Peripheral Arterial Injuries: an Indian Experience

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Abstract Arterial injuries present the most challenging conditions in surgical practice. Many fail to reach the specialist in time and end up losing limbs or lives. Though well addressed elsewhere, it has received less attention in developing countries like India. There is a need to study these injuries from the perspective of countries like India. The aims of the study are to (1) analyze the epidemiology, presentation, and outcomes of arterial injuries operated by the author in Indian settings; (2) identify factors associated with adverse outcomes; and (3) discuss the critical issues with relevance to our country. Retrospective analysis of arterial injuries operated by the author between July 2010 and February 2014 at our institution was performed. Patients with feasibility of revascularization were included and nonviable limbs requiring primary amputations were excluded. Sixty-one patients fulfilled the criteria of which 55 (90.1 %) were males and 6 (9.8 %) females aged between 5 and 70 years. The mean duration of presentation was 21 h. Majority were resultant of road traffic accidents (62.7 %). Among 49 (80.3 %) noniatrogenic injuries, the mechanism was blunt in 46 (93.8 %, $n=49$) and penetrating in 3 (6.1 %) cases. Iatrogenic injuries were seen in 12 (19.6 %) cases. Lower limbs accounted for 37 (60.6 %) cases, popliteal segment being common, 22 (36 %) cases. Bony injuries were associated in 39 (63.9 %) cases. The most common procedure was interposition graft (49.1 %). Six (9.8 %) patients required an amputation resulting in 55 (90.1 %) salvaged limbs.

Reaching a specialist center in appropriate time can result in good limb salvage rates and functional outcomes. Creating awareness and training the personnel are the critical issues in the management of arterial injuries in India.

Keywords Vascular injuries · Trauma · Developing country · India

Introduction

Arterial injuries pose one of the most challenging and fascinating conditions in the field of surgery [1]. Though rare, they can be associated with significant morbidity and devastating complications such as threat to the limb or the life. Peripheral arterial injuries account for approximately 40–75 % of all vascular injuries [2]. Risk factors, diagnosis, and the management considerations vary depending on the vessel. However, in general, early diagnosis and interventions are paramount for improving the likelihood of favorable outcome [3].

A surgeon has to be prepared to assess these urgently and decide the best management options depending on the individual patient's condition. Very few studies on vascular injury are reported from developing countries like India [3], and a single-surgeon experience on the outcomes are lacking. There is a need for a study on this condition in order to analyze and find the critical issues in the management of these injuries in the Indian scenario. Hence, this study retrospectively analyzes the spectrum of arterial injuries that underwent revascularization by a single surgeon and identifies key factors associated with major amputations. Unique challenges posed by these injuries with relevance to India are discussed in this article.

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Methods

This retrospective study was carried out in the Department of Surgery at St John's Medical College which is a tertiary care referral teaching hospital. Consecutive cases with arterial injuries revascularized or repaired by the author were included irrespective of the etiology. The study period was between July 2010 and February 2014. Patients presenting with late complications were also included. Exclusion criteria were patients with advanced ischemia that required primary amputation, venous injuries, and cases operated by other surgeons or departments.

All the patients were assessed in the emergency department, operating room, or bedside by the surgeon. For all trauma cases the ATLS protocol was followed. Patients underwent clinical examination, ABI measurement, and Doppler evaluation when hard signs of vascular injuries were absent. Patients with clinically considered reversible ischemia, such as the presence of sensation, some motor activity, arterial Doppler signals, and viable muscles on fasciotomy whenever done, were shifted for exploration after optimizing. Patients with advanced ischemia that required primary amputation were excluded.

Once in theatre, under anesthesia parts were prepared by standard methods. Contralateral uninjured limb was prepared in case of need for vein for arterial graft. All the vascular repairs preceded the orthopedic or plastic surgery procedures in case of polytrauma. Proximal and distal control was taken. Heparin was given unless contraindicated. Revascularization was performed either by primary repair, resection and end-to-end anastomosis, or reversed vein graft. Fasciotomy was done in patients with delayed presentation or high suspicion of possible compartment syndrome. Veins were not repaired routinely. Nerves were marked with ligatures and repaired electively at a later date. Soft tissue cover of repair was always ensured. Return of pulses or Doppler flow signals were confirmed at the end of the procedure. All the data including demography of patients, clinical presentation, duration from time of injury, vessel involved, type of injury, associated injuries, type of repair, adjunct procedures, and complications in the hospital were recorded. Patients whose limbs were viable and wounds healed at the time of discharge were considered salvaged.

Results

A total 61 patients fulfilled the criteria and were included in this study; of which 55 (90.1 %) patients were males and 6 (9.8 %) were females. The age group ranged from 05 to 70 with the mean age being 28. Fifty-five patients were adults (90.1 %) and six were children (9.8 %). The leading cause of injuries was noniatrogenic in 49 cases (80.3 %) with road traffic accidents leading the list whereas iatrogenic accounted

for 12 cases (19.6 %) (Table 1). Among noniatrogenic injury, the mechanism of injury was blunt trauma in 46 cases (93.8 %). The most common presentation was ischemia in 46 cases (75.4 %), followed by pseudo aneurysms in 8 (13.1 %) patients and hemorrhage in 5 cases (8.1 %). Time from injury to presentation ranged from 30 min to 36 h with the mean of 21 h (Table 2). Lower limb was involved in 37 cases (60.6 %) and upper limbs in 24 (39.3 %). The most common artery injured was the popliteal artery in 22 cases (36 %), followed by brachial in 21 cases (34.4 %) (Table 3). A single artery was injured in all the cases. Orthopedic injuries were the most common injuries associated with vascular injuries in 39 (63.9 %), followed by soft tissue injury in 34 (55.7 %) patients and neurological injuries (19.2 %). Interposition grafts with reversed vein was the technique used in 30 (49.1 %) cases, mostly the saphenous vein ipsilaterally (95 %) and the cephalic vein in 5 % (Table 4). PTFE graft was used in four cases (6.5 %). Other revascularization procedures performed included resection of damaged segment of the artery and end-to-end anastomosis in 17 cases (27.8 %) and primary repair in 8 cases (13.1 %). Orthopedic intervention was performed in 34 cases (55.7 %). Fasciotomy was performed in 49.1 % (30) of patients. Major amputations were required in six cases (9.8 %) and were all lower limbs. Among the complications, wound infections accounted for 14 cases 22.9 % and thrombosis in 5 cases (8.1 %) (Table 5). One patient (1.6 %) died of myocardial infarction. Of the 55 salvaged limbs, 45 (81.8 %) patients achieved functional recovery and 10 (18.1 %) patients had some form of neurological deficits.

Discussion

Arterial injuries are rare but are associated with significant morbidity and mortality. Peripheral vascular injuries comprise of 3 % of all civilian trauma [4]. This study focuses on the arterial injuries in particular and addresses all the arterial injuries irrespective of etiology faced by a vascular surgeon in everyday practice. There are very few articles from India addressing arterial injuries resultant of trauma [3]. This is the first study from a developing country like India to include the iatrogenic injuries in addition to the traumatic injuries. All the reported series in literature are institutional and none

Table 1 Causes of arterial injury

Cause	Numbers	Percentage
RTA	38	62.2
Iatrogenic	12	19.6
Workplace	08	13.1
Fall	02	3.2
Assault	01	1.6

Table 2 Time from injury to arterial procedures

Time (h)	Numbers	Percentage
0–6	08	13.1
7–12	22	36.0
13–24	18	29.5
>24	13	21.3

of these are single-surgeon experience; this is to date is the first largest, single-surgeon experience series.

Young men in productive age group (mean age 28 years) account for large number of patients as in the case of any trauma, which correlates with other studies [3, 5, 6]. Many of these patients are breadwinners of the family, and outcomes of arterial injury can have a major impact on the economy in addition to the health care burden. Road traffic accidents account for majority of these injuries (62.2 %) much alike civilian trauma in other studies [7]. Road traffic injuries account substantially to the disease burden of trauma in India, and safety regulations need to be followed strictly to prevent many of these injuries [8].

Penetrating traumas are more common causes of arterial injuries in studies from US to UK [2, 9]. Blunt trauma accounted for majority of these cases in this study which is similar to an Australian study [6]. The percentage of blunt trauma is very high—46 of 49 trauma (93.8 %) cases—in this series compared to any study, probably due to lower incidence of gunshot and stab injuries. Iatrogenic injuries accounted for 15–20 % of civilian trauma as seen in the present study [10]. Open procedures accounted for majority of iatrogenic injuries unlike percutaneous vascular interventions in the west [11]. Vascular interventions caused iatrogenic injuries in 5 out of 12 cases. In urban settings, upper and lower extremity injuries account for 40 and 20 % respectively [12]. Involvement of the lower limbs was more common (35) compared to the

Table 3 Arterial segments involved

Artery	Numbers	Percentage
Upper limbs		
Subclavian	02	3.2
Axillary	01	1.6
Brachial	21	34.4
Radial/ulnar	00	00
Total	24	39.3
Lower limbs		
Iliac	05	8.1
Femoral	06	9.8
Popliteal	22	36
ATA/PTA	04	6.5
Total	37	60.6

Table 4 Arterial procedures

Procedure	Number	Percentage
Vein interposition	30	49.1
End-to-end anastomosis	17	27.8
Simple repair	08	13.1
PTFE graft	04	6.5
Vessel release	02	3.2

upper limbs (22) in this study as seen in previous other series [5], whereas only another study from north India showed more upper extremity involvement [3].

This study shows the popliteal artery was the most common artery injured; however, in many studies from west, the popliteal injuries are less than 0.25 % [13].

Although described as golden period [14], few of our patients (13.1 %) presented within 6 h. The mean duration of presentation to the specialist center was 21 h which is very late than any published literature so far. This reveals the lack of awareness and recognition of vascular injuries. India is one of the most populous countries in the world and one with a high burden of trauma deaths and disability. There are significant deficiencies in current trauma systems in India [15]. Another important cause would be the lack of vascular expertise availability in many centers [16].

Extremity arterial injuries have varied clinical presentations. A few patients present with obvious clinical evidence, or “hard signs,” of arterial disruption such as pulsatile external bleeding, an enlarging hematoma, absent distal pulses, or an ischemic limb. For patients with overt signs of arterial injury, immediate surgical exploration in the operating room without further diagnostic testing is preferred [17]. All our patients presented with hard signs such as absent pulses and cold extremities and were taken to operating room without any delay. The role of angiographic evaluation is controversial mostly limited to absent hard signs but high-suspicion situation like dislocations of the knee [18]. There is no role for angiography

Table 5 Complications

Complications	Numbers	Percentage
Wound infection	14	22.9
Major amputation	06	9.8
Thrombosis	05	8.1
Hematoma	03	4.9
Deep vein thrombosis	03	4.9
Blow out	02	3.2
Reperfusion injury	02	3.2
Death	01	1.6

in the presence of hard signs. No angiographic evaluation was performed in these cases.

Open arterial repair remains the golden standard of care but there is growing interest in endovascular options in select areas. The most common procedure was interposition graft which is similar to other studies [6, 19]. Many cases had segmental loss necessitating interposition graft for tension-free repair. Autogenous vein graft was used in majority of cases due to its proven benefit [20]. Prosthetic grafts were used in three patients with proximal vessel injury where no suitable autogenous conduit was available. Endovascular repair is finding a place in management of arterial injuries in isolated arterial injury or select areas where surgery is difficult [21]. We did not perform any endovascular interventions as all the cases were major injuries and surgically accessible areas and required many concomitant procedures. There is a role for temporary shunting of arteries in some cases, where fractures are unstable and require prior skeletal fixation or time to shift to optimal center is long [22]. In this study, all patients underwent vascular repair prior to skeletal fixation and no shunting was required. Venous repair remains a controversial issue in patients with arterial injuries; it is a time-consuming process with uncertain benefits especially in patients with multiple injuries [23]. No major venous reconstruction was performed in this study.

Liberal fasciotomy should be applied prophylactically to reduce risk of adverse limb outcomes [24]. Patients who underwent delayed fasciotomies had twice the rate of major amputation and a threefold higher mortality [22]. Fasciotomy was applied in 47.3 % of the cases in this series, which is higher as compared to other studies probably related to delayed presentation and low threshold for the procedure. Reperfusion injury develops in delayed revascularization either as compartment syndrome, renal failure, or multiorgan dysfunction. The exact data of reperfusion injury following extremity revascularization is not available. In our series, patients developed compartment syndrome and other renal failure that recovered following amputation.

About 16 % early complications and 20 % late complications tend to occur despite of optimum revascularization requiring redo procedures or amputations [25, 26]. Modern day amputation rates have decreased to 6.5–20 % for blunt injuries and 0.4–4 % for penetrating injuries [27]. In this study, major amputation was required in six patients (9.8 %), two due to failed repair, three due to sepsis, and one due to reperfusion injury. All amputations were in lower limbs due to popliteal artery injury except for one femoral artery blowout; this correlates with studies by others [28].

Injuries resulting from high-impact trauma, polytrauma, delayed presentation, old age, and comorbidities were associated with complications in this study. Limb salvage rates were 90.1 %. Hafez et al. reported limb salvage in 84 % of patients and Razmadze et al. in 77 % of patients [25, 29]. Mortality due

to peripheral arterial injury is rare and one patient in this study died due to myocardial infarction. All the patients including amputees with prosthesis were ambulant at the conclusion of study.

Limitations of the study include the nonestimation of vascular injury incidence in trauma, smaller series, and single-surgeon experience.

Conclusion

Early recognition and referral to a specialist can result in good limb salvage rates and functional outcomes. Adherence to road safety regulations can prevent trauma and majority of arterial injuries in developing countries. Developing countries face special problems like lack of availability of vascular specialist for the burden of vascular injuries of such huge population and lack of awareness which need to be addressed aggressively. Training general surgeons and trauma surgeons in management of vascular injuries can be a key solution for this critical issue.

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