnar

**Table 3.** The anatomical distribution of vascular injuries

Name of vessel	Total	
	n	%
Brachial artery	12	12.9
Axillary artery	1	1.1
Radial artery	30	32.2
Ulnar artery	15	16.1
Common femoral artery	1	1.1
Superficial femoral artery	28	30.1
Profunda femoral artery	2	2.2
Popliteal artery	3	3.2
Tibialis anterior artery	1	1.1
Tibialis posterior artery	4	4.3
Subclavian vein	2	2.2
Profunda femoral vein	1	1.1
Superficial femoral vein	17	18.3
Popliteal vein	3	3.2
Vena cava inferior	1	0.8
Aorta	4	4.3

artery injuries. In this study, one patient had brachial and popliteal artery injuries, the other one had tibialis anterior and posterior arteries injuries. The remaining one patient with concomitant nerve injuries had four vessel trauma involving superficial and profunda femoral arteries and veins. When the concomitant nerve injuries were grouped according to their locations, upper extremity vascular injuries were dominant (n: 12, 12.9%). When we evaluated the etiology of the trauma in these patients, the most common mechanism appeared to be the penetrating injury with sharp instruments in 12 of the patients (80%). Two of the remaining patients were injured due to gunshot wounds, and the last patient had vascular injury due to blunt trauma as a result of a car accident.

After appropriate vital precautions were taken, as required, surgical interventions for the treatment of vascular injuries were performed. When a multidisciplinary approach was needed, the surgery was conducted by a team consisting of cardiovascular, plastic, and orthopedic surgeons. The technical details used specifically for the treatment of vascular injuries were recruited from the surgical operation epicrisis documents in the patient files. We found that most of the vascular injuries (n: 74, 79.6%) were treated by using a single type of surgical technique. Nineteen patients (20.4%) had vascular injuries that required to be treated by using multiple techniques. The operation techniques used in the treatment of patients in the present study are documented in Table 4.

The postoperative short-term follow-up of the patients revealed that amputation incidents required for three patients (3.2%). One of them had both tibialis anterior and posterior artery injuries that were treated using end-to-end anastomosis and saphenous vein graft. The remaining two patients had tibialis posterior artery injuries which were treated by end-to-end anastomosis. The mortality rate in this study was found as 1.1% and belonged to the patient with vena cava inferior injury and treated by using end-to-end anas-

**Table 4.** Surgical treatment modalities for vascular injuries

Surgical technique	Total	
	n	%
Primary repair	14	15.1
End-to-end anastomosis	70	75.3
Saphenous vein graft	18	19.4
Synthetic graft	9	9.7
Endovascular treatment	3	3.2

tomosis. Two patients with traumatic type 3 aortic dissection due to car accident were treated by Thoracic endovascular aneurism repair (TEVAR), and one patient with profunda femoralis arteria injury due to sharp instrument was treated by endovascular coil embolization. Two patients with thoracic aortic injury, who were with unstable hemodynamic parameters, were treated by synthetic graft interpositions.

## DISCUSSION

There are several studies on the epidemiological consequences of vascular injuries (4–6). Although geographical, socioeconomic, and cultural factors are significant determinants for the etiology and type of vascular injuries, they have negligible effects on the demographics of patients with vascular trauma (1, 3). The dominant gender injured by vascular trauma was almost always the male (5, 6). In a recent study, male to female ratio of patients with vascular injuries was estimated as 4.4:1 (6). Similarly, the ratio of male patients in vascular injury groups in various studies ranged between 80% to 99% (5, 7–15). Since 73.1% of the patients with vascular injuries in the current study were male our results were consistent with these data.

There are controversial of results obtained from studies regarding the etiology of vascular injuries. However, the number of studies that demonstrated the dominance of penetrating trauma (2, 3, 7, 12, 13, 16–18). in the etiology of vascular injuries seem to be relatively more than the opposite (6, 8, 9, 19). The penetrating injuries were mostly due to stab wounds in the European countries, while firearm injuries were dominant in countries where firearms were used more widely. For the upper extremity, penetrating trauma mechanism was more common with 73% (4, 20). In different studies conducted in Turkey, vascular injury rates due to penetrating trauma have been reported as 86.4%, 53.1% and 94% (14, 15, 21). We found that the ratio of vascular injuries due to penetrating trauma was 87.8%, which represented a supporting value for the previous study results that favor penetrating over blunt trauma in the etiology of vascular injuries. We propose that the quantitative discrepancy regarding penetrating versus blunt trauma in the etiology of vascular injuries across various studies is primarily due to the geographical and sociocultural factors of the populations studied.

The trauma records of the European studies showed a greater number of lower extremity injuries compared to upper extremity (8, 22). On the other hand, a position study on emergency vascular injuries reported that the upper and lower extremity vascu-

lar injuries had similar frequencies (3). In contrast, there are also study results reporting that upper extremity vascular injuries are higher than lower extremities (9, 15, 23). In the current study, we found that the vascular injuries in the upper extremities were more (52.9%) than those of the lower extremities (39.9%).

Lower extremity vasculature are relatively more injured with in 70% of the patients that presented vascular injury to urban trauma centers with peripheral blunt trauma and the femoral vessels were found to be involved (3). Superficial femoral, radial and ulnar arteries were the most commonly injured vessels of the lower and upper extremities in several studies (7, 14, 16). In the current study, we found that the radial and superficial femoral artery injuries were the most involved vessels. Forearm arterial injuries are found to be the most commonly injured vessels in other studies (4, 20, 23). The results of our study were completely consistent with these data, as we also observed the involvement of upper extremity vessels in the same order as: radial (n: 30), ulnar (n: 15), brachial (n: 12), and axillary (n: 1) arteries. In most studies, the lower extremity injury due to penetrating trauma was most commonly seen in the superficial femoral artery, and venous injuries were most commonly associated with the femoral vein (4, 15, 24). In the present study, the most injured vessel of the lower extremity was the superficial femoral artery, followed by the superficial femoral vein. This was consistent with previously published data.

The concomitant injuries of tendons and nerves were observed significantly more frequently in the upper extremities with blunt trauma (14). The brachial artery injury was frequently associated with skeletal and neurological injuries (4, 20). In a study, it was found that nerve injuries in approximately 30% of the patients with vascular injuries (15). We found neural injuries in 16.1% of the patients with vascular trauma. The relatively low frequency of concomitant injuries in our study might supposedly have reflected the dominance of penetrating trauma in the etiology of vascular injuries that were observed in this study.

Vascular injury can often be the component of a severe or multiple injury and vascular repair should be performed primarily (10). In a study, primary repair of the lower extremity vascular injuries was suggested. The authors recommended the use of contralateral reversed saphenous vein in femoral and popliteal artery injuries that required graft use (3). End-to-end anastomosis and interposition graft can be used successfully in ulnar and radial artery injuries (9). In a similar study to the current study, the most used surgical procedure for vascular injury treatment was primary repair in 65% of the patients (23), and also end-to-end anastomosis and saphenous vein graft interposition were used in 44% and 38% of the time, respectively (23). In a previous study, saphenous vein graft interposition was recommended as the best surgical procedure for injuries to the superficial femoral artery (4). In our study, the most used surgical technique was end-to-end anastomosis, followed by saphenous vein graft, both of which were successfully and consistently used according to the recommendations in the literature.

The need of an amputation due to vascular injury in the upper extremities is almost always the result of a complicated injury to the common brachial vessel. With popliteal artery injuries

caused by blunt traumas, there is a risk of amputation approximately three times higher than penetrating injuries (3). In a study investigating the relationship between amputation and various vascular injuries, most of the amputated patients had lower limb vascular injuries, especially caused by blunt trauma (19). The rate of limb salvage in a very recent study was 82.7% (6). In a study performed on emergency vascular injuries in Turkey, the mortality rate was reported as 6.2% (14). In our study, the mortality and the amputation rates were found as 1.1% and 3.2%, respectively. In this context, the low rates of amputation might be the result of penetrating trauma dominance in the etiology of vascular injuries in our patient series.

Patients with traumatic aortic dissection have a 90% risk of mortality. The patients, who have been treated with open surgery, have a 2–26% risk ratio of paraplegia (25). Endovascular repair with descending aortic injuries does not require thoracotomy, single lung ventilation and the use of cross-clamp to the aorta. In the literature, it was reported that no mortality or paraplegia in endovascular treatment groups (25). However, surgical groups had 16–17% mortality and 16% paraplegia rates. Because of this reason, endovascular treatment is more popular in the treatment of traumatic injuries of the great arteries (25). In the current study, we had four patients with aortic trauma. Two patients with traumatic type 3 aortic dissection due to car accident was treated by endovascular therapy and two patients with thoracic aortic injury, who were with unstable hemodynamic parameters, were treated by synthetic graft interpositions. None of these patients developed mortality, plegia or other complications.

The current study had some limitations and this was a retrospective study. Patient data with a sufficient number of blunt injuries could not be accessed. Due to its retrospective nature bear, it caused the inclusion of only patients whose data could be accessed. This situation caused the relative patient numbers to be insufficient.

In conclusion, our study had limited epidemiological data. Since there are no established standards in the evaluation of vascular trauma, the current study might provide a significant contribution to the evaluation of vascular trauma. In the future, similar comparative studies are needed to determine the medical needs of patients with vascular trauma.

**Ethics Committee Approval:** Ethical approval was obtained from the ethics committee of Erciyes University Faculty of Medicine (date: 06.02.2019, number: 2019/104).

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