

## ORIGINAL RESEARCH

# An Epidemiologic Overview of Traumatic Vascular Injuries in Emergency Department; a Retrospective Cross-Sectional Study

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**Abstract:** **Introduction:** Vascular system injuries (VSIs) are one of the main causes of preventable mortality and morbidity of trauma patients. This study aimed to evaluate baseline characteristics, presenting signs, managements, and outcomes of patients presenting to emergency department (ED) with traumatic VSIs. **Methods:** This retrospective cross-sectional study was conducted on patients with traumatic VSIs admitted to the ED of a referral tertiary trauma center, during one year. Using a pre-prepared checklist, demographics, pre-hospital care, type of VSIs, injury severity score (ISS), anatomical location of trauma, associated injuries, method of surgery, complications, and outcome were collected from patients' profiles and reported. **Results:** One hundred and twelve patients with the mean age of  $33.5 \pm 14.7$  (range = 8 - 80) years were studied (90.2% male). Most of the patients were categorized as mild or moderate in terms of their ISS. 90 (80.4%) patients had at least one soft sign and 99 (88.4%) patients had at least one hard sign. Isolated arterial injury was diagnosed in 90 (80.4%) patients, isolated venous injuries in 12 (10.7%) cases, and combined arteriovenous injuries in 10 (8.7%) patients. The most common associated injury was tendon rupture (63.4%) and nerve injuries were present in 60.7% of patients. 1 (0.9%) patient died, 6 (5.4%) patients went through amputation, and 3 (2.7%) patients were discharged against medical advice. The rest of the patients were discharged in perfect health. There was a significant correlation between trauma type ( $p = 0.001$ ), upper and lower extremity trauma ( $p < 0.001$ ), presence of distal ischemia and lack of pulse ( $p = 0.041$ ), penetrating injury close to a major vessel ( $p = 0.006$ ), type of injured vessels and arteries ( $p < 0.001$ ), injury to nerve ( $p = 0.011$ ) and tendon ( $p = 0.007$ ), presence of open fracture ( $p = 0.005$ ), multiple trauma ( $p < 0.001$ ), method of surgery ( $p < 0.001$ ), and number of postoperative complications ( $p < 0.001$ ) with poor outcome. **Conclusion:** The findings showed that the majority of the studied patients were young males, most of whom were discharged in perfect situation. Those who presented with higher ISS, or were affected by blunt trauma or injury to lower limb arteries had worse outcome than the others.

**Keywords:** Emergency Service, Hospital; Epidemiology; Patient Outcome Assessment; Vascular System Injuries; Wounds and Injuries

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## 1. Introduction

Vascular system injuries (VSIs) cause 20% of deaths following civilian traumatic events. It was reported that about 1.5% and 1-2% of civilian trauma patients in the US and Australia, respectively, suffer from a VSI; and the overall mortality resulting from VSIs is 20-26% (1, 2). VSIs have become one of the main causes of preventable mortality and morbidity in trauma patients (3-5). VSIs are also one of the most challenging types of trauma regarding the demand of medical staff's urgent attention and specific interventions (6-8). The management of these patients in the emergency department (ED), as well as selecting the management method are always accompanied by many challenges. It is likely that, periodically reviewing these cases can provide valuable information to the medical team, so such studies have been proposed as a necessity. Therefore, this study was conducted to present the statistics and patterns of civilian traumatic VSIs in a referral center.

## 2. Methods

### 2.1. Study design and setting

This retrospective cross-sectional study was conducted on patients with traumatic VSIs admitted to the ED of Sina Hospital, a referral tertiary trauma center in Tehran, Iran. The study proposal was approved by the ethics committee of Tehran University of Medical Sciences (codes: IR.TUMS.SINAHOSPITAL.REC.1399.095 and IR.TUMS.SINAHOSPITAL.REC.1399.096). Patients' personal information were gathered, analyzed, and presented anonymously. The researchers adhered to the ethical principles of Helsinki recommendations.

### 2.2. Participants

Sample selection was performed using census manner, so all trauma patients with clinical evidence of VSIs admitted to the hospital, from 1 November 2018 until 30 October 2019, were included. Those with incomplete or distorted information in their hospital files were excluded.

### 2.3. Data gathering

Data regarding demographics, pre-hospital care, radiology, presentation to operation interval, type of VSIs, the injured vessels, nature of injuries, blood pressure (BP) on admission, Glasgow coma scale (GCS) on admission, injury severity score (ISS), hard signs (including pulsatile bleeding, expanding hematoma, signs of distal ischemia, and absent pulse) and soft signs (including non-expanding hematoma, injury to an adjacent nerve, penetrating injury to a major vessel, and unexplained hypotension), anatomical location of trauma (neck, thorax, abdomen, upper and lower ex-

trimities), blood transfusion, associated injuries, method of surgery (end-to-end anastomosis, ligation, and saphenous vein interposition), comorbidities, complications, length of hospital stay, and outcome were collected using a pre-designed checklist. Data were extracted from patients' profile. The required information was collected in advance by trained experts in the form of National Trauma Registry of Iran.

### 2.4. Outcome

Outcomes included discharge in perfect health, discharge against medical advice, amputation, or death; of which amputation and death were considered as poor outcomes.

### 2.5. Statistical analysis

All statistical analyses were conducted using the SPSS-25 (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp; 2017). Study findings were reported as frequency (%) or mean  $\pm$  standard deviation (SD) for categorical and numerical variables, respectively. The comparisons were done using Chi-Square or Fisher's exact test. The mean differences of numerical variables in the two group were compared using independent t-test. The p-values lower than 0.05 were considered statically significant.

## 3. Results

### 3.1. Baseline characteristics

One hundred and twelve patients with the mean age of  $33.5 \pm 14.7$  (range: 8 - 80) years were studied (90.2% male). The baseline characteristics of the studied patients are presented in table 1. Most of the patients were categorized as mild or moderate in terms of their ISS. Penetrating trauma was present in 98 (84.8%) patients and blunt trauma in 14 (12.5%) cases. The most frequent site of injury was upper extremities (88.4%). Table 2 lists the frequency of hard and soft signs of VSI on admission. 90 (80.4%) patients had at least one soft sign and 99 (88.4%) patients had at least one hard sign. Pulsatile bleeding and lack of pulse were the most common hard signs.

### 3.2. Management

Table 3 summarized the management, operative findings, and outcomes of patients. Among the patients who underwent imaging prior to surgery, computed tomography angiography (CTA) was the most frequent imaging modality. Blood transfusion prior or during surgery was performed for 27 (24.1%) patients. The time interval between taking the patient to the ED and transferring them to the operating room varied from 1 to 21 hours (the median of the duration was 4 hours).

Open surgery was performed for all the patients. During ex-



**Table 1:** Baseline characteristics of the studied patients (n=112)

Variable	Number (%)
<b>Sex</b>	
Male	101 (90.2)
Female	11 (9.8)
<b>Age group (years)</b>	
<20	20 (17.9)
20-40	69 (61.6)
>40	23 (20.5)
<b>Nationality</b>	
Iranian	105 (93.8)
Non- Iranian	7 (6.3)
<b>Marital status</b>	
Single	73 (65.2)
Married	39 (34.8)
<b>Glasgow coma scale</b>	
15	88 (78.6)
<15	5 (4.5)
Not recorded	19 (16.9)
<b>Prehospital care</b>	
Performed	84 (75.0)
Not performed	28 (25.0)
<b>Injury severity score</b>	
Minor (1-8)	54 (48.2)
Moderate (9-15)	51 (45.5)
Serious (16-24)	7 (6.3)
Severe (25-49)	0 (0.0)
Critical (50-74)	0 (0.0)
Maximum 75	0 (0.0)
<b>Type of trauma</b>	
Penetrating	98 (87.6)
Blunt	14 (13.4)
<b>Anatomical location</b>	
Neck	12 (10.7)
Thorax	5 (4.5)
Abdomen	5 (4.5)
Upper extremities	99 (88.4)
Lower extremities	13 (11.6)

ploration and surgery, isolated arterial injury was diagnosed in 90 (80.4%) patients, isolated venous injury in 12 (10.7%) cases, and combined arteriovenous injury in 10 (8.7%) patients. The most common associated injury was tendon rupture, which accounted for 63.4% of all the cases. Nerve injuries were present in 60.7% of patients.

### 3.3. Outcomes

One (0.9%) patient died; 6 (5.4%) patients went through amputation, and 3 (2.7%) patients were discharged against medical advice. The rest of the patients were discharged in perfect health. 9 (8%) patients had one and 5 (4.5%) patients had two postoperative complications. Surgical site and graft infection was the most commonly reported postoperative complication. The mean length of hospital stay of the study patients was  $7.66 \pm 10.73$  days; and the mean hospitalization cost of them was  $1241.68 \pm 1600.46$  US \$ ( $136584670.14 \pm$

**Table 2:** Frequency of hard and soft signs in the studied patients

Variable	Number (%)
<b>Soft signs</b>	
Non-expanding hematoma	3 (2.7)
Injury to an adjacent nerve	58 (51.8)
Penetrating injury close to a major vessel	57 (50.9)
Unexplained hypotension	1 (0.9)
<b>Hard signs</b>	
Pulsatile bleeding	68 (60.7)
Absent pulse	68 (60.7)
Signs of distal ischemia	14 (12.5)
Expanding hematoma	1 (0.9)
Audible bruit	0 (0.0)
Palpable thrill	0 (0.0)

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There was a significant correlation between trauma type ( $p = 0.001$ ), trauma to upper and lower extremity trauma ( $p < 0.001$ ), presence of distal ischemia and lack of pulse ( $p = 0.041$ ), penetrating injury close to a major vessel ( $p = 0.006$ ), type of injured vessels and arteries ( $p < 0.001$ ), injury to nerve ( $p = 0.011$ ) and tendon ( $p = 0.007$ ), presence of open fracture ( $p = 0.005$ ), multiple trauma ( $p < 0.001$ ), method of surgery ( $p < 0.001$ ), and number of postoperative complications ( $p < 0.001$ ) with poor outcome.

## 4. Discussion

More than 100 patients with traumatic VSIs were evaluated in this study. The majority of them were young males, and most were discharged in perfect condition; albeit there were some with poor outcomes. Isolated arterial injury was the most commonly diagnosed VSI, followed by venous injuries, and combined arteriovenous injuries. Tendon rupture was the most common associated injury. Those who presented with higher ISS, or were affected by blunt trauma or injury to lower limb arteries had worse outcomes than the others.

The retrospective analysis of the patients admitted during the one-year study period showed that the majority of the patients were males between the ages of 20-40 years old. The preponderance of males in patients with VSIs has been mentioned in other studies (3, 4, 6, 9-12). But when it comes to age, the average age of the patients was reported in both young and middle-aged ranges (3, 4, 6, 9-12).

Pre-hospital emergency cares were provided for 75% of the patients in our study. In this study, any action in order to control bleeding, such as pressure dressing, was considered a pre-hospital care, so the reported statistics are higher than that of reported in a previous similar study (13).

The ISS score showed great efficiency in predicting the severity of the outcome, and it was known that those with higher ISS had a significantly higher risk of severe outcome (3, 12). As expected, patients with higher ISS were more frequently



**Table 3:** Patients' management, on operative findings, and outcomes

Variable	Number (%)
<b>Imaging performed</b>	
CTA	13 (11.6)
Color Doppler sonography	7 (6.3)
Angiography	5 (4.5)
CTA + Color Doppler Sonography	2 (1.8)
None	85 (75.9)
<b>Type of vessel</b>	
Vein	12 (10.7)
Artery	90 (80.4)
Both	10 (8.9)
<b>Nature of injury</b>	
Complete tear	97 (86.6)
Partial tear	9 (8.0)
Thrombosis	4 (3.6)
Pseudo aneurysm	0 (0.0)
Other	2 (1.8)
<b>Injured artery</b>	
Axillary	2 (2.0)
Brachial	13 (13.0)
Radial	22 (22.0)
Ulnar	39 (39.0)
Femoral	1 (1.0)
Popliteal	7 (7.0)
Ulnar and radial	10 (10.0)
Other	6 (6.0)
<b>Associated injuries</b>	
Tendon	71 (63.4)
Nerve	68 (60.7)
Open fracture	8 (7.1)
Closed fracture	2 (1.8)
<b>Blood transfusion</b>	
Performed	27 (24.1)
Not performed	85 (75.9)
<b>Method of surgery</b>	
End-to-end anastomosis	55 (49.5)
Ligation	35 (31.5)
Saphenous vein graft	17 (15.2)
Ligation and anastomosis	1 (0.9)
None	3 (2.7)
Unclear	1 (0.9)
<b>Outcome</b>	
Discharged after procedure	102 (91.1)
Amputation	6 (5.4)
Discharged against medical advice	3 (2.7)
Mortality	1 (0.9)
<b>Postoperative complication</b>	
Surgical site and graft infection	8 (7.1)
Compartment syndromes	7 (6.3)
Failure of vascular repair or reconstruction	6 (5.4)
Anastomotic complication	2 (1.8)

CTA: computed tomography angiography

faced with severe outcome.

In our study, the majority of the traumas were due to penetrating injuries, mostly to upper extremities, frequently caus-

ing ulnar artery tear. Upper-extremity trauma is much more common in large urban trauma centers, such as Tehran, which includes a higher percentage of penetrating injuries. Conversely, medical centers located in a less violent areas, such as rural areas, typically include a higher percentage of blunt injuries, most often due to motor vehicle collisions (MVC) (14). Nevertheless, blunt trauma and lower extremity injuries were more likely to cause severe outcomes, compared to other locations and mechanisms. Findings suggest that the anatomical location of the injury is more important than the number of anatomical sites injured in the occurrence of severe outcome. As for the mechanism of the trauma, the results are similar to reports by Baram et al. (6) in Kurdistan and Perkins et al. (3) in United Kingdom (UK), in which penetrating injuries were more common than blunt injuries (3, 6).

In our study, the most common mechanism of injury, among both blunt and penetrating traumas, were MVC and stab wound, retrospectively. Similar to the study by Perkins et al. (3) in the UK, stab wounds were the most frequent cause of penetrating VSIs, and MVC and falling from height were the predominant causes of blunt VSIs (3). But in study of Baram et al. (6) in Kurdistan, only 15% of injuries were caused by stab wound and the majority of recorded VSIs were caused by high velocity missile gunshot (6).

In a study by Menakuru et al. (10), conducted in North India, blunt injuries accounted for 84% of the assessed injuries (falling from height and MVC were the most common mechanisms). Blunt injuries were also more frequent in a study by Sah et al. (9) from Nepal (68%) and Meyer et al. (4) from Germany (60, 4%), that in both studies, MVCs were the predominant cause of traumatic VSIs. In a study conducted in the same center (Sina hospital in Tehran, Iran) by Salimi et al. (11) over a period of 14 months (between March 2002 to May 2003), blunt injury was reported in 56.1% of the cases, in which, MVC (especially while motorcycling) was the most common mechanism of injury followed by sharp objects, especially stab wounds.

As for the anatomical location of the trauma, in studies by Menakuru et al. (10) and Baram et al. (6), brachial artery was injured most commonly followed by the superficial femoral and popliteal arteries; and Meyer et al. (4) reported that the most commonly affected artery was the popliteal artery, followed by the axillar artery. In studies by Menakuru et al. (10) and Sah et al. (9), upper limb injury was more common than lower limb VSIs. But in a previous study conducted in the same center, injuries to the lower limb were more common and the most common anatomical site of vascular injury was knee (11).

A factor that may contribute to the distribution of penetrating and blunt injuries is the location of injury, and the relationship between the outcome and this variable had been

mentioned in many studies (4, 12, 14, 15); but in few previous reports, like ours, there was not any statistical significant difference in this regard (3, 14). It should be mentioned that most of the previous studies pointed that amputation rate and mortality depended on location of injury, and patients with lower extremity injury had a higher risk of severe outcome (3, 15, 16); and the rate of severe outcome was significantly higher in patients with femoral, popliteal or brachial injury compared to other sites (4, 12, 17).

In our study, patients mostly presented with pulsatile bleeding, lack of pulse, and injury to an adjunct nerve, which was similar to the report by Salimi et al. (11). The presence of distal ischemia and lack of pulse were independent predictors of severe outcome (16). In our study, patients with two or three hard signs faced severe outcome more frequently. Any delay in diagnosing VSI can cause ischemia and irreversible damage, and in cases where clinical examination indicates VSI, delaying treatment for diagnostic procedures is not indicated (9). In this study, 76% of the patients were sent to the operating room without performing imaging. Among those patients who underwent radiological procedures, CTA was used for most of the cases. In a report from Sah et al. (9), the majority of the cases (53%) were diagnosed using duplex, followed by additional imaging using CTA in 30% of the case, while just 17% of the cases were diagnosed only on clinical judgment. In a study by Meyer et al. (4) in Germany, CTA was used in almost 60% of the cases pre-operatively.

The importance of early presentation after VSI is well-recognized and six hours has long been considered as the golden time after peripheral VSI (18). In our study, the time interval between arrival to the ED and patients' transfer to the operating room varied from 1 to 21 hours and the median duration was 4 hours. In comparison, in a study done by Myers et al. (19) in USA, the time reported from hospital arrival to the operation room, determined in 66 patients, was 162 minutes (10 to 720 minutes). The reason for this time difference, is that in patients with stable hemodynamics, surgery was postponed so that both vascular and reconstructive surgeries were performed simultaneously, due to accompanying vascular and nerve injury. In some other published papers, presentation-operation interval was not separately reported, and mainly the time interval between the accident and the start of surgery was investigated (6, 9, 16).

In this study, VSIs mostly presented with associated tendon and nerve injuries, which differed from other studies where the most common associated injury was fractures (6, 9, 10). In a study done at the same center, the most common accompanying injuries were muscle injuries followed by fractures (11).

In our study, patients with injury to nerve or tendon or having an open fracture as associated injury have a higher probability of severe outcome, which is in line with findings of

some previous similar studies (12, 16, 17). In comparison, patients with nerve and tendon injuries had a lower percentage of severe outcome, which could be due to other associated injuries (such as fractures and multiple trauma) in people without nerve and tendon damage.

Open surgery was performed for all the patients in this study; and end-to-end anastomosis was the most common type of vascular reconstruction used in this study, which was similar to some similar studies (6, 9, 10). The preferred approach to VSIs in upper and lower extremities, which comprised most of our patients, is open surgery. However, endovascular approaches are also used in this regard. For instance, endovascular approach was used in 11.5% of patients in a study by D'Alessio et al. (12).

In this study, 6 (5.4%) patients went through amputation, while amputation rates ranged from 6.4% to 14.6% in other similar studies (4, 6, 10-12). The overall postoperative mortality rate was 0.9% (1 patients), while the mortality rate in previous studies has been reported between 2.1% to 18% (3, 4, 6, 10-12).

In this study, surgical site infection and compartment syndrome were the most common causes of postoperative complications. This is comparable to those reported by Sah et al. (9) and Menakuru et al. (10), in which this rate was reported as 6% and 11%, respectively. It is commonly believed that postoperative complications like surgical site infection and compartment syndrome are independent predictors of severe outcome (6, 12, 16, 17).

This study with an average of almost one week of hospitalization had the lowest mean duration of hospitalization among similar studies (4, 11, 12), which can be explained by the large number of patients with radial and ulnar artery injury, who usually do not require long hospitalization.

## 5. Limitations

Retrospective studies, in nature, are always accompanied by limitations such as missed or incomplete data. We tried to eliminate such limitations using the records of registry of "National Trauma Registry of Iran". About the post-operative complications, some of which may have occurred after discharge, there may be a recall bias in the process of recording patient's information. It is noteworthy that adding early or late post-discharge outcome would be valuable. The small number of cases with amputation and other severe outcomes may also prevent the generalization of the results.

## 6. Conclusion

The findings showed that the majority of the studied patients were young males, and most were discharged in perfect health. Most of the patients presented with penetrating trauma, mainly due to stab wound. The surgical man-



agement consisted of open surgery, mostly done using end-to-end anastomosis. Those who presented with higher ISS, or were affected by blunt trauma had worse outcomes than the others. Patients with arteriovenous injuries and injury to femoral, popliteal, and brachial arteries were more likely to face severe outcomes.

## 7. Declarations

### 7.1. Acknowledgments

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### 7.2. Authors' contributions

The conception and design of the work by PF and AB; Data acquisition by NM and MB; Analysis and interpretation of data by ME, PF and AB; Drafting the work by NM, MB and MF; Revising it critically for important intellectual content by PF and AB; All the authors approved the final version to be published; AND agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are addressed.

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### 7.4. Conflict of interest

The authors declare that there are no conflicts of interest.

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