Management of vascular injuries during war in Jazan (Saudi Arabia): epidemiology and tips for vascular surgeons deploying to wars

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Background
Extremity vascular injuries represent 50–70% of all injuries treated during wars. Hence, our objectives are to elaborate the challenges of vascular war injuries and to clarify their mechanisms, pattern, effectiveness of management and outcomes during war in Jazan.
Patients and methods
This is a descriptive study of patients with war-related vascular injuries treated in King Fahd Teaching Hospital during the war in Jazan (Saudi Arabia) from February 2016 to May 2016. The study included age, mechanism of injury, site of vascular injury, pattern of repair, and clinical outcome.
Results
This study included 56 patients with a mean age of 37 years. All patients were men (100%); four (7.1%) patients were civilians; 23 (41%) patients presented with blast injuries; and 33 (59%) patients presented with gunshot injuries. There were 40 (71.4%) arterial injuries, 16 (28.6%) venous injuries, and seven combined injuries (arterial and venous). Repair was done in 37 patients and ligation in 19 patients. Primary amputation was done in eight patients and secondary amputation in one patient.
Conclusion
Management of vascular injuries during wars presents a unique challenge to surgeons; standard vascular technical repair remains the gold standard management in vitally stable patients; primary extremity amputation is a lifesaving procedure in unstable patients with other life-threatening injuries.

Keywords:
management, vascular injuries, war injuries

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Introduction

Recently attention has refocused on certain principles regarding surgical management of casualties during wars and the advances in management of patients with acute injury have evolved from experience of military surgeons during the time of war [1]. Major vascular injury of extremities represents one of the most challenges for trauma surgeons. Patients with vascular injuries usually reach hospitals in hemorrhagic shock and the management needs staged and multidisciplinary methods. The increased use of high-energy weapons in modern warfare is associated with severe vascular injuries that may affect the arteries and veins of the whole body as well as soft tissue, nerve, and skeletal injury, and is common in wartime, inducing bleeding, ischemia, and may end in amputation in association with multisystem injuries [2]. High-speed projectile injury is more injurious than do low-speed projectiles. Besides, an inflammatory response occurs 2 or 3 days after injuries, or even up to 5 days after injury if a ruptured blood vessel develops thrombosis or continues to bleed [3].

More than 90% of vascular injuries can be diagnosed by history taking and physical examination for the presence of hard signs such as pulsatile bleeding, palpable thrill, expanding hematoma, and/or signs of distal ischemia [4]. There is an increase in the use of ultrasound for the diagnosis of vascular injuries in civilian and military wars. But arteriography is still the gold standard to diagnose vascular injury and to provide a road map to guide surgical exploration and repair [5].

Patients and methods

All patients presented to King Fahd Teaching Hospital during the war in Jazan (Saudi Arabia) from February 2016 to May 2016. Informed consent was applied in all patient before any intervention. Advanced Trauma Life Support was performed to all the patients. Advanced Trauma Life Support included the following:

(1) Primary survey (ABCDE):
   (a) airway and cervical spine control,
   (b) breathing and ventilation,
   (c) circulation and hemorrhage control,
   (d) disability and neurological status,
   (e) exposure depending on the environment.

(2) Secondary survey.
   When patients became stable, secondary survey was through top-to-toe examination.

(3) Definitive care.
   The patients were then managed according to the injury. Patients with active bleeding were managed by compression and rapid transfer to the operating room (OR). Vascular examination was done to stable patients with assessment of pulses and signs of ischemia. Duplex and/or computed tomography angiography were requested in some patients to confirm the injuries and identify their sites. In OR and under general or spinal anesthesia, exploration was done and the injury was managed as interposition graft using saphenous vein; sometimes synthetic graft was used in the absence of saphenous vein, primary repair, ligation, or primary amputation. All patients' data were collected retrospectively and were analyzed according to age, sex, mechanism of injury, site of vascular injury, associated injuries, type of vascular intervention either repair or ligation, amputation either primary or secondary, and clinical outcome. All patients with comminuted and open fractures were managed by an external fixator. Outcomes were assessed clinically and by duplex until the patients were discharged.

Statistical analysis

Description of categorical variables was in the form of frequency and percent. Comparison between categorical variables was carried out by c^2 test. Fisher's exact test was used instead of the c^2 test when one expected cell or more were less than or equal to 5. The significance of the results was assessed in the form of *P* value that was significant when *P* value less than or equal to 0.05.

Results

During the period of this study, there were a total of 56 patients with major vascular injuries. All patients were men (100%); their mean age was 37 years. Four (7.1%) patients were civilians; 52 (92.9%) patients were soldiers.

Table 1 shows the anatomical sites of vascular injuries. Forty-eight (85.7%) patients had extremity injuries

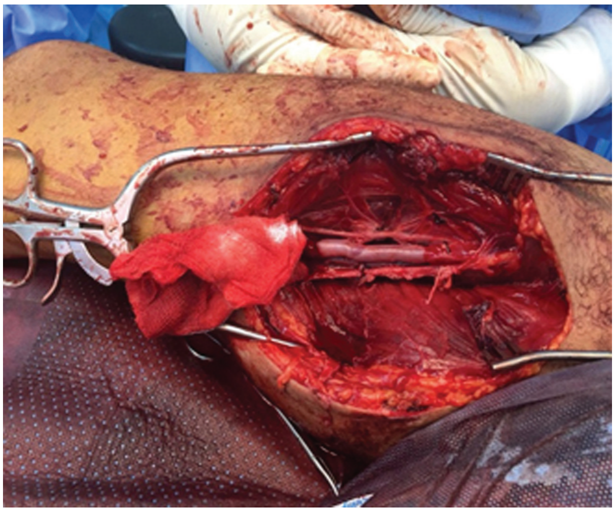
Table 1 Anatomical sites of vascular injuries

	Count	%
Mechanism of injury		
Gunshot injury	33	58.90
Blast injury	23	41.10
Region		
Head and neck	5	8.9
Chest	2	3.6
Abdomen and pelvis	1	1.8
Upper limb	19	33.9
Lower limb	29	51.78
Site of vascular injury		
CFA	2	3.60
SFA	9	16.10
POP	3	5.40
PTA	4	7.10
TPT	3	5.4
Subclavian	2	3.60
Axillary	3	5.40
Brachial	6	10.70
Radial	4	7.10
Ulnar	2	3.60
Carotid	2	3.60
IJV	3	5.40
Innominate	2	3.60
SFV	7	12.50
Brachial vena comitans	2	3.60
Iliac vein	1	1.80
CFV	1	1.80
Crushed limb	9	16.10
Management		
Repair	37	66
Ligation	19	34
Associated injury	29	51.80
Associated injuries		
Fractured femur	10	34.50
Fractured tibia	9	31.00
Fractured pelvis	2	6.90
Fractured humerus	6	20.70
Fractured radius	2	6.90
Amputation	9	16.10
Amputation type		
AKA	5	55.50
BKA	4	44.50

AKA, above knee amputation; BKA, below knee amputation; CFA, common femoral artery; CFV, common femoral vein; IJV, internal jugular vein; POP, popliteal; TPT, tibio peroneal trunck; PTA, posterior tibial artery; SFA, superficial femoral artery; SFV, superficial femoral vein.

both in upper and lower limbs and eight (14.2%) patients had injuries in the head, neck, chest, and the pelvis. Injuries were caused by bullets in 33 (59%) cases and by blast injury in 23 (41%) cases (Table 2).

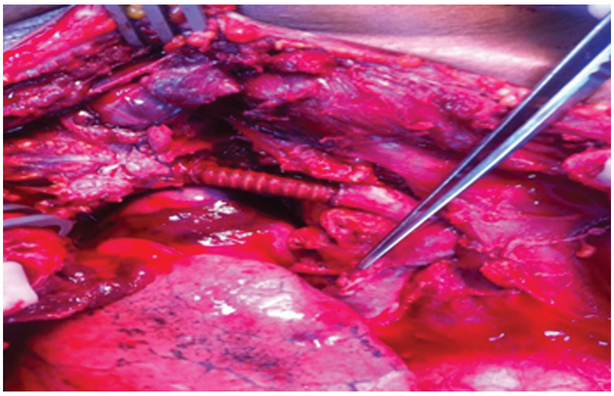
Figure 1



Repair of SFA by saphenous interposition graft. SFA, superficial femoral artery.

Arterial repair was done in 33 patients; interposition saphenous vein graft was used in 32 patients (Fig. 1), and in one patient with subclavian artery injury, prosthetic graft was used due to the very small diameter of both saphenous vein (Fig. 2). No primary repair of arterial injuries was done. In venous injury, repair was done in four patients, primary repair in three cases (two superficial femoral vein and one iliac vein) and in one patient, interposition

Figure 2



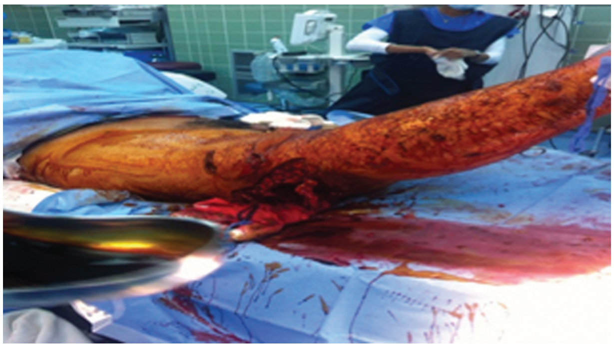
Repair of right subclavian artery by synthetic graft and ligation of right brachiocephalic vein.

Table 2 Comparison between gunshot injury and blast injury cases

	Mechanism of injury				*P* value
	Gunshot injury		Blast injury		
	Count	%	Count	%	
Site of vascular injury					
CFA	2	6.10	0		0.22
SFA	4	12.10	5	21.70	0.33
POP	2	6.10	1	4.30	1.00
PTA	2	6.10	2	8.70	0.70
Subclavian	1	3.00	1	4.30	1.00
Axillary	2	6.10	1	4.30	1.00
Brachial	3	9.10	3	13.40	0.68
Radial	2	6.10	2	8.70	1.00
Ulnar	2	6.10	0		0.22
Carotid	2	6.10	0		0.22
IJV	3	9.10	0		0.13
Innominate	2	6.10	0		0.22
SFV	2	6.10	5	21.70	0.08
Brachial vena comitans	0		2	8.70	0.16
Iliac vein	1	3.00	0		0.4
TPT	2	6.10	1	4.30	1.00
CFV	1	3.00	0		0.4
Crushed limb	0		9	39.10	<0.001
Management					
Repair	27	73	10	27	<0.001
Ligation	9	47.3	10	52.4	0.31
Associated injury	15	45.50	14	60.90	0.25
Amputation	0		9	39.10	<0.001

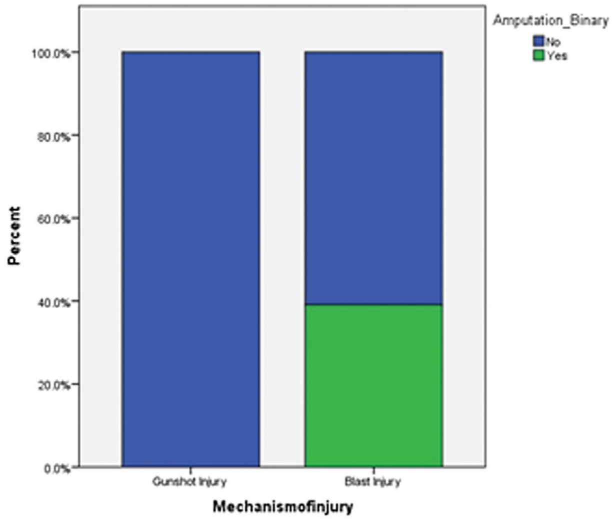
CFA, common femoral artery; CFV, common femoral vein; IJV, internal jugular vein; POP, popliteal; TPT, tibio peroneal trunck; PTA, posterior tibial artery; SFA, superficial femoral artery; SFV, superficial femoral vein.

Figure 3



Crushed leg and thigh after blast injury that needed primary above-knee amputation.

Figure 4



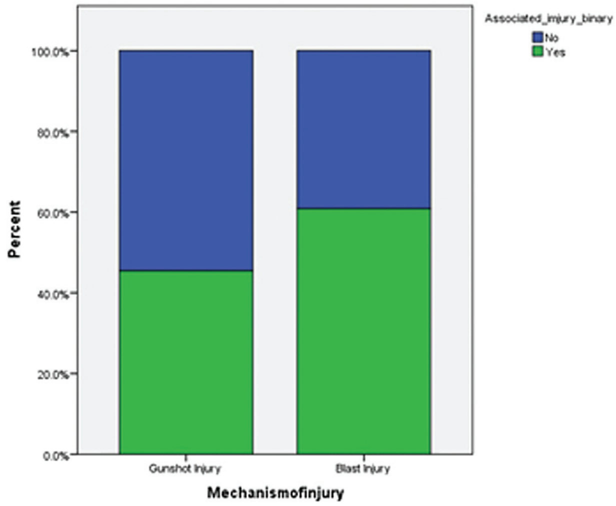
Relation between mechanism of injury and amputation.

saphenous vein graft was used for repair of common femoral vein. Ligation was done in 19 (34%) patients. Arterial ligation in seven cases (three posterior tibial arteries, three radial arteries, and one ulnar artery). Ligation of veins was done in 12 cases (six superficial femoral vein, three internal jugular veins, two innominate veins, and one brachial vena comitans). Primary amputation was done in eight cases (five cases of above-knee amputation and three cases of below-knee amputation) due to crushed limbs (Fig. 3). Secondary below-knee amputation in one patient due to secondary hemorrhage after 10 days of vascular repair. Figures 4 and 5 show the relation between mechanism of injury versus amputation and associated injuries.

Discussion

Gunshot and blast injuries represented the majority of vascular injuries in this study. Most of the injuries

Figure 5



Relation between mechanism of injury and associated injuries.

occurred in the extremities followed by head and neck and the least in the chest and abdomen most probably due to death at the field of war.

In this study, injury of superficial femoral artery, brachial artery, and tibial arteries were the most injured vessel. This is similar to other studies. Fox *et al.* [6] reported the involvement of superficial femoral artery and brachial artery in 44% of their cases. During the Vietnam War, injury of the superficial femoral artery and brachial artery were the most common injured arteries [7]. Ballad Vascular Registry during war in Iraq included injury of the superficial femoral artery in 90 cases and popliteal artery in 44 cases [8]. In the literature, among 6808 reported vascular injuries in wars, femoral artery injuries were the most common (35%) followed by brachial artery injuries (31%) [9].

In our study, repair of arterial injuries by reversed saphenous interposition graft was the most common method of management that was used (33/56). The Feliciano [10] study showed that early limb salvage rate was higher on using venous grafts. They were more affordable than when artificial grafts were placed. The cumulative patency rate and limb salvage rate did not differ significantly, suggesting that artificial grafts had less priority especially when the vein was not available. Prosthetic graft was used only in one patient with subclavian artery injury due to the very small diameter of both saphenous veins. Use of the synthetic graft is still controversial as it associated with increased incidence of infection and poor outcomes [11].

Repair of venous injury is still a controversial issue. However, most of the surgeons agree that repair of venous injury by means other than end-to-end anastomosis and lateral suturing is a time-consuming procedure without large benefits especially in patients with multiple injuries [7]. In our series, repair of venous injury was done in four cases with lateral suturing in three cases and one case by interposition saphenous graft in the common femoral vein due to lost segment of the vein.

Ligation of venous injury during wars was commonly used [12]. In this study ligation of injured veins was done in 12 cases to avoid prolonged procedure and save time.

Primary amputation was done because of mangled limb with extensive tissue loss and massive bone injury, while secondary amputation was related to infection after vascular repair or delayed presentation. Wani *et al.* [13] treated 360 patients with war-related arterial injuries over 13 years in Kashmir with extremity amputation rates of less than 5%. Taking decision for limb amputation is more difficult than it seems; in the early period of war, we tried to save as much limbs as we could, but we learned later on that is not achieved all the time. Sometimes primary and early amputation can be the best option to save patients' lives. Rate of amputation depends on many factors, mechanism of injury, severity of limb injury, time of limb ischemia, and presence of associated injuries [14]. In this study, primary amputation was done in eight cases (five cases above-knee amputation and three cases below-knee amputation) due to mangled extremity and instability of the patients. Secondary amputation was done in one patient due to secondary hemorrhage from vascular anastomosis after 10 days of vascular repair.

Rasmussen *et al.* [15] have used temporary shunts in 30 extremities with vascular injury as a damage control in the Iraq war, especially for proximal and major vascular injuries with no shunt-related complications with 86% being patent and only 7% needing early amputation. In our study, we did not use vascular shunt for any patient because of rapid transfer of the patients to the OR and rapid intervention.Sometimes, in this study imaging studies such as ultrasound technology and computed tomography angiography were used for the diagnosis of vascular injuries especially occult injuries in the chest, abdomen, and neck. Duplex ultrasound has been successfully used for the diagnosis of vascular injuries in Iraq war [14]. We did not use any means of angiography or endovascular means in this study. The value of endovascular interventions in the diagnosis and management of vascular injuries in both civilian and war practice is well studied [16]. Fox *et al.* [6] reported the experience of management of 107 soldiers during Iraq/Afghanistan wars and found that endovascular intervention resulted in lowering of morbidity and mortality rates in multiple injured patients.

Conclusion

Management of vascular injuries during wars presents a unique challenge to surgeons and the availability of vascular surgeons during wars is an important issue. Standard vascular technical repair remains the gold standard management in vitally stable patients after vascular injury while primary extremity amputation is a lifesaving procedure in unstable patients with other life-threatening injuries.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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