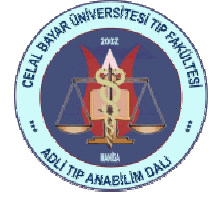




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## Medico-legal evaluation of vessel injuries of limbs in Turkey [Ekstremitte damar yaralanmalarının Türkiye'deki mediko-legal değerlendirmesi]

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### Abstract

This study evaluated 372 cases of post-traumatic extremity vessel lesions, for which Forensic Medicine Council, Istanbul, Turkey prepared medico-legal evaluation reports between 1998 and 2000. The study group (n=372) comprised of 346 men (93.01%) and 26 women (6.99%), and their ages ranged between 6 and 73 years (30.18 ± 6.13). There were 378 artery (74.47%), and 131 vein injuries (25.53%) out of a total of 509 extremity vessel injuries. The most frequently injured arteries and veins were femoral artery (n=73), and profound femoral vein (n=41) respectively. The causes of injuries were as follows: cutting and stabbing objects, in 160 cases (43.01%); gunshots in 136 cases (36.56%); traffic accidents in 52 cases (13.98%); work accidents in 23 cases (6.18%); and blunt trauma in one case (0.27%). These injuries were accompanied by local nerve lesions (27.15%), local bone lesions (37.10%), and injuries to other organs (11.02%). The medico-legal evaluations by the Forensic Medicine Council showed that there were vital risks in 371 cases. Additionally, there were "organ dysfunction" in 37 (9.95%) and "organ loss" in 53 (14.25%) cases. The results of this study suggested that the main causes of severe vessel injuries, i.e. accompanied by bone and nerve lesions, and had serious consequences such as amputation, permanent disorders or loss of function, were gunshot injuries and traffic accidents.

### Keywords:

Vessel injuries, trauma, vital risk, organ dysfunction, organ loss, Turkish Penal Code.

### Özet

Bu çalışmada, 1998-2000 yılları arasında Türkiye, İstanbul, Adli Tıp Kurumu tarafından haklarında mediko-legal rapor düzenlenmiş ve posttravmatik ekstremitte damar lezyonu bulunan 372 olgu değerlendirilmiştir. 372 olgunun 346 sı erkek (93.01%), 26 sı (6.99%) kadın idi ve yaşları 6-73 (ortalama; 30.18± 6.13) arasında idi. Toplam 509 ekstremitte damarında yaralanma mevcut olup 378 inde (74.47%) arter ve 131 inde (25.53%) ven yaralanmaları vardı. En sık yaralanan arter arteria femoralis (n= 73) ve en sık yaralanan ven vena profunda femoralis (n= 41) idi. Yaralanmalar; 160 olguda (43.01%) delici ve/veya kesici aletlere, 136 (36.56%) olguda ateşli silah yaralanmalarına, 52 olguda (13.98%) trafik kazalarına, 23 olguda (6.18%) iş kazalarına, 1 olguda (0.27%) diğer künt yaralanmalara bağlı idi. Olguların 27.15% inde bölgesel sinir lezyonları, 37.10% inde bölgesel kemik lezyonları, 11.02% inde diğer organ yaralanmaları eşlik ediyordu. Adli Tıp Kurumu'nda yapılan değerlendirmede görüldü ki: 371 olguda hayati tehlike bulunmaktaydı. Ayrıca olguların 37 (9.95%) sinde uzuv zaafi ve olguların 53 (14.25%) inde uzuv tatili vardı. Elde edilen sonuçlar, kemik ve sinir lezyonlarının eşlik ettiği ve amputasyon, kalıcı fonksiyon azalması veya kaybı gibi ciddi sonuçları olan ağır damar yaralanmalarının temel nedeninin ateşli silah yaralanmaları ve trafik kazaları olduğunu ortaya çıkarttı.

### Anahtar Kelimeler:

Damar yaralanmaları, hayati tehlike, uzuv zaafi, uzuv tatili, Türk Ceza Kanunu.

## 1. Introduction

Cardiovascular system injuries have attracted the attention of all physicians since the very beginning of humanity. Hippocrates, emphasizing the significance of such injuries, said: "...one who wants to be a surgeon must follow an army..." [1].

Thanks to the practical experience from the wars, combined with homograft and heterograft vessel plantations, and quick access and diagnostics opportunities, vessel surgery has become an important branch that can be applied to all vessels in the body successfully. These developments dramatically decreased the rates of mortality and amputation in heart-vessel injuries [1, 2].

However, hemorrhage shock in acute injuries, infection, difficulties in selection of graft for infected wounds, preservation of graft applied to infected wounds, problems caused by venous grafts in the course of time, complications in chronic cases, and other organ injuries accompanying vessel injuries may give rise to negative conditions [2-3].

The treatment of injuries is the work of surgeons. But its medico-legal evaluation is the work of forensic scientists.

In Turkey, the term of penalty for the convicts or the amount of compensation depend on whether or not the crime was committed intentionally, the fault properties in the crime, and the seriousness of injuries in victims. Courts decide on the intention and properties of fault while evaluation by medico-legal experts about the seriousness of the injuries in the victims is needed. The medico-legal evaluation of injuries is based on the articles of Turkish Penal Code and Turkish Commercial Law. Those criteria are used to determine the "the duration of cessation of daily activities", whether or not there is "the vital risk", "organ dysfunction" or "organ loss" and if there is a disability what "percentage of disability" is. In actual terms, "the duration of cessation of daily activities" is not defined as the duration of hospitalization or healing, and does not change with age, sex or the profession of wounded. It is only used for the calculation of "percentage of disability". The duration of cessation of daily activities is standardized and tabulated. For instance, unless a complicated extremity amputation is likely to develop in this period, the duration of cessation of daily activities is twenty-five days. There is "vital risk" if there is one of following: Skull fractures, intracranial lesions, pneumothorax and/or haemothorax, the lesions of visceral organs or main vessel injuries, cervical vertebral fractures (on or above third cervical vertebrae), the lesions of spinal cord, second degree burns of more than 25% of the body surface, third degree burns of more than 10% of the body surface, serious poisonings. On the other hand, if there is between 20% and 50% permanent loss of function or anatomical structure of an organ or an extremity, such

cases are classified as "organ dysfunction". If this loss is more than 50%, then such cases are classified as "organ loss" [4].

The applicable laws stipulate that relevant penalties are increased in cases of vital risk and organ dysfunction, and further increased in case of an organ loss. Additionally, amount of compensation is calculated based on the above criteria and "percentage of disability".

The aim of this study was to examine the cases of extremity vessel lesions and the judicial consequences in relation to the medico-legal evaluation of findings by the said Council.

## 2. Material and method

Forensic Medicine Council is a governmental expert authority having its base in Istanbul, the largest metropolis of Turkey.

This retrospective study is based on 372 cases with vessel injuries in extremities. In selection of these cases, medico-legal reports together with the medical case notes prepared upon examination by the local health authorities and when necessary, judicial reports by Forensic Medicine Council were examined.

These cases were medico-legally evaluated after being classified according to their demonstrative and clinical properties.

The  $\chi^2$  test was used for statistical evaluation.

## 3. Results

In this study, 372 medico-legal reports about post-traumatic extremity vessel lesions prepared between 1998 and 2000 have been explored.

The study group (n=372) comprised of 346 men (93.01%) and 26 women (6.99%), and their ages varied between 6 and 73 years (mean  $\pm$  standard deviation =  $30.18 \pm 6.13$ ).

Injuries of lower and upper extremity vessels were found in 237 (63.71%) and 135 (35.29%) cases out of 372, respectively.

There were 378 artery injuries (74.47%), and 131 vein injuries (25.53%) out of a total of 509 extremity vessel injuries.

The injury was confined to a single artery in 216 (58.06%) cases, and a single vein in 20 (5.38%) cases. In 32 cases (8.6%) two arteries; in 7 cases (1.88%) two veins; in 96 cases (25.81%) one artery and one vein; and in 1 case (0.27%) two arteries and one vein were injured.

The most frequently injured arteries were femoral artery (n=73), popliteal artery (n=53), and brachial artery (n=53); and the most frequently injured veins were profound femoral vein (n=41), femoral vein (n=30), and the popliteal vein (n=24). The frequency of injuries in other arteries and veins were low (Table 1).

Table-1. 509 injured vessels in 372 cases

Injured vessel	n	%
Axillary artery	13	2.55
Brachial artery	45	8.84
Radial artery	42	8.25
Ulnar artery	53	10.41
Superior ulnar collateral artery	1	0.20
Profound femoral artery	47	9.23
Femoral artery	73	14.34
Popliteal artery	53	10.41
Anterior tibial artery	15	2.95
Posterior tibial artery	30	0.59
Fibular artery	1	0.20
Circumflex femoral artery	1	0.20
Dorsal artery of the foot	4	0.79
Axillary vein	3	5.89
Brachial vein	11	2.16
Radial vein	2	0.39
Ulnar vein	3	0.59
Superior collateral ulnar vein	1	0.20
Profound femoral vein	40	7.86
Popliteal vein	24	4.72
Femoral vein	30	5.89
Greater saphenous vein	11	2.16
Posterior tibial vein	1	0.20
Lesser saphenous vein	4	7.86
Accessory saphenous vein	1	0.20
<b>Total</b>	<b>509</b>	<b>100</b>

The causes of injuries were as follows: cutting and stabbing objects in 160 cases (43.01%); gunshots in 136 cases (36.56%); traffic accidents in 52 cases (13.98%); work accidents in 23 cases (6.18%); and other blunt trauma in one case (0.27%). There were no iatrogenic injuries due to catheterization in our study group.

The vessel injuries were accompanied by local bone lesions in 110 (29.57%) cases, nerve lesions in 73 (19.62%) cases, and combined bone and nerve lesions in 28 (7.53%) cases. In addition, there were injuries in 41 (11.02%) cases in other organs besides vessel injuries.

Upon examination of the clinical findings in medico-legal reports, it was possible for all cases to determine the time between the time of injury and the medical/surgical intervention. The number of acute patients presented to the hospital in the first two days, and chronic patients after the second day were 351 (94.35%), and 21 (5.65%) respectively. There were two or more clinical findings in most of these cases. Primary finding upon examination was pain around the injury (n=146, 39.25%). Other findings are summarized in Table 2.

It was found that all chronic patients, 12 (57.14%) had arteriovenous fistula, and 9 (42.86%) had traumatic

pseudoaneurysm. As for the cases with arteriovenous fistula, it was noted that an average of 43 days passed before they were admitted to a health organization (range: 3-289 days). This was 20 days in cases with pseudoaneurysm (range: 5-130 days). All subjects with arteriovenous fistula and 88.89% of those with pseudoaneurysm were males. The mean ages were 27.8 and 34.4 years in cases with arteriovenous fistula, and pseudoaneurysm, respectively. Arteriovenous fistulas most frequently developed between the superficial femoral artery and femoral vein (41.67%). On the other hand, pseudoaneurysm most frequently occurred in the profound femoral artery (44.45%).

Vessel lesions were found in 351 acute patients, upon the first medical examination, and in 27 (7.69%) of them amputation was performed due to large soft tissue loss, fragmented fractures, nerve injuries, ruptured and disrupted vessel injuries, and progressive infections. In the remaining cases (n=324), 318 arterial lesions were repaired by various surgical methods. As for the treatment of 103 venous lesions, surgical interventions other than amputation were applied. Similarly, in 21 chronic patients, surgical interventions other than amputation were applied.

As for 324 acute patients on whom surgical interventions other than amputations were carried out,

complications developed in a total of 70 (21.60%) cases: infections in 34 (10.49%) cases, peripheral circulation problems due to thrombus formation in 21 (4.63%) cases, both infection and peripheral circulation problems in 15 (4.63%) cases. As for the 21 chronic patients who did not have amputation, complications developed in a total of 6 (28.57%) cases: infections in 4

(19.05%) cases, and peripheral circulation problems in 2 (9.52%) cases. Secondary operations were deemed necessary for 37 (49.33%) cases with complications out of 75, and 22 of them (29.33%) had amputation. One case who received surgical intervention twice had to undergo a third operation due to recurrent thrombus formation.

Table-2. Clinical symptoms in 372 cases

Clinical symptoms	n=	%
Pain of extremity	146	39.25
Decrease in or loss of distal pulsation	114	30.65
Systolic soufflé, thrill	105	28.22
Systole-diastolic soufflé, thrill	74	19.89
Oedema and hyperemia around the injury	60	16.12
Intermittent claudication	45	12.10
Infection	38	10.22
Vasodilatation	23	6.18
Hypertrophy of the distal part of the extremity	13	3.49
Nicholandoni- Brahman's sign	11	2.95
Pulsatile swelling	9	2.42
Shock	8	2.15

(There is more than one clinical symptom for some patients)

The total rate of primary and secondary amputations carried out in all vessel injuries was 13.17% (n=49). The majority of these cases (n=40, 81.63%) had popliteal artery injury and all those who had popliteal artery injury had amputation. Bone and large tissue lesions combined with fragmentation in arteries were identified in 42 (85.71%) cases. Incurable circulatory disorders and infections developed in the remaining 7 (14.29%) cases.

The medico-legal evaluations by the Forensic Medicine Council concluded that there was a vital risk in 371 cases. Vital risk was not present in one case with injuries in superior ulnar collateral artery and superior ulnar collateral vein.

On the other hand, 37 (9.95%) cases with 20% to 50% permanent loss of function in extremity were classified

as “organ dysfunction”, and a total of 53 (14.25%) cases, including 49 cases with amputation and 4 cases with more than a 50% permanent loss of function in extremity were classified as “organ loss.” The factors that gave rise to dysfunction and loss of function were nerve and fragmented bone lesions for all cases.

The causes of injuries in 90 cases classified as “organ dysfunction” or “organ loss” was gunshots in 51 cases (56.67%), motor vehicles in 34 cases (37.78%), work machines in 3 cases (3.33%), cutting and stabbing objects in 2 cases (2.22%). To put in another way, permanent symptoms developed in 34 (65.38%) cases out of 52 injuries due to traffic accidents, in 51 (37.5%) cases out of 136 injuries due to gunshot wounds, in 3 (13.04%) cases out of 23 injuries due to work accidents, and in 2 (1.25%) cases out of 160 injuries due to cutting and stabbing objects (Table 3).

Table-3. Correlation between causes and medico-legal outcome in 372 cases

Medico-Legal Conclusion ► Origins ▼	Injury		Organ Dysfunction		Organ Loss		Total	
	n=	%	n=	%	n=	%	n=	%
Injury by traffic accidents	52	100	13	25.00	21	40.38	34	65.38
Injury by firearms	136	100	21	15.44	30	22.05	51	37.50
Injury by industrial accidents	23	100	1	4.35	2	8.69	3	13.04
Injury by cutting and/or stabbing tools	160	100	2	1.25	0	0	2	1.25
Injury by other blunt tools	1	100	0	0	0	0	0	0
<b>Total</b>	<b>372</b>	<b>100</b>	<b>37</b>	<b>9.95</b>	<b>53</b>	<b>14.25</b>	<b>90</b>	<b>24.19</b>

(Percentages were calculated horizontally)

#### 4. Discussion

The findings of this study confirm other studies establishing that the majority of the cases sustaining vessel injuries were males (93.07% in the present study). The mean age of our cohort was 30.18 years. This also was comparable to the findings of various studies. A literature review revealed that males comprised 84-100% of those who sustained vessel injuries [2, 3, 5-7] and their mean age ranged between 26.0 and 39.7 years [3, 5, 8-10]. Men are much more exposed to trauma and vessel injuries possibly due to their active life styles and their relatively aggressive attitudes both in business and in their private lives. The fact that the mean age of those who have vessel injuries is approximately 30 can be explained by the comparatively high level of activity of the said age group in the society.

In this study, the percentage of lower and upper extremity vessel injuries were 63.71%, and 36.29%, respectively. These percentages are in agreement with the respective values of 62% and 38% [11], and 71%, and 24% [2] reported in two recent articles. On the other hand, studies conducted in other countries report a reversed injury percentages in lower, and upper extremity vessels, i.e. 26 and 40 – 50%, respectively. The high percentage of lower extremity vessel injuries in Turkey can be explained by taking into consideration the high number of injuries caused by gunshots, and cutting and stabbing objects. Shooting/stabbing in the lower extremity is generally regarded as a warning from the organized-crime syndicates in Turkey.

The majority of previous studies reported that the most frequently injured vessel among both upper and lower extremity vessels was brachial artery [8, 12-19]. Taken individually, the most frequently injured upper extremity artery was reported to the ulnar artery [20], or the axillary artery [2]. Similarly, the most frequently injured vessel of the lower extremity was reported to be the superficial femoral artery in the majority of the previous studies [2, 3, 8, 14, 17, 21, 22], with the exception of the popliteal artery [5, 23]. We found that the frequency of injury to the femoral artery was 14.34% (n=73), to the popliteal artery was 10.41% (n=53), and to the ulnar artery to be 10.41% (n=53).

Blunt traumas and injuries caused by cutting and/or stabbing objects are reported to be the main causes of extremity vessel injuries [5, 11, 12, 14, 24-26]. Various studies on extremity vessel injuries suggested different results as to the causes of the injuries. The main cause of extremity vessel injuries was blunt traumas in 57% of the cases [12]; cutting and/or stabbing objects in 49% [1], 62% [3], 55% [14], 53% [13], and 67% cases [25]; traffic accidents in 72% [5] and 45% of the cases [8]; and gunshot wounds in 53% [26], and in 47% of the cases [2], respectively. In this study, we found that the main cause of vessel injuries was cutting and/or stabbing objects (43.01%).

It was stated in previous studies that extremity vessel injuries were accompanied by nerve injuries in 7 – 64 % of the cases [2, 12, 20, 27-29], fractures in 4 – 86 % cases [2, 5, 20, 21, 23, 27-29], and other organ injuries in 1 – 64 % of the cases [2, 3, 12, 23]. It was not surprising to find that our study was in agreement with the aforementioned wide ranges, with 27.15% of cases having local nerve lesions, 37.10% having local bone lesions and 11.02% having other organ lesions.

The clinical findings in cases with vessel injuries were defined by Sayin et al. as pain of the extremity (41.8%), systolic soufflé and thrill (33.2%), a decrease in or a loss of distal pulsation (31.7%), systole-diastolic soufflé and thrill (26.4%), pulsatile swelling (26.4%), intermittent claudication (19.7%), oedema and hyperemia around the injury (13.5%), infection (13.5%), Nicholandoni-Brahman's sign (12%), vasodilatation (9.6%), hypertrophy of the distal part of the extremity (4.3%), ulceration and hyper pigmentation (3.8%), shock (3.8%), signs of gangrene (1.9%), symptoms of cardiac inefficiency (1.4%). On the other hand, the percentages of present study are given in table-2. Clinical findings were less observed and less apparent in our series compared to a previous study because the percentage of chronic patients in our series (5.65%) is much less than that of the series of Sayin et al. (64%) [2]

For vessel injuries, the amputation rates were 49% in WW2, 13 – 25% in Korean War, and 8% in Vietnam War [1]. Even though these rates reach 57% in various military series, it is between 0 – 9% in civilian series [2, 6, 9, 11, 14, 22, 17-23, 28]. On the other hand, Davidovic et al. reported that the amputation rate was 3.1% in two distinct series of late-treated cases [30, 31]. The said rate was 13.17% in our study. The reasons for amputation in the literature were blunt traumas and gunshot wounds, injuries to the popliteal artery, late diagnosis, late treatment, insufficient antibiotherapy, inappropriate surgical procedure [25, 27]. Cases reviewed in this study who amputation include soldiers injured during combat against terrorist activities (the exact number was no available). They were exposed to heavy arms, and their injuries were more severe. Furthermore, due to the fact that transportation service is to a large extent provided by motorways in Turkey, increasing traffic accidents causes severe injuries. The factors with the highest impact on the indication for amputation were arterial injuries, including 40 (81.63%) cases with popliteal artery injuries whom all had amputation, bone and large tissue lesions combined with fragmentation in arteries (42 cases, 85.71%), and development of incurable circulatory disorders and infections (7 cases, 14.29%). No amputations were carried out in the 21 chronic patients, and the success rate of treatment in all cases can be explained by having less severe injuries, and by the short time between the time of injury and the time of admittance to a health organization in comparison to those reported in the literature [32-34].

The development of arteriovenous fistula and pseudoaneurysm is another complication of vessel injuries. There were 13 (3.49%) cases with arteriovenous fistula, and 9 (2.42%) with pseudoaneurysm out of 372 cases in this study. These rates range between 4.7 and 35% for arteriovenous fistula and 2.7 and 52.5% for pseudoaneurysms in the literature [2, 32, 33, 35]. The subjects were males in all cases with arteriovenous fistula, and in 88.89% of cases with pseudoaneurysm. The mean ages were 27.8 and 34.4 years in cases with arteriovenous fistula and pseudoaneurysm, respectively. These percentages conform to the respective percentages for male population of 90-100%, and the mean age of 25-31.7 years as reported by other studies [32, 33]. When the cases with arteriovenous fistula and pseudoaneurysm were compared, male/female ratio was found to be higher in cases with arteriovenous fistula while the mean age was higher in cases with pseudoaneurysm. Arteriovenous fistulas most frequently occurred between the superficial femoral artery and the femoral vein (41.67%). On the other hand, pseudoaneurysms were most frequently in the profound femoral artery (44.45%). These findings are in agreement with literature [32-34, 36].

The medico-legal evaluations by the Forensic Medicine Council showed that there was a vital risk in 371 cases (99.99%). In spite of the fact that advances in medicine/surgery decrease the vital risk, the current mortality rate can be as high as 15.8% in vessel injuries [1, 2]. Since this study did not take the data on the deceased into account, mortality rate was not calculated. Thirty-seven (9.95%) cases with 20 to 50% permanent loss of function in extremity were classified as permanent "organ dysfunction", and a total of 53 (14.25%) cases, including 49 cases with amputations and 4 cases with more than a 50% permanent loss of the functions in extremity, were classified as "organ loss". All 90 cases with "organ dysfunction" or "organ loss" had nerve lesions and/or fragmented bone lesions. Permanent symptoms developed in 34 (65.38%) cases out of 52 injuries due to traffic accidents, in 51 (37.5%) cases out of 136 injuries due to gunshot wounds, in 3 (13.04%) out of 23 injuries due to industrial accidents, and in 2 (1.25%) cases out of 160 injuries due to cutting and stabbing objects. These results suggest that more severe and permanent symptoms develop secondary to gunshot wounds and traffic accidents and these cases may eventually progress to amputation.

## 5. Conclusion

A great deal of young people are frequently exposed to recurrent surgical operations due to vessel injuries in extremities, and the proportion of those who lose their limbs, or suffer from permanent dysfunction or total loss of function in extremities, cannot be ignored. Though not included in the present study, the current mortality rate cannot be ignored either.

The rates of mortality, amputation, and permanent dysfunction or total loss of function can be decreased by immediate referral to a clinic and prompt diagnosis and appropriate treatment. Notably, we suggest that the most significant factor contributing to bone and nerve lesions accompanying the vessel injuries are gunshot wounds and traffic accidents.

Other important factors that would help prevention of vessel injuries and consequential permanent complications are tougher control over the use of firearms among civilians, aggravated legal penalties for offenders of the crime for injuries or deaths by firearms, closer international collaboration against terrorism, support for peaceful policies, encouragement for alternative transportation systems in substitution for motorways, increased control over worksite safety, and above all education for people.

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