

Brachial artery injury in Al-Emamain Al-Kadhymain Medical City, Baghdad, Iraq: a single-center clinical experience

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Aims: To identify the most common causes, associated injuries, and management approaches in the case of brachial artery injuries.

Methods: This was a retrospective survey conducted in Al-Emamain Al-Kadhymain Medical City, Baghdad-Iraq, which included 104 patients who were diagnosed to have brachial artery injury during the period from January 2015 to April 2021. The evaluated factors included demographic data, site of injury, causes of injury, associated injury, type of treatment, and complications.

Results: One hundred and four patients were registered in the present study. The majority were males (86.7%) and half of the cases were in the 31–40 years age group. Most of the patients were military (83.7%). In 57% of the patients, the injury was on the left side. Penetrating injuries were the commonest types of brachial artery injuries (92.3%), while blunt trauma occurred in 7.7%. According to the treatment approach, 81.7% of the patients were treated with end-to-end anastomosis. Regarding the associated injury, 43.2% of the patients had venous injuries, 35.5% had a fractured humerus, and 31.7% had nerve injuries.

Conclusion: Brachial artery injuries are most commonly caused by penetrating trauma. Venous injury was the commonest associated injury of brachial artery injury. The most frequent surgical intervention was surgical end-to-end anastomosis.

Key words: brachial artery, vascular injury, fractured humerus, nerve, venous injury.

Poranění brachiální tepny v Al-Emamain Al-Kadhymain Medical City v iráckém Bagdádu: klinické zkušenosti jednoho pracoviště

Cíl: Stanovit nejčastější příčiny, související poranění a léčebné postupy v případě poranění brachiální tepny.

Metoda: Jednalo se o retrospektivní studii provedenou v Al-Emamain Al-Kadhymain Medical City v iráckém Bagdádu a bylo do ní zařazeno 104 pacientů, kterým bylo v období od ledna 2015 do dubna 2021 diagnostikováno poranění brachiální tepny. Byly vyhodnoceny následující faktory: demografické údaje, místo poranění, příčiny poranění, související poranění, typ léčby a komplikace.

Výsledky: Do této studie bylo zařazeno 104 pacientů. Převážnou většinu tvořili muži (86,7 %) a polovina případů byli pacienti ve věkové skupině 31–40 let. Většina pacientů byli vojáci (83,7 %). U 57 % z nich se poranění nacházelo na levé straně. Nejčastějším typem poranění brachiální tepny bylo penetrující poranění (92,3 %), tupé poranění se vyskytlo u 7,7 %. Pokud jde o léčebný přístup, u 81,7 % pacientů byla provedena anastomóza end-to-end. Co se týká souvisejících poranění, 43,2 % pacientů utrpělo žilní poranění, 35,5 % mělo zlomeninu humeru a 31,7 % utrpělo poškození nervu.

Závěr: Poranění brachiální tepny jsou nejčastěji způsobena penetrujícím poraněním. Nejběžnějším souvisejícím poraněním brachiální tepny bylo žilní poranění. Nejčastější chirurgickou intervencí byla anastomóza end-to-end.

Klíčová slova: brachiální tepna, cévní poranění, zlomenina humeru, nerv, žilní poranění.

DECLARATIONS:

Ethical principles compliance:

The authors attest that their study was approved by the local Ethical Committee and is in compliance with human studies and animal welfare regulations of the authors' institutions as well as with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects adopted by the 18th WMA General Assembly in Helsinki, Finland, in June 1964, with subsequent amendments, as well as with the ICMJE Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals, updated in December 2018, including patient consent where appropriate.

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Introduction

The brachial artery (BA) is the axillary artery extension that supplies the major arterial circulation to the arm. It starts at the teres major inferior border and finishes in the cubital fossa opposite the radial neck, in which it divides into the ulnar and radial branches beneath the bicipital aponeurosis. The BA lies anterior to the triceps and brachialis muscles and is generally superficial and perceptible along its course (1).

Extremity vascular trauma poses several diagnostic and therapeutic challenges. In modern combat, the increased employment of high-energy weaponry is linked to significant vascular damage. During the last Iraqi war (early in this century), the rates of trauma victims reached 50-70% (2). Injuries to the BA are the most common in the upper limbs. Even though vascular injuries due to blunt trauma are uncommon, they represent attentive conditions as they are readily neglected unless the clinician has a strong suspicion (3). Hard indicators such as pulsatile bleeding, palpable thrill, growing hematoma, and/or evidence of distal ischemia can be detected in more than 90% of vascular injuries by obtaining a medical history and performing a physical examination. In both civilian and military fields, the use of ultrasonography for the identification of vascular injuries is on the rise (4).

Vascular injuries should be detected and treated as part of the total patient resuscitation, using the recognized standards of "advanced trauma life support" procedures. Joint effort, awareness of the occasional indirect clinical signs of arterial injuries, a high suspicion index, operative communiqué, proper use of imaging techniques, thorough familiarity with applicable diagnostic tools, and surgical repair sequence are just a few of the crucial issues that will result in successful outcomes (5).

The aim of this study was to identify the most common causes, associated injuries, and management approaches in the case of brachial artery injuries.

Patients and Methods

Study setting and design

This was a retrospective survey conducted in Al-Emamain Al-Kadhymain Medical City

Tab. 1. Distribution of the participants according to their basal characteristics (N = 104)

Characteristic	No.	%	
Gender	Male	90	86.7
	Female	14	13.3
Age group (years)	< 30	31	29.8
	31–40	52	50.1
	> 40	21	20.1
Occupation	Military	87	83.7
	Civilian	17	16.3
Side of brachial artery injury	Right side	45	43
	Left side	59	57
Mechanisms of injuries			
Penetrating injuries	Bullet injuries	76	73.1
	Single large shells	14	13.5
	Multiple missiles	6	5.8
Blunt injuries		8	7.7

Tab. 2. Distribution of the enrolled patients according to the surgical interventions

Surgical interventions	No.	%
End-to-end anastomosis	85	81.7
Fasciotomy	15	14.4
Repair of muscle or tendon	12	11.5
Vein graft interposition	10	9.6
Ligation	9	8.7
Amputation	6	5.8
Arteriovenous fistula	3	2.9
Embolectomy	3	2.9
Shunt use	2	1.9
Prosthetic graft	0	0

Surgical Department, Baghdad, Iraq. The data were collected retrospectively during the period from the 1st of January 2015 to the 1st of April 2021.

Study population

The study included a review of the records of 104 patients who were admitted to the hospital and diagnosed with brachial artery injury, and in whom physical examination and Doppler ultrasound revealed the absence of arterial pulses. Twenty-one patients were submitted to angiography to confirm BA injury preoperatively.

The patients (N = 104) were evaluated according to their basal characteristics, surgical interventions, signs, symptoms, and associated injuries, the associated injury (some patients presented with more than one injury).

Ethical issues

The study protocol was approved by authorities of health directorate (ID T-009013, 2021); ethics committee of the hospital (ID BB-0023), with the director of the hospital being the chairperson of the ethics committee; and College of Medicine, Al-Nahrain University (ADI: 1201-D-21-

2020). As this study had a retrospective design, no patient consent was obtained; however, every precaution was taken to protect the privacy of patients. The entire study was conducted according to the principles set forth in the Helsinki Declaration.

Statistical analyses

The statistical analysis included descriptive data using numbers and percentages. The data were collected, processed, and transferred to MS Word Excel sheet, using Windows 10. The frequencies and percentages were used for nominal parameters. The data were processed and analyzed by using computer software SPSS (Statistical package for social science) version 24.

Data availability

The data associated with this paper are available on reasonable request from the corresponding author.

Results

Twenty-one patients were submitted to angiography to confirm BA injury preoperatively. Of the total, males were predominant

Tab. 3A. Distribution of the patients according to the local presentation of the affected limb for all 104 patients studied

Presenting manifestations		No.	%
Absent pulse		92	88.5
Ischemia		90	86.5
Hemorrhage		90	86.5
Venous injuries		45	43.3
Bone fractures	Humerus	37	35.6
	Radius or ulna	11	10.6
Peripheral nerve injuries		33	31.7
Pseudoaneurysm		21	20.2
Hematoma		14	13.5
Tendinous injuries		12	11.5
Pulse insufficiency		12	11.5
Compartment syndrome		4	3.8

Tab. 3B. Distribution of the patients (N = 104) according to the associated systemic injuries other than the affected limb

Associated injury	No.	%
Chest injury	17	16.3
Abdominal injury	4	3.8
Head injury	4	3.8

(86.7%), half of the patients belonged to the 31-40 years age group, 83.7% of the patients were military, and in 57% of the patients, the injury was on the left side. Penetrating injury was the mechanism causing 92.3% of BA injuries, while blunt trauma was the cause in the remaining 7.7% (Tab. 1). Bullet injury was the most common form of penetrating trauma (76 out of 96). Other forms of penetrating trauma in a descending order of incidence were single large shells in 14 patients and multiple missiles in 6 patients.

The mean admission period was 13 days (range, 4–30 days). Prolonged hospitalization was needed for those who were subjected to fasciotomy owing to a musculoskeletal injury, nerve injury, venous repair, or compartment syndrome. Follow-up was typically required for neurologic or orthopedic examination.

Different surgical interventional approaches were reported in the present study (Tab. 2). The outcome was successful in almost all cases of vascular interventions and subsequent encouraged salvage rate of affected limbs (the amputation rate was 5.8%). A total of 81.7% of the patients were treated with end-to-end anastomosis. Moreover, ligation of veins was done in 22 cases of venous injuries and simple venorrhaphy was performed in 23 cases. In 14.4% fasciotomy was required and in 11.5% muscle repair was mandatory. Twelve patients

had either muscular or tendinous injuries that were repaired intraoperatively by orthopedic surgeons.

Autologous, reverse, interposition graft of saphenous veins for 10 cases of BA injuries, and in 6 cases, the preferred surgical option was amputation of the affected limb at different levels. Nine cases of BA injuries had severely damaged brachial arteries were compulsory ligated. Three cases of BA injuries developed early postoperative re-thrombosis, for which arterial reperfusion was achieved by embolectomy. No case of BA in this study required any prosthetic graft, stenting, or carpal-tunnel release.

Among the 6 patients who required amputation, three cases required an above-elbow amputation, two of them an amputation performed at the wrist level, and one at the level of the phalanges.

In this retrospective study, associated presenting manifestations were found in most (87%) of the cases (Tab. 3A and 3B). Thirty-three of 104 patients had peripheral nerve injury: 17 had mixed nerve injuries to both ulnar and median nerves, 6 had median nerve injuries only, and 10 had ulnar nerve injuries only. Twelve of the thirty-three associated nerve injuries were repaired intraoperatively by neurosurgical specialists, followed by postoperative evaluation for any neural deficit. Afterwards, some of the patients showed functional debility throughout the follow-up period.

In the current study, some patients presented with multiple injuries at the time of presentation, with 43.3% of the patients having a combined arterial and venous injury (of either the cephalic or basilic veins). Twenty-one of these patients had pseudoaneurysm of BA, but presented late (2-4 weeks) after upper limb injury. They were managed with saphenous vein graft interposition (Figures 2a and 2b) and/or primary repair. Furthermore, 35.5% had a fractured humerus and 11 patients had injuries to the bones of the forearm. Most frequently, fractures occurred among patients with bullet injuries (20 patients); a fracture was also found in 4 patients with multiple missile injuries (6 patients). All fractures were managed with external fixation (Figures 1a and 1b) and 31.7% had nerve injuries.

Discussion

In the current study, males represented the bulk of cases (90 cases; 86.7%). For comparison, similar results were obtained by another study in Iran. This male preponderance results from the fact that men are much more energetic and exposed to violent activities (6).

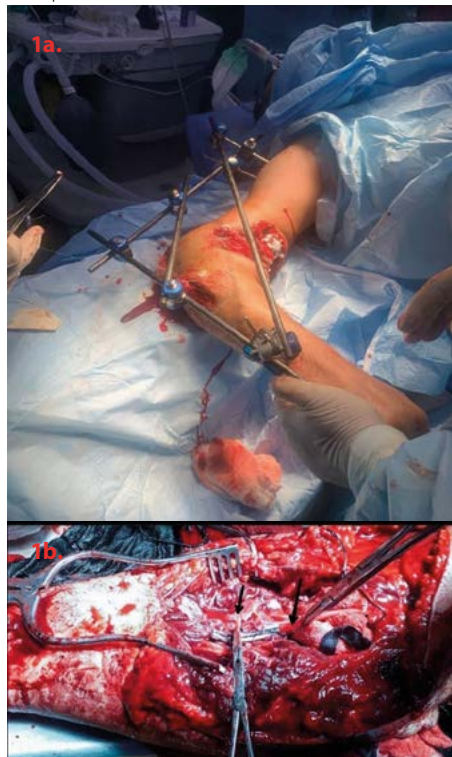
Those in the 31-40 years age group were affected most commonly, representing 50.1%. This is in agreement with a Turkish study (7). By contrast, Bitsch M. et al found that the 20-30 years age group was the most common age group (60% of those affected) (8). This might be related to the sample distribution as most of the patients were military.

Left-side injury was the commonest and represented 57% of all cases. This result agrees with the study by Ekim et al who found that the left hand is more commonly affected and accounts for 67.3% of all injuries (9).

Associated nerve injuries were common in these cases (31.8), a finding which was also identified by other studies (10). Anatomically, the BA is bounded by three vital nerves: the radial, ulnar, and median nerves, and their courses extend along the humerus. These nerves are also often injured in cases of BA injuries with resultant neural deficits.

In the current study, some postoperative complications were reported in 12 patients, including wound infection (3 patients), neurological deficit (3 patients), ischemic changes caused by thrombosis (2 patients), or venous

Fig. 1a, 1b. (1a): A 25-year-old male presented with a history of gunshot to the right upper limb, causing a compound fracture of the humerus, proximal radius, and ulnar bones associated with BA injury; (1b): the same patient explored for BA injury; both proximal and distal ends of the BA are arrowed



repair (4 patients). The wound infections were healed in two weeks after effective antibiotic therapy. Three out of the six patients who suffered postoperative thrombosis underwent successful embolectomy, while in the remaining three, amputation of the limb was required. Similar outcomes were also published by other surgeons (10).

A closer look at the data indicates that penetrating trauma was the most common cause of BA injury followed by blunt trauma, a finding discordant with the study conducted by Asensio, J. et al., where vascular injury resulted mainly from a fractured humerus in 57% of cases, followed by contusion in 33% and penetrating injury in 10% of the cases (9). Blunt trauma and stab wounds were the most commonly detected injuries in a prior study (11). This variation could be owing to the fact that the majority of patients in the present study were military and were injured by explosions or bullet injuries.

Surgical treatment in the current study included anastomoses (81.7%), an autogenously vein interposition graft (9.6%), and ligation (8.7%), while in the study by Andreev A. et al,

55% of the patients were managed with end-to-end anastomosis and 45% were treated with autogenous grafts (12).

The proportion of BA reconstruction using interposition of the great saphenous vein is relatively small in this case series, because most of our cases (76%) were caused by bullet injuries (Tab. 1) which required only end-to-end anastomosis because of a short arterial defect of about less than 1 cm in length. Thus, only those with long defects were treated with interposition of the great saphenous vein graft.

It is worth mentioning that 75 patients referred with brachial artery injury were rescued by the referring hospital in terms of ABC life-saving measures. The remaining 29 patients reached the ED of our center and were managed according to standard approaches.

The overall survival rate in the current case series was 97.2% (4 deaths only). Each yielded from coexisting other multiple severe injuries, such as penetrating head, chest, and abdominal injuries. None of the demises were due to their BA injuries. Comparable outcomes were also published by vascular surgeons from the USA in their case series that included 124 patients two years ago (13).

The first of the four deaths was a 25-year-old male who presented with two gunshots, with one involving the right brachial artery and the other causing severe intracranial hemorrhage, and the patient died two days postoperatively at the RCU. The second victim presented with associated abdominal polytraumatic injuries involving the right hepatic lobe, spleen, IVC, and large bowel. The patient died due to multiple organ failure after seven hours in the RCU. The third fatality was a 55-year-old heavy smoker who presented with superadded COPD and left-sided lung contusion. It was reported that the mortality rate among cases with lung contusion may reach up to 25% in a recent cohort (14). The last dead patient presented with a blast injury that, in addition to the right brachial vessels, involved the head, abdomen, and bilateral chest injuries. The patient required massive blood transfusion, and unfortunately passed away seven hours postoperatively after exploratory laparotomy and right thoracotomy.

Fig. 2. (2a) A 30-year-old male with a history of large shell injury to the BA with segmental loss of 3 cm who required interposition reverse great saphenous vein (2b)



Patients who died as a result of brachial artery injuries per se or with associated injuries before hospital admission were excluded from this case series. However, a rough estimate of a prehospital death rate of about 5% can be assumed. Almost all were due to massive or associated head, abdominal, and chest injuries.

Most patients in the current study had an associated injury besides BA injury. In comparison, another study by Visser P.A. et al. revealed that 58% of cases were associated with a chest injury which was the commonest general injury (15). Most patients in the current study were injured by an explosion, and this might explain the multiple injuries.

Several surgeons provided insight as regards the management of BA injuries. Difficulties and failures were not infrequent, given the arterial small size, superficial site, and the high incidence of spasm develop-

ment, compared to arterial injuries of the lower limbs (16).

When repairing vascular injuries, ischemic time is a crucial interval, which is the time to restore blood flow after vascular injury. In addition, the influence of associated reperfusion injuries is a vital predictor of limb rescue (10). One of the objectives of this study was to shed light on this point in order to decrease the ischemic time among patients with BA injuries, although with military experiences the general conditions differ from civilian ones. Unfortunately, the authors were unable to document ischemic time and hence unable to compare its impact among different patient categories.

In this study, the keystone of diagnosis of BA injury was based on clinical and Doppler findings at presentation. The authors suggest

that angiography is a useful approach for detecting vascular lesions, although time-consuming, particularly in traumatic injuries necessitating urgent intervention, especially in those with hard signs of vascular injury. Angiography is highly valuable, mainly in those with soft signs or multiple latent arterial injuries (17).

Some vascular surgeons have used angiography in cases with arteriovenous fistula or pseudoaneurysm to identify the site of BA injury and/or during endovascular surgery (9).

Conclusion

The study concluded that the commonest cause of BA injuries was penetrating trauma and that venous injury was the most frequent associated injury. In addition, the

victims of BA injury were predominantly males aged 31-40 years. The most common surgical intervention was surgical end-to-end anastomosis. Beyond the golden hour, performing revascularization is still appropriate to preserve normal limb function, based on the clinical findings.

Limitations

The study did not include the cases of BA injuries that had died from concomitant injuries and suffered fewer ischemic spells than those who survived and underwent vascular repair.

Unavailability of angiography at the time of BA injury in some instances made its diagnosis difficult with other diagnostic modalities.

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