MEDICOLEGAL AND CLINICAL ASPECTS OF PERIPHERAL VASCULAR INJURIES: A RETROSPECTIVE STUDY

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ABSTRACT

Background: Vascular trauma is one of the devastating types of injuries whether accidental or intentional. Despite this fact, there is an obvious deficiency in the educational sessions for vascular surgeons concerning the appropriate medicolegal dealing with such injuries. Aim: To report the experience of vascular limb trauma

highlighting the medicolegal and clinical findings. **Methods:** A 5-years retrospective study with a follow up period of 1.5 years studying the data of peripheral vascular injuries at three specialized trauma centers with special emphasize on the cause, the type, and the outcome of this trauma in relation to sociodemographic factors. Obtained data were statistically analyzed using the SPSS computer program (version 23). **Results:** This study included 350 trauma patients (287 males and 63 females) who presented with peripheral vascular injuries. The patients' age ranged from < 8 years to >50 years. There was a significant association between the age and the circumstances of trauma. The most encountered causative mechanisms were traffic accidents (45.7%) and firearms (21.7%). There was no significant association between outcome and age ($p = 0.114$) or circumstances of trauma ($p = 0.208$). There was a highly significant association between the outcome and the duration of hospital stay ($p < 0.001$). Lower limb injuries were higher in frequency than upper limb injuries (n = 286 and 123) respectively. Upper and lower limbs arterial injuries had a significantly higher frequency rate than the venous injuries. Ulnar artery and brachial vein injuries was the most frequently encountered upper limb arterial and venous trauma, while the femoral artery and the deep femoral vein were the most commonly affected lower limb vessels. Bone injuries were the most frequently accompanying injuries (44.6% of total cases). **Conclusion:** As any sort of injury may possess medical and lawful perspectives, medicolegal investigations have to take the crown's position when studying trauma cases, going hand in hand with the clinical aspect.

Keywords: Peripheral vascular trauma; Medicolegal aspects; Traffic accidents

INTRODUCTION

Trauma is accused of 10% of all deaths worldwide, and the fifth leading cause of expressed disabilities **(Puvanachandra et al., 2012)**. It remains the most important public health problem and the main cause of mortality and disability through the first four decennia of life **(Nepal et al., 2015, Andreas et al., 2016)**.The implication of trauma varies from threatening life to destruction of mental and physical health as well as, the negative impacts on both frugal and social up growth (**Gupta et al., 2015; Mahran et al., 2016)**.

The influence of undue mechanical forces on the body tissues may result in compression, traction, and torsion as well as shearing **(Ding et al., 2016)**. Factors affecting the consequent damage implicate the type of the imposed mechanical force and the nature of the targeted tissues **(Barekand Haque, 2013)**.

One of the important categories of any wound is its inflection's manner whether suicidal or accidental **(Carla et al., 2017)**.

They are usually classified into; abrasions (grazes or scratches), contusions (bruises), lacerations (cuts or tears) and incised wounds (slashes or stabs) **(Ding et al., 2016)**.

By 2020, injuries are anticipated to exceed communicable diseases on a

secular standard as the prime reason of inability **(Kubat et al., 2015; Rich and Walker, 2016)**.

Developing countries still have a defect in injury prevention programs. This may be caused by many factors such as; the imperfect information for studies, lack of accuracy in detecting trauma bearding and Nevertheless, in other areas such as Egypt and according to the World Health Organization (WHO) report, road-related injuries mortality accounts for 2.37% of the total death cases annually .The death rate is 14.46 per 100.000 of population. **(Abdulla et al., 2015)**.

These injuries are one of the grave causes for morbidity and mortality. They are believed as the fifth leading cause of death and the main occasion for hospitalization for approximately one-quarter of all in patients **(Ghaleb et al., 2018)**.

Vascular trauma whether arterial, venous, and/or blood- rich organ injuries are among the life threating conditions. They may be due to blunt trauma leading to crushing or stretching to the blood vessel or a penetrating injury resulting in puncture, torning or severing of a blood vessel **(Kubat et al., 2015; Rich and Walker, 2016).**

Vascular trauma may cause clot formation or a life-threatening haemorrhage that interrupts the normal blood flow to the body organs and/or extremities. **(Nepal et al., 2015; Raherinantenaina et al., 2016).**

On the other hand, wall defects, complete or partial transections, as well as arterio-venous fistulae (AVF) may accompany penetrating trauma**(Rich and Walker, 2016; Weale et al., 2018)**.

Arterial spasm may be caused by blunt or penetrating trauma to the extremities **(Eachempati et al., 2002; Kubat et al., 2015).**

A traumatic false aneurysm is formed when the surrounding tissues encapsulate The aim of this study was to retrospectively analyze the cases of limbs' vascular trauma in a period of 5 years with a follow up period of 1.5 years. It also aimed to describe the available medicolegal aspects beyond such injuries in those cases.

PATIENTS AND METHODS

This five years - retrospective study took place from January 2012 to December 2016 with a follow up period of 1.5 years. It included all patients presented with sustained extremities vascular injuries who were treated at three tertiary referral centres in the Eastern Province, Saudi Arabia. After obtaining the approval of the institute research board with regard to the ethical issues of the study, demographic and clinical data, as well as, laboratory and radiological findings were reported through each patient's file. Data was analyzed and the following relationships were studied:

A) Circumstances of the injuries in relation to age, sex of the studied patients and the origin of trauma.

B) Age and sex in relation to the time they asked medical advice as well as the period of hospital stay after the intervention.

C) The frequencies of the injured vessels in relation to the type and site of injury.

D) Vascular injuries in relation to other accompanied lesions such as musculoskeletal injuries.

Diagnosis was based on the essence of history and both the hard and soft clinical signs of arterial injury (e.g. progressively increasing hematoma, pulsatile bleeding, impalpable distal pulses, the presence of thrill, and bruit) as described in **(Table1), (Strong and Edwards 2002**; **Nazem et**ories. Pearson's Chi-square test was applied to examine the association between two variables. Fisher exact or Fisher-Freeman-Halton Exact tests were employed if the expected count was less than five in any cell. Significance was adopted at $p < 0.05$ for interpretation of results of tests **(William et al., 2015**).

Table (1): Hard and soft signs of arterial injury **(Strong and Edwards 2002**; **Nazem et al., 2009).**

Hard signs	Active hemorrhage
	Absent distal pulses or ischemia
	Expanding or pulsatile hematoma
	Bruit or thrill
Soft signs	Subjective reduced or unequal pulses
	Large non-pulsatile hematoma
	Orthopaedic injuries carrying a high index of suspicion of vascular injury
	Neural injury
	History of large hemorrhage on

RESULTS

In this study, 350 victims with limb injuries were included; out of which 63 (18%) were women and 287 (82%) were men. They were of different ages ranging from 5 years up to 65 years with the mean of 23.27± 7.83 years. The most encountered causative mechanisms were traffic accidents (45.7%) and firearms (21.7%). As illustrated in (**Figure 1),** the highest incidence of trauma was in age group 20-35 years (males 34.5%, females 8.5%) while the lowest incidence was encountered in age group < 8 with a statistically significant results

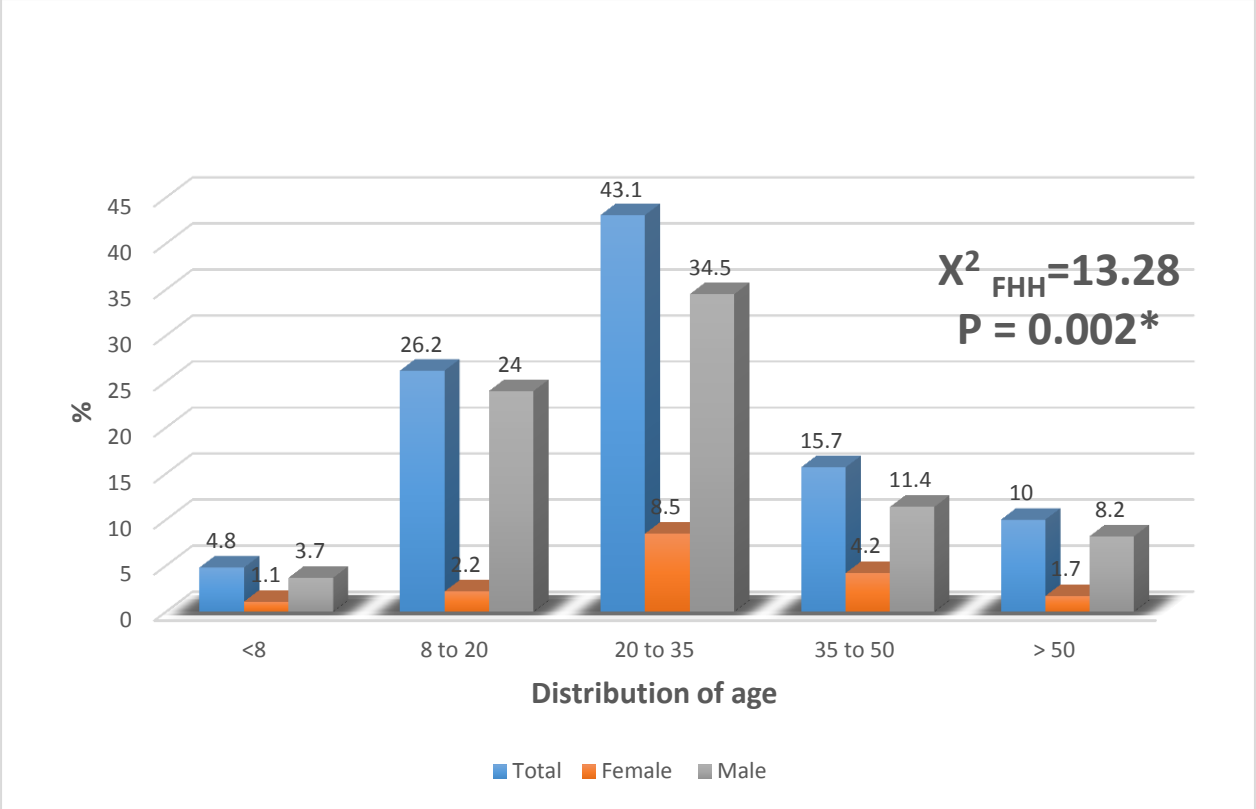

Figure (1): distribution of age in relation to sex, *significant at 0.01.

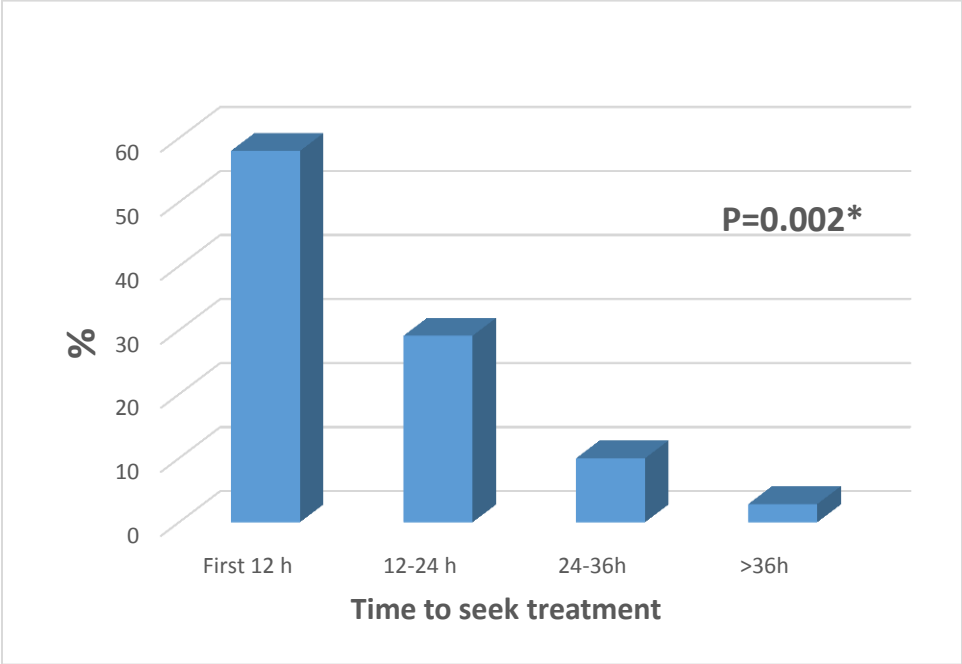

Figure (2): Time between trauma and seeking treatment in all patients, *significant at 0.01.

Table (2): Association between circumstances of trauma and sex, age, and causative instruments

		Circumstances of trauma								Fisher-Freeman-Halton test	
		Total (n = 350)		Accidental (n = 70)		Assault (n = 275)		Self-inflicted (n = 5)			
		n	%	n	%	n	%	n	%	X^2	p
Sex	**Female**	63	18.0%	12	17.1%	50	18.2%	1	20.0%	0.290	1.000
	Male	287	82.0%	58	82.9%	225	81.8%	4	80.0%		
Age (Years)	**<8**	17	4.9%	8	11.4%	7	2.5%	2	40.0%	95.900	<0.001*
	8 to 20	92	26.3%	10	14.3%	80	29.1%	2	40.0%		
	20 to 35	151	43.1%	11	15.7%	140	50.9%	0	0.0%		
	35 to 50	55	15.7%	15	21.4%	40	14.5%	0	0.0%		
	> 50	35	10.0%	26	37.1%	8	2.9%	1	20.0%		
Causes	**Cutting/stabbing tools**	42	12.0%	12	17.1%	30	10.9%	0	0.0%	5.225	0.697
	Firearms	76	21.7%	15	21.4%	60	21.8%	1	20.0%		
	Industrial accidents	53	15.1%	8	11.4%	45	16.4%	0	0.0%		
	Traffic accident	160	45.7%	33	47.1%	123	44.7%	4	80.0%		
	Other blunt tools	19	5.4%	2	2.9%	17	6.2%	0	0.0%		

n: number; * significant at p <0.05.

For (n = 75, 21.43%) of cases. As shown in (**Table 2)**, there was no significant association between the circumstances of trauma and sex (p = 1.000), or the causative mechanism (p = 0.697). However, there was a highly significant association between the age and the circumstances of trauma. The assaulted cases aged between 20-35 years approaching higher percentage (50.9%) versus (15.7% and 0 %) for accidental and self-inflicted respectively. Lower limb injuries were higher in frequency than upper limb injuries (n = 286 and 123) respectively. As many victims had multiple injuries, the sum of injuries was far higher than the total number of victims. The total number of injured vessels in both upper and lower limbs in the studied victims was 409 in the 350 cases. Moreover, lower extremity vascular trauma accounted for a whether in the upper or in the lower limb **(Table 3)**. As demonstrated in **(Table 3),** upper limb arterial injuries had a significantly higher frequency rate (n = 107, 26.2% of all vascular injuries) than the venous injuries (n = 16, 3.9%, p<0.001). Ulnar artery injury was the most frequently encountered upper limb arterial trauma (n = 33, 8.1%) followed by the brachial injury (n = 32, 7.8%), **(Figure 3)** and the radial injury (n = 29, 7.1%). On the other hand, brachial vein injury was the most common venous injury affecting the upper limb (n = 10, 2.4%), followed by the axillary vein (n = 3, 0.7%). In continuity with (**Table 3)**, lower limb arterial trauma showed a significantly high frequency rate (n = 200, 48.9%) than the venous injuries (n = 86, 21 %, p<0.001). The femoral artery was the most commonly affected

Table (3): The injured vessels in the upper and lower limbs

Site of injury	Injured vessels	n	% of total vessel injuries
Arteries of upper limb (n = 107, 26.2% of all injured vessels)	Axillary	12	2.9
	Brachial	32	7.8
	Radial	29	7.1
	Ulnar	33	8.1
	Superior ulnar collateral	1	0.2
Veins of upper limb (n = 16, 3.9% of all injured vessels)	Axillary	3	0.7
	Brachial	10	2.4
	Radial	1	0.2
	Ulnar	1	0.2
	Superior ulnar collateral	1	0.2
Arteries of lower limb (n = 200; 48.9% of all injured vessels)	Deep femoral	48	11.7
	Femoral	65	15.9
	Popliteal	47	11.5
	Anterior tibial	15	3.7
	Posterior tibial	22	5.4
	Fibular	1	0.2
	Circumflex femoral	1	0.2
	Dorsal artery of the foot	1	0.2
Veins of lower limb (n = 86, 21.0% of all injured vessels)	Deep femoral	33	8.1
	Femoral	26	6.4
	Popliteal	23	5.6
	Greater saphenous	1	0.2
	Lesser saphenous	1	0.2
	Accessory saphenous	1	0.2
	Posterior tibial	1	0.2
Pearson's Chi square test (limb & vessels)	X^2	13.375	
	p	<0.001*	
Chi square goodness of fit test (arteries & veins)	X^2	10.087	
	p	<0.001*	
Chi square goodness of fit test (upper & lower limbs)	X^2	10.112	
	p	<0.001*	
Chi square goodness of fit test (arteries & veins in upper limb)	X^2	8.115	
	p	<0.001*	
Chi square goodness of fit test (arteries & veins in lower limb)	X^2	6.682	
	p	<0.001*	

n: number; * significant at p <0.05.

Furthermore, the most frequently affected lower limb veins were the deep femoral (n = 33.8.1%) followed by the femoral (n = 26, 6.4%), and the popliteal vein (n = 23, 5.6%). Bone injuries ntly encountered (44.6% of total cases), followed by nerve injuries (32%). In addition, concomitant nerve and bone injuries were reported in (14.9%) while an isolated blood vessel

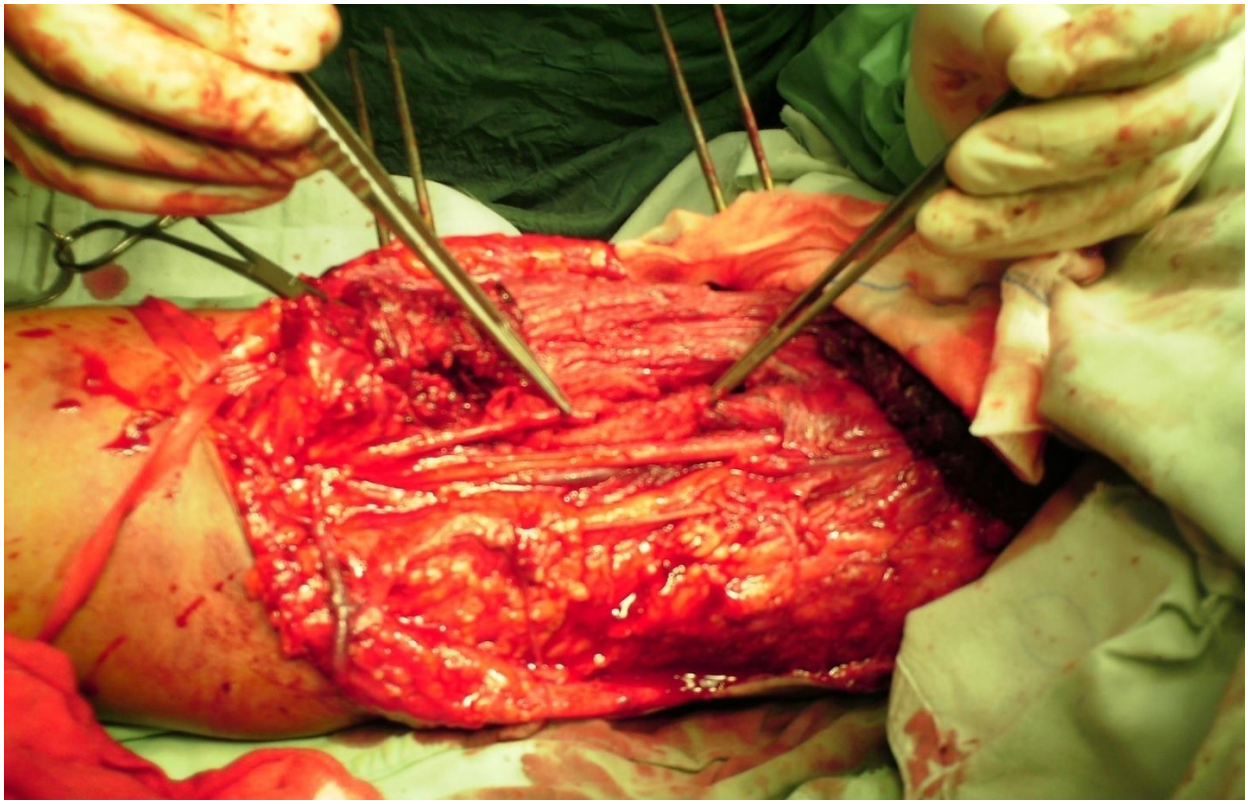

Figure (3): injury of the brachial artery.

Figure (4): Brachial artery injury associated with soft tissue and comminuted bone injury with external fixator.

Table (4): Association between the affected limb and the injuries

	Site of injuries						Pearson's Chi square test	
	Total (n = 350)		Upper limb (n = 123)		Lower limb (n = 286)			
	n	%	n	%	n	%	X^2	p
Isolated vessel injuries	25	7.1%	10	8.1%	15	6.6%	0.279	0.598
Accompanied injuries:								
Bone	156	44.6%	41	33.3%	115	50.7%	9.695	0.002*
Nerve	112	32.0%	37	30.1%	75	33.0%	0.321	0.571
Both bone and nerve	52	14.9%	16	13.0%	36	15.9%	0.513	0.474
Others	64	18.3%	19	15.4%	45	19.8%	1.023	0.312

n: number; * significant at p <0.05.

(14.9%) while an isolated blood vessel injury was reported in (7.1%). There was no significant association between the injured limb and the type of the accompanying trauma except in bone fractures that showed a significantly higher rate in lower limb versus those in the upper limb (i.e. 50.7% versus 33.3% in upper limb) p=0.002. These results are shown in (**Table 4).** The outcome of studied victims is demonstrated in (**Table 5),** most victims suffered complications (n = 178,50.85%), 110 cases improved and major surgical interventions were performed in 50 out of them via primary Furthermore, 46 cases had impaired limb functions, 10 cases lost extremities, and 6 cases died, with a statistically significant difference (p<0.001). There was no significant association between outcome and age (p = 0.114) or circumstances of trauma (p = 0.208). There was a highly significant association between the outcome and the duration of hospital stay (p < 0.001); as significantly higher percentages of improved cases had a hospital stay less than 14 days. Moreover, complicated cases had higher frequencies that stayed 14-21

Figure (5): Primary repair with end-to-end vascular anastomosis of the radial artery

Table (5): Association between the outcome of the studied victims and each of age, circumstances of trauma and hospital stay.

		Outcome										Chi square goodness of fit test	
		Improvement (n = 110)		Complications (n = 178)		Impaired functions (n = 46)		Loss of extremities (n = 10)		Death (n = 6)		X^2	p
												307.657	<0.001*
		n	%	n	%	n	%	n	%	n	%	Pearson's Chi square test	
												X^2	p
Age	<8	2	1.8%	11	6.2%	4	8.7%	0	0.0%	0	0.0%	22.981	0.114
	8 to 20	30	27.3%	50	28.1%	8	17.4%	4	40.0%	0	0.0%		
	20 to 35	47	42.7%	80	44.9%	16	34.8%	4	40.0%	4	66.7%		
	35 to 50	20	18.2%	19	10.7%	13	28.3%	1	10.0%	2	33.3%		
	> 50	11	10.0%	18	10.1%	5	10.9%	1	10.0%	0	0.0%		
Circumstances of trauma	Accidental	22	20.0%	40	22.5%	5	10.9%	2	20.0%	1	16.7%	5.272	0.208
	Assault	85	77.3%	137	77.0%	40	87.0%	8	80.0%	5	83.3%		
	Self-inflicted	3	2.7%	1	0.6%	1	2.2%	0	0.0%	0	0.0%		
Hospital stay	< 3 days	20	18.2%	10	5.6%	0	0.0%	2	20.0%	1	16.7%	93.200	<0.001*
	3 - 7 days	30	27.3%	20	11.2%	6	13.0%	2	20.0%	1	16.7%		
	7 - 14 days	45	40.9%	43	24.2%	13	28.3%	3	30.0%	0	0.0%		
	14 - 21 days	7	6.4%	65	36.5%	12	26.1%	2	20.0%	0	0.0%		
	> 21 days	8	7.3%	40	22.5%	15	32.6%	1	10.0%	4	66.7%		

n: number; * significant at p <0.05.

Figure (6): Femoral injury with interposition reversed saphenous vein graft

DISCUSSION

Extremity vascular injuries pose a challenge to most surgeons. It is considered to be a major cause of morbidity and mortality in the developing countries. They are usually due to street offenses, imperfect roads planning, firearms, and other weapons correlated

trauma (**Khan et al., 2015; Joshi, 2016)** as well as self-inflection **(Izawa et al., 2016)**.

According to the tort classical deterrence theory, the probability of litigation enforces the health care providers to be more cautious in their practice based on the well established standards of patients care, thereby, enhancing patient outcomes **(Demetriades, 2011; Minami et al., 2014).**

Most of this study population was males (82%). This can be supported by previously published reports in which number of males is higher than females by variable percentage **(Klinkner et al., 2007; Sciarretta et al., 2014; Allen et al., 2015; Gurien et al., 2017; Kayssi et al., 2018)**. The current work

at different ages ranging from 5 years up to 65 years. The most commonly affected age group was 20-35 years coinciding with data in the literature **(Joshi, 2016)**.This might be attributed to the finding that this age category may be commonly exposed to high-risk events as it is considered the most productive age **(Manakuru et al., 2005).**

In our existing results, traffic accidents were reported as the most common mechanism of vascular trauma (45.7%) leading to either isolated vascular injuries or accompanying limb musculoskeletal fracture. Comparable data was notified in the literature with a variable degree (**De Feyter 2003; Asirdizer et al., 2004: Milas et al., 2004; Linton et al., 2008; Adams 2014; Ziffra e t al., 2018).**

On the other hand, **(Ekimand Tuncer, 2009)** had reported penetrating trauma as the main causative mechanism in their study on 49 patients with brachial artery injuries. The results of the current work revealed no signif- icant association between the circumstances of trauma and sex or the causative mechanism. This may be attributed to the new development of the Saudi society where women are offered more freedom to share in the professional work life as a as well as the recent permission of car driving. One the other hand, **(Mostafa et al., 2002)** concluded that gender-specific trauma's frequencies, circumstances, and outcome in favour of males. In this work, most injuries occurred due to assault in 275 patients (78.57%), followed by accidental in (20 %), and self-inflicted in (1.43%). This data is contradicting to previously published reports that showed the prevalence of assault injuries to be 63% in Australian (**Taylor and Cameron 1998)**, and 35% in Indian populations (**Swarnkar et al., 2016)** respectively.

However, self-inflicted injuries were observed in the younger age group (i.e. < 20 years) with a higher incidence rate. This result coincides with that reported in an American study (**Bukur et al., 2011; Minami et al., 2014)** and with study from Canada **(Kayssi et al., 2018).**

The highly significant association between the outcome and the duration of hospital stay proved in this study was in agreement with that reported in other work investigating the ordinarily applied measurement for quality of care inside the hospitals **(Lingsma et al., 2018).**

The most commonly encountered lesion in the current study was lower limb trauma (70%) with an injury to the superficial femoral artery coinciding with a previously published report (**Bukur et al., 2011; Balestrine et al., 2014; Leow et al., 2016).**

Arterial injuries showed a significantly increased rate compared to those presented with the venous injury. Both upper and lower extremity arterial injuries accounted for (26.2% and 48.9%), respectively. This m ay be compared to those presented with venous injuries as it accounted for (3.9% and 21%) in the upper and lower limbs, respectively. Previous studies reported an increased incidence of lower extremity more than upper extremity vascular injuries that consistent with the report in this literature **(Harris and Hordines, 2003, Fowler et al., 2009)**.

The second most commonly encountered pathology following vascular injury in patients with multiple injuries was the bony fracture (44.6%). This result is approximately similar to a reported percentage of 37% in the literature **(Manakuru et al., 2005)**.

The complications of traumatic extremity injuries were observed in most of our treated victims 50.85% (n=178), while 46 cases (13.4%) had impaired limb function and disability. This functional disability was coinciding with that reported in others literature **(Franz etal., 2009; and Jaipuria et al., 2014)**. It may raise an important issue as regards the legal compensations and the quality of life.

CONCLUSION

Traffic accidents are the most accused reason for vascular limb injuries followed by gunshot either assault or self-inflicted. The current work had investigate numerous points of forensic interest in relation to vascular trauma but because it was conducted in a retrospective manner, the medicolegal data obtained from the patients' files are fewer if compared with those acquired from autopsy or recently injured cases. This might reflect the defects in forensic dealing with all cases of trauma and hence throw light on the importance of the proper forensic documentation with such injuries. This appropriate documentation might be of great significance for both patients and surgeons especially in cases liable to develop legal and/medicolegal consequences.

RECOMMENDATION

Conduction of adequate educational sessions for vascular surgeons concerning the appropr- iate medicolegal aspects dealing with vascular injuries. Raising public awareness about the implication of first aid measures for trauma management. Thoroughly employing road safety and transportation tools. Establishment of decisive international measures to combat all forms of terrorism. Proper implementation of safety and security measures in all worksites. A strict surveillance along the utilizing of weapons amongst civilians

and increase lawful punishment for assaulters of the offense for trauma or killing by firearms or other types of weapons.

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الملخص العربى

الجوانب الطبية الشرعية والسريرية لإصابات الأوعية الدموية الطرفية: دراسة استرجاعيه

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تعتبر إصابات الأوعية الدموية إحدى أنواع الإصابات المدمرة سواءً كانت عرضية أو متعمده وعلى الرغم من ذلك، هناك نقص واضح في الجلسات التعليمية لجراحي الأوعية الدموية حول التناول الطبي الشرعي المناسب لهذه الإصابات وتهدف هذه الدراسة التي شملت 350 مريضًا (287 من الذكور و 63 من الإناث) ، تتراوح أعمارهم من أقل من 8 سنوات إلى أكثر من 50 سنه إلى عرض خبرة التعامل مع إصابات الأوعية الدموية وتسليط الضوء على النتائج الطبية الشرعية والسريرية من خلال دراسة استرجاعيه لمدة خمس سنوات بالإضافة لفترة متابعه للحالات مقدارها سنه ونصف على بيانات مرضى إصابات الأوعية الدموية في ثلاثة مراكز متخصصه لعلاج هذه الإصابات مع التركيز على سبب الإصابة ونوعها ونتيجة الإصابة وعلاقتها بالعوامل الاجتماعية الديموغرافية وتحليل هذه البيانات إحصائياً باستخدام برنامج التحليل الإحصائي (SPSS) ، وقد أظهرت نتائج تلك الدراسة وجود أعلى ارتباط إحصائي بين حدوث الإصابات والفئه العمرية (20 - 35) في كل من الذكور والإناث كما كانت أكثر الإصابات التي تمت مراجعتها تعزى الى الحوادث المرورية (45.7٪) ، ثم الأسلحة النارية (21.7٪). كما لم يتبين وجود ارتباط إحصائي بين السن والحالة السريرية النهائية للمريض (القيمة الاحتمالية =0.114) ، ولا بين ظروف الإصابة والحالة السريرية النهائية للمريض (القيمة الاحتمالية =0.208) ، بينما تبين وجود ارتباط إحصائي قوى بين فترة المكوث بالمستشفى والحالة السريرية النهائية للمريض (القيمة الاحتمالية > 0.001) كما كانت نسبه إصابات الأطراف السفلية في المجمل أكثر من الأطراف العلوية (286 حاله للأطراف السفلية مقابل 123 للأطراف العلوية). وكان معدل إصابات الشرايين أعلى من معدل إصابات الأوردة في الأطراف العلوية والسفلية على السواء. وقد سجلت إصابات الشريان الزندي والوريد العضدي أعلى نسبه إصابات لأوعيه الأطراف العلوية بينما سجلت إصابات الشريان الفخذي والوريد الفخذي العميق أعلى نسبه إصابات لأوعيه الأطراف السفلية. كما سجلت إصابات العظام أعلى نسبه إصابات مصاحبه لإصابات الأوعية الدموية (44.6 ٪ من مجموع الحالات). وخلصت الدراسة إلى ضرورة تبوء فحوصات الطب الشرعي لموقع الصدارة جنبا الى جنب مع الجوانب السريرية أثناء التعامل الطبي مع حالات الإصابات بمختلف أنواعها.