OLGU SUNUMU / CASE REPORT

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Perspectives from a role-2 hospital: A 5-year accumulated vascular injury experien

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ÖZET

Rol-2 hastane cephesinden 5 yıllık damar yaralanmaları tecrübesi

Giriş ve Amaç: Bu çalışmanın amacı yüksek hızlı parça tesirine bağlı ciddi damar yaralanmalarının tedavisinden elde edilen derslerin paylaşılmasıdır.

Materyal ve Metod: Çalışma retrospektif vaka serisi olarak dizayn edilmiştir. Çalışmada klinik ile fotoğraf, X-ray ve CT gibi veriler birlikte değerlendirilriştir. Çalışmada savaş ile ilgili olmayan kaza, düşme vs yaralanmalar dışlanmıştır. Veriler SPSS-22 ile incelenmiştir.

Sonuçlar: Tüm vasküler yaralanmaların, 33 (% 58) arter yaralanması, 24 (% 42) venöz yaralama olarak tespit edilmiştir. Genel olarak, yaralanmaların % 65'i ekstremite yaralanmalarıdır. Ekstremite yaralanmalarının 24 (% 42) alt ekstremite iken(p> 0.36) üst ekstremite, 23 (% 40)'dır.Ekstremite damar yaralanmalarının 28(%60)aynı ektremitede kırık ile birlikte tespit edilmiştir.

Tartışma: Bizim çalışmamıza ekstremite damar yaralanmaları, hakimdir. Üst ekstremite damar yaralanmaları(% 42), alt ekstremite (% 40)'dır. Çalışma sadece Rolü 2 tedavileri içermektedir. Damar yaralanmaları, mortalite ve uzuv kaybı içermemektedir.

Sonuç: Operasyon alanı, taktik durum, yaralanma cinsi ve fizyolojisi savaş alanında vasküler yaralanmalarda damarın bağlanması veya onarılması kararında etkilidir. Uzun süreli takipler ile büyük damar yaralanması veri sonuçları özellikle Rolü 2 seviyesinde askeri cerrahlar için daha iyi tedavi ve eğitim stratejilerini oluşturmak için analiz edilmelidir.

Anahtar Kelimeler: *Savaş alanı, damar yaralanması, patlayıcı, ateşli silah.*

SUMMARY

Background and Aims: The aim of this paper is to convey lessons learned from the high velocity missile related severity of combat vascular injuries.

Material and Methods: The study was designed as retrospective case series in order to overcome difficulties associated with confounding factors. Clinical and objective data (case photographs, x-rays, and CT scans) were thoroughly reviewed. Non-combat related injuries, as such accidental injuries (falls, car crash, etc.) were excluded and only explosives and high-energy bullets-related injuries were included in the study. Data was statistically analyzed using SPSS-22 software.

Results: Of all vascular injuries, 33(58%) were documented as venous and 24(42%) as arterial injuries. Overall, 65% of the injuries were extremity injuries and extremity vascular injuries were the most common: 24(42%) in the upper extremity, 23(40%) in the lower extremity ($p > 0.36$). Twenty-eight (60%) casualties with extremity vascular injuries had concomitant fractures on the same extremity.

Discussion: Extremity vascular injuries predominate in our study. Upper extremity vascular injuries were also the most common (42%) followed by the lower extremity (40%) injuries. This is probably due to IEDs frequently located on the sloping land. As the study only involved treatment in the Role 2, data shows no vascular injury related mortality, limb loss or other morbidities.

Conclusion: In combat situations, the decision to ligate or repair a venous injury was made according to the tactical situation, availability of the operating theatre, associated injuries and physiological status of the casualty. Larger vascular injury data with long term follow up should be analyzed to provide outcomes data and to establish better treatment and training strategies for military surgeons especially at Role 2 level.

Key words: *Combat, vascular injury, explosive, gunshot*

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Introduction

Recognition of the bleeding soldier and prioritizing him among many others with complicated injuries has always been challenging in the history of war (1). In this race against the platinum few minutes (2), tactical casualty care and evacuation is further complicated by the fact that these interventions are to be performed under fire with limited medical supplies (3,4). Hemorrhage from various types of blood vessels, which is not amenable to compression, remains the leading cause of potentially preventable death, accounting for more than 50% fatalities on the battlefield (5).

The rate of combat related vascular injury in World War I (WWI), WWII, Korean and Vietnam Wars have been reported to be 0.4% - 1.3%, 0.96%, 2% and 3%, respectively (6). Despite the emphasis on its consequences, the epidemiology of combat related vascular injuries have not been sufficiently delineated in reports on recent military conflicts.

Turkish Military have been fighting against national threats for over 30 years now and estimates of vascular injury rates still stem from individual efforts and a joint combat trauma database should be established. Data and analysis of data are required for future improvements in a trauma system. We may deduce from this fact that the system cannot improve without data. If the population at risk is the military, the efforts to report on vascular injury epidemiology might provide insight for informed military medical personnel training and tactical planning. The objective of this study is to characterize the epidemiology of vascular injury and explain the surgical approach in their treatments in the context of the capabilities of our combat support hospital.

Material and Methods

Currently, the first extensive injury data records are archived at the level of Combat Support (Role 2) Hospitals. Our Role 2 Combat Support Hospital consists of 7/24 available trauma surgeons, emergency medicine specialists, tactical and medical evacuation teams. Our first objective is to encounter and prioritize the casualties in a multiple or mass casualty situation. The second objective is to perform damage control surgery in order to stabilize life-threatening injuries and limb salvage. This attitude shifts towards definitive surgery under available logistic circumstances. The Turkish Military Combat Support Hospitals have extended surgical and logistic capabilities including surgical intensive care units (SICU) for postoperative care.

All medical evacuations to a Role 3 hospital were performed using military helicopters and flight times were approximately

45 minutes. Tactical situation, suitable weather conditions, emergency of and need for more complex reconstructive surgery, clinical status of the casualty, incoming more casualties, etc., were all critical factors in the decision-making process for medical evacuation. Thus, postoperative follow up periods for even similar casualties were variable and hospital stay of casualties was not included in the study. Experienced medical personnel for en-route care used mobile ventilators and physiological monitoring devices, as appropriate. There were no mortalities during evacuations.

Data between June 1st 2005 and June 1st 2010 were retrospectively reviewed. The study was designed as retrospective case series in order to overcome difficulties associated with variable follow up periods (2 hours to 7 days), possible confounding factors such as lack of consistent data relating to physiologic variables during the admission and before evacuation periods. Another important confounding factor for the analysis of outcomes (i.e. limb loss) was regarded as the presence of different surgical teams within the five years period. In order to overcome the selection bias in case series study design, two dedicated surgeons that involved in the chart review process were blinded for the purpose of the study.

Clinical and other objective data like case photographs, x-rays, and CT scans were thoroughly reviewed to fill standardized data collection sheets to be used in the study. Unfortunately, taking photographs of all individual cases were ignored by the surgeons and only available pictures were used in the study and in the current report. Non-combat related injuries, as such accidental injuries (falls, car crash, etc.) were excluded and only explosives and high-energy bullets-related injuries were included in the study. Data included casualties without protective body armor, demographics, date and time to admission and mechanism of injury, associated injuries, and detailed anatomical location of injuries, surgical and medical treatments performed.

Decision to perform surgery was based mainly on physical signs (hard-soft signs) and a hand held continuous-wave Doppler examination. We also used C-arm imaging device (GE OEC MED. Compact 7700 110kV) for diagnostic arteriography as a useful adjunct. All surgical procedures were performed at our Role 2 hospital before medical evacuation by military helicopters to a Role 3 hospital.

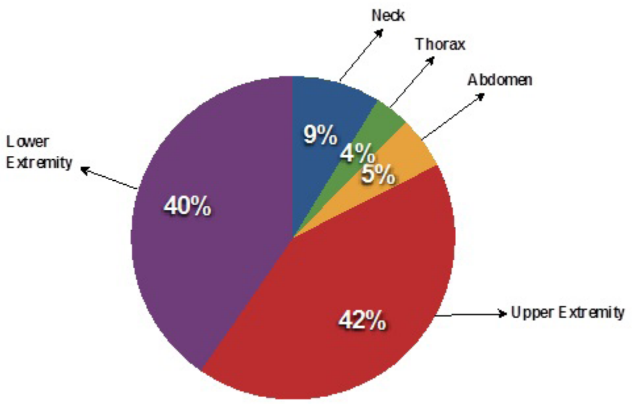
Data was statistically analyzed using SPSS-22 software (Statistical Package for the Social Sciences, IBM Inc., USA). Statistical tests included Mann Whitney U test and Chi Square test were used as appropriate. A value of <0.05 was considered statistically significant.

Results

Retrospective data analysis of this 60-month study revealed 846 casualties; 43 (5.3%) casualties had 57 vascular injuries. Of 43 male casualties; 34 (79%) were Turkish Military personnel, 6 (14%) were civilian guards, 3 (7%) were civilian citizens and their ages ranged from 12 to 55 years (mean= 25; median= 21). Tactical evacuation of all casualties (time from injury to Role 2 admission) was performed in less than one hour. The mean time from admission to the onset of surgery was 28 ± 6 minutes.

Explosives accounted for 78% of all injuries and 60% of vascular injuries. Vascular injuries sustained from gunshot wounds (GSW) were 40% (p = 0.02). Of all vascular injuries, 33(58%) were documented as venous and 24(42%) as arterial injuries. (Table) Explosives caused multiple injuries in ≥ 2 anatomic regions in 18(42%) patients with vascular injuries (p < 0.01). These injuries were complicated multiple soft tissue injuries that required complex wound care and reconstructive measures. All GSW related vascular injuries inflicted only one anatomic region of the body.

Although ligation of some venous injuries seems to be a prudent tactical approach in austere circumstances, 28(85%) of venous injuries were repaired. Overall, 65% of the injuries were extremity injuries and extremity vascular injuries were the most common: 24(42%) in the upper extremity, 23(40%) in the lower extremity (p > 0.36). The other vascular injuries were located in; 5(9%) the cervical area, 3(5%) abdomen and 2(4%) the torso area (Figure 1: Distribution of Vascular Injuries).



Venous injuries were most commonly diagnosed during surgical exploration of arterial injuries, 15 of 24(63%) arterial injuries were associated with concomitant venous injuries. Overall, in 8(24%) of 33 reconstructed venous injuries venous thrombosis was diagnosed in the early postoperative period, before the evacuation. Evacuation was postponed, thrombectomy and revision of the anastomosis was performed.

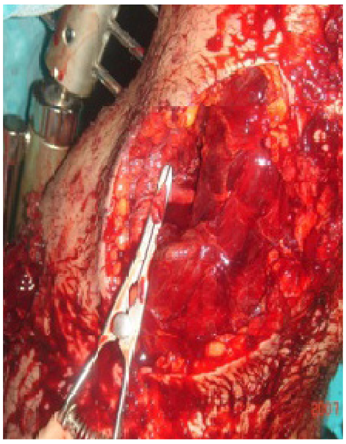
Eight (14%) casualties with uncompressible vascular injuries and proximal vascular injuries of the extremities had systolic blood pressures less than 70 mmHg during admission. They were successfully resuscitated using fresh whole blood donated by the "the walking blood banks". One casualty with a caval vein injury had also concomitant liver and duodenum injuries. Data shows that 35 units fresh whole blood was transfused during the resuscitation and surgical intervention periods. Liver and duodenum were primarily repaired. Two subclavian vein injury casualties had concomitant pneumothorax, which were treated with chest tubes. Four casualties (7%) with compressible vascular injuries had systolic blood pressures between 70-90 mmHg due to delays in tourniquet application by the soldier himself or medic due to active combat. Majority of these hypotensive casualties (70%) were injured by explosive mechanisms.

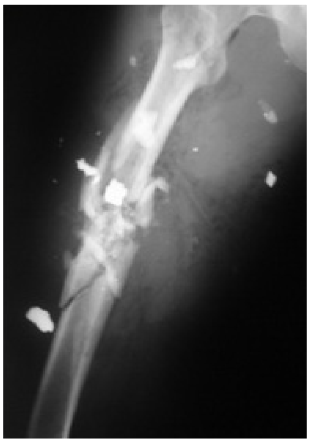
We used temporary shunts in four casualties (ext. iliac artery, int.iliac vein and femoral artery-vein injuries) as a damage control measure. The heparinized shunts (sterile iv tubes) were in place for a mean of 130 minutes (min 110 minutes, max 150 minutes). These shunts all worked well and definitive surgeries were performed in our Role 2. The casualties with external iliac artery and femoral artery injuries, fasciotomy were also performed after vascular reconstruction procedures.

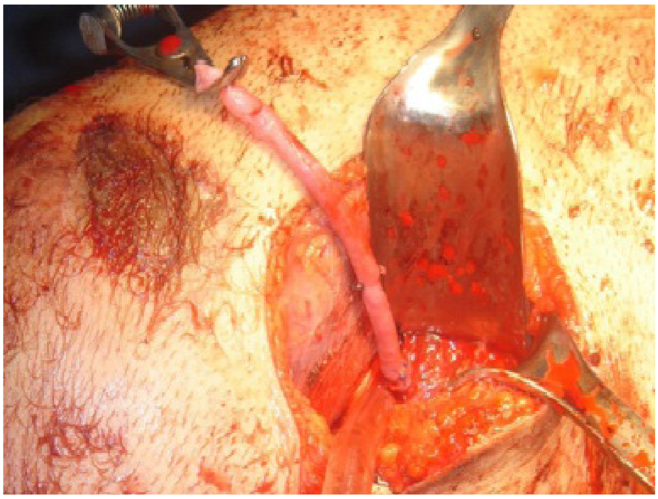
During the resuscitation and surgery of the external iliac artery injury, data shows that 70 units of fresh frozen plasma and fresh whole blood were used. This patient was re-operated due to graft disruption in the early perioperative period and revision of the anastomosis was performed. He also had concomitant multiple small bowel and rectum injuries. Small bowel injuries were treat by resection and rectum was primarily repaired followed by a sigmoid colostomy. We were able to follow this patient's outcome through echelons of care. He had an extended SICU stay (45 days) and eventually recovered from sepsis and respiratory complications in Role 4 hospital.

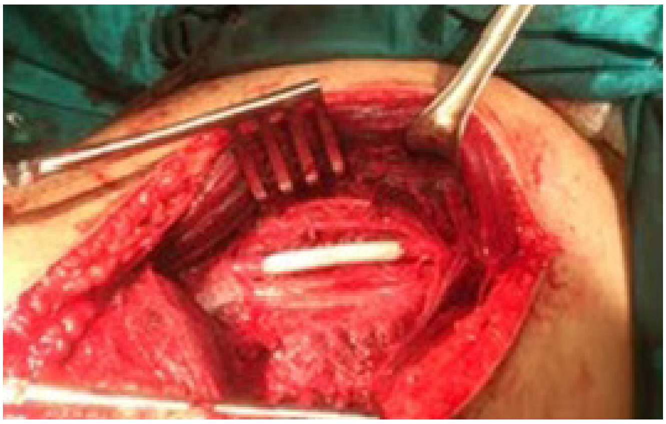
Twenty-eight (60%) casualties with extremity vascular injuries had concomitant fractures on the same extremity. However, when all extremity fractures were analyzed, 28(83%) of the lower extremity and only 6(25%) of the upper extremity vascular injuries were associated with fractures on the same extremity (Figure 2: Femur type 3c fracture with femoral artery injury Figure 3: Transected artery and external fixator application. Figure 4: Saphenous vein reconstruction) Prior to revascularization, we preferred external fixation of the skeleton for rapid stabilization except in one patient.

We used saphenous vein bypass graft (SVBG) in 12 of 24 artery injuries and in 3(25%) of these patients, with brachial, femoral, popliteal artery injuries, vein graft thrombosis was diagnosed immediately after the surgery and Fogarty catheter embolectomy was performed (Figure 5: Superficial femoral artery injury due to a secondary missile-Gentle thrombectomy to a none back bleeding transected artery using a Fogarty catheter. Figure 6: PTFE graft reconstruction. Figure 7: Closure of the surgical incision. Entrance wound on the skin was included in the incision.) We used PTFE graft for the repair of 3 (13%) arterial injuries. (Table) Intra-operative completion arteriography was performed as a useful adjunct to prevent technical errors.









As in high velocity missile related injuries a high degree of wound contamination is extremely common, irrigation of the wounds to remove gross contamination with normal saline, pedicled or free tissue flap coverage to protect vascular repair and prophylactic antibiotics (cefazolin and gentamicin) were routinely used. Except for the administration of heparinized saline through the inflow and outflow vessels and shunt materials during the vascular reconstruction procedures, we did not routinely use systemic heparinization. Upon the hemodynamic stabilization but not necessarily stable casualties were evacuated to a Role 3 hospital within 4 hours.

Table. Vascular Injuries

Region	Name of Vessel	No	GSW	IED	Surgical Procedure	No
Neck	Int.Jugular Vein	2	-	2	Vein Repair	2
	Ext. Jugular Vein	3	-	3	Vein Repair	1
					Ligation	2
Thorax	Subclavian Vein	2	2	-	SVBG	2
Abdomen	V.Cava Inf	1	1	-	Vein Repair	1
	Ext.Iliac Artery	1	1	-	PTFE Graft	1
	Int.Iliac Vein	1	1	-	End to end anastomosis	1
Upper Extremity	Axillary Artery	1	1	-	SVBG	1
	Brachial Artery	3	1	2	SVBG	3
	Radial Artery	4	1	3	End to end anastomosis	2
					Repair	1
	Ulnar Artery	3	-	3	End to end anastomosis	3
	Brachial Vein	6	4	2	SVBG	5
					Vein Repair	1
	V.Cephalica	4	-	4	Ligation	1
					Vein Repair	3
	V.Basilica	3	-	3	Vein Repair	3
Lower Extremity	Femoral Artery	3	2	1	SVBG	3
	Superfical Femoral Artery	2	1	1	PTFE Graft	2
	Ant. Tibial Artery	4	2	2	SVBG	2
					End to end anastomosis	2
	Popliteal Artery	3	3	-	SVBG	3
	Superfical Femoral Vein	9	3	6	Ligation	2
					Vein Repair	3
					SVBG	4
	Common Femoral Vein	2	1	1	SVBG	2

GSW: Gunshot wound,
IED: Improvised explosive device,
SVBG: Saphenous vein bypass graft

Discussion

The treatment of casualties in a rapidly shifting and hazardous combat environment is a real challenge for the medical personnel and tactical evacuation to a surgical facility may simply take hours (2,7). On the other hand, data suggest that mortality and morbidity in vascular injuries is inversely proportionate to elapsed time to surgical treatment (8,9). The above data emphasize that an expeditious evacuation, uninterrupted pre-hospital care (tactical combat care and en-route care) and appropriate allocation of the casualties to a vascular surgery capable hospital is required. These principles are important determinants of outcome in vascular trauma.

Extremity vascular injuries predominate in our study, representing 82% of injuries treated. This is close to the 79% rate reported by White *et al.* (6). However, their study revealed 1570 vascular injuries; upper and lower extremity vascular injuries accounted for 32%(511/1570) and 47%(736/1570) of all vascular injuries, respectively. In the current study, upper extremity vascular injuries were also the most common (42%) followed by the lower extremity (40%) injuries. This is probably due to IEDs frequently located on the sloping land. Moreover, 60% of vascular injuries were associated with bone fractures and were treated with orthopedic fixation preceded by vascular reconstructions.

In our retrospective case series, 5.3% of casualties had vascular injuries. Demirkilic (10) reported 116 vascular injuries caused by high velocity missiles that were treated in Role 3 and 4 military hospitals. However, their report did not include vascular injury rate, mechanism of injury, rates of damage control or definitive vascular surgeries performed at Role 2 hospitals, before evacuation to a Role 3. Early reports from Iraqi freedom reported a vascular injury rate of nearly 5%.(11,12) White *et al.* (6) analyzed their comprehensive Joint Theater Trauma Registry and compared vascular injury rates between

Iraq (12.5%) and Afghanistan (9%) campaigns. Findings from their study demonstrated that the most commonly injured vessels were to be distal extremities.

The repair of most venous injuries, particularly the popliteal vein since it is a single return conduit, should be attempted. Rich (13) have reported that venous repair produced a lower incidence of venous insufficiency and post-phlebitic syndrome when compared to ligation in the lower extremity. He also stated that no evidence supported a more aggressive approach in the upper extremity veins. In combat situations, the decision to ligate or repair a venous injury was made according to the tactical situation, availability of the operating theatre, associated injuries and physiological status of the casualty (13). We agree on this attitude towards venous injuries in a "mission restricted" Role 2 hospital.

Measures that drastically decrease warm ischemia time and prompt treatment

of vascular injuries are important factors for limb salvage (14). Arterial injury and compound fractures due to high velocity missiles are usually associated with extensive tissue damage and interruption of collateral circulation that are significant risk factors for limb loss (15). However, recent studies reported a high limb salvage rates that can approach 100% (16). In our study, we noted no vascular injury related limb loss in the early postoperative period.

Although wounding mechanisms are similar to the recent reports, and our casualty data between 2005-2007 show that explosives account for 78% of all injuries (Unpublished data, A.UNLU,M.D.), our vascular injury rates are nearly half of those published. This is in contrast to the findings of White *et al.* (6) that proposed the increased use of explosives may increase vascular injury rates. Long evacuation times which may decrease the presentation of *'still alive'* vascular injury casualties at the hospital does not seem applicable since our tactical evacuation times have changed since 2005 and all tactical evacuations (from the incidence to hospital admission) have occurred within an hour. However, our study represent data from a Role 2 hospital and their data comprise the rates of Role 2 to Role 5 hospitals. Moreover, a case series study only deals with data available during the research and it is highly likely to find lower rates of injuries when compared to prospectively recorded database analyses. The above facts and lack of follow up data through echelons of care are among the most prominent weaknesses of this study.

Despite the weaknesses of this study, we were able to convey important lessons learned during the management of past vascular injury treatment. Transfusion of 70 and 35 units of blood transfusions were performed during the treatment of two casualties. These constitute huge burdens for the logistic infrastructure of such a mission-restricted hospital. Repair or interposition grafting are now applied frequently for the reconstruction of combat vascular injuries. Ligation was performed as an important strategy under austere tactical conditions, especially for minor or distal vascular injuries. However, larger vascular injury data with long term follow up should be analyzed to provide outcomes data and to establish better treatment and training strategies for military surgeons.

References

1- DeBakey ME, Simeone FA. Battle injuries of the arteries in World War II: An analysis of 2,471 cases. Ann Surg. 1946; 23: 534-579.

2- Martinowitz U, Zaarur M, Yaron BL. Treating traumatic bleeding in a combat setting: possible role of recombinant activated factor VII. Mil Med. 2004; 169: 8-16.

3- Butler FK, Hagmann J, Butler EG. Tactical casualty care in special operations. Mil Med. 1996; 161: 3-16.

4- Holcomb JB. Fluid resuscitation in modern combat casualty care: lessons learned from Somalia. J Trauma 2003; 54: 46-51.

5- Bellamy RF. The cause of death in conventional land warfare: implications for combat casualty care research. Mil Med. 1984; 149: 55-62.

6- White JM, Stannard A, Burkhardt GE. The Epidemiology of Vascular Injury in the Wars in Iraq and Afghanistan. Ann Surg 2011; 253:1184-1189.

7- Beekley AC. United States military surgical response to modern large-scale conflicts: the ongoing evolution of a trauma system. Surg Clin N Am 2006; 86: 689-709.

8- Gofrit ON, Leibouci D, Shapira SC. The trimodal death distribution of trauma victims: military experience from the Lebanon War. Mil Med. 1997; 162: 6- 24.

9- Johannigman JA. Maintaining the continuum of en route care. Crit Care Med. 2008; 36: 377-382.

10- Demirkiliç U, Kuralay E, Yilmaz AT. Surgical approach to military vascular injuries. Cardiovasc Surg. 1998; 6: 342-346.

11- Clouse WD, Rasmussen TE, Peck MA. In theater management of vascular injury: 2 years of balad vascular injury. J Am Coll Surg. 2007;204:625-632.

12- Rasmussen TE, Clouse WD, Jenkins DH. Echelons of care and the management of wartime vascular injury: a report from the 332nd EMDG/Air Force Theater Hospital, Balad Air Base, Iraq. Persp Vasc Surg Endovasc Ther.2006;18(2):91-99.

13- Rich NM. Management of venous trauma. Surg Clin North Am. 1988; 68: 809-821.

14- Russel WL, Sailors DM, Whittle TB. Limb salvage versus traumatic amputation. A decision based on a seven-part predictive index. Ann Surg. 1991; 213: 473-481.

15- Hafez HM, Woolgar J, Robbs JV. Lower extremity arterial injury: results of 550 cases and review of risk factors associated with limb loss. J Vasc Surg. 2001; 33: 1212-1219.

16- Frykberg ER. Advances in the diagnosis and treatment of associated vascular injury. J Bone Joint Surg Br. 1990; 72: 116-120.