Original Article

Pattern of Extremity Arterial Injury and Outcome of Repair in Southwest, Nigeria

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Abstract

Background: Extremity arterial injuries are an important cause of loss of life/limb after trauma. Early intervention is important for the good outcome. **Objectives:** The objective of this study is to review the pattern of presentation and study the factors that influences the outcome of extremity arterial injuries in our hospital. **Patients and Methods:** This is a retrospective study of all patients with injuries to the extremity arteries requiring surgical intervention from July 2007 to June 2015. Data obtained included biodata, ischemic time, arteries involved, surgical intervention, and outcomes and analyzed using SPSS version 22. **Setting:** Our hospital is the main referral hospital for vascular trauma serving four adjoining states in Nigeria and is linked to major cities by at least 3 Trunk-A federal roads. **Subjects:** The subjects are patients who were managed in our cardiovascular surgical unit for the study duration (July 2007–June 2015) who had extremity arterial injuries. **Results:** A total of 36 patients presenting with 40 arterial injuries in 37 limbs were studied. The mean age was 28.4 ± 10.3 years with male preponderance (88.9%). Gunshot injuries were the most common cause of arterial injuries (37.8%), followed by assault (27%). The mean time from injury to presentation for acute injuries was 20.4 h but 23 of the patients (63.8%) presented to the accident and emergency department within 12 h of injury. A limb salvage rate of 64.9% was achieved though ischemic times of ≥12 h were associated with poor outcomes. **Conclusion:** Prolonged ischemic time is associated with poor outcomes. Efforts should be put in place to reduce the limb ischemic times.

Keywords: *Extremity arterial injury, limb salvage, Nigeria*

Introduction

Injuries have been referred to as the neglected disease-causing about five million deaths each year.[1] Injuries to the extremity arterial tree are an important cause of loss of limbs and limb dysfunction following trauma to the extremities.[2] These injuries have been on the increase following a rise in motor vehicle accidents and missile injuries[3] among civilian population. With injury to major extremity arteries, excessive hemorrhage or ischemia may occur, both of which have serious implications for the patient and the surgeon.[4] Hemorrhage may lead to hemorrhagic shock, multiple organ dysfunction, and loss of life. Hemorrhagic shock on its own may worsen the impact of ischemia on the limb and reduce ischemic threshold time to as low as 1 h as previously demonstrated in animal studies.[5] In patients with total acute limb ischemia, a "golden period" of 4–6 h follows after which irreversible ischemia occurs[6] with many of these patients subsequently requiring an amputation. Revascularization after this period may be hazardous to the patient given the risk of reperfusion injury. For the extremities, however, it has to be noted that ischemia time does not always correlate with the degree of tissue ischemia.[7]

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The major causes of extremity arterial trauma include road traffic accidents, stabs, machete cuts, and blunt trauma and may occur in isolation or with other coexisting injuries.[2,8]

The priority in managing these patients is to preserve life and this may involve securing hemostasis in arterial injury; adequate resuscitation is thus the initial necessary step and other life-threatening injuries must be addressed first.[9] Different injuries may be tackled simultaneously by different trauma teams to minimize the loss of life and to maximize the limb salvage rates.[4,9]

Extensive investigations may not be appropriate in the setting of these injuries as they may unnecessarily prolong ischemia time,[10] thus a high index of suspicion for arterial injury and a good clinical examination are important. In the presence of hard signs of vascular injury (pulsatile hemorrhage, expanding hematoma, and any of the classic signs of limb ischemia such as pallor, pulselessness, poikilothermia, paralysis, and paresthesia), immediate operation on the injured vessel is appropriate without extensive investigations.[4]

The burden of arterial injuries is not known in Nigeria; however, several studies have been conducted in different parts of Nigeria, looking into the incidence and outcome of arterial injuries. Thomas *et al*.[10] in Lagos, South Western Nigeria saw 41 patients with arterial injuries in his 8 year study with an amputation rate of 9.8%. Adeoye[11] in Ilorin, North Central Nigeria, noted that trauma accounted for 73.3% of peripheral vascular procedures performed at his center.

The aim of our study is to document the pattern of extremity arterial injuries and outcome of surgical repair in our environment.

Patients and Methods

This is a retrospective study of all the patients with extremity arterial injuries managed by our cardiovascular surgical unit between July 2007 and June 2015 (8 years) at our tertiary level center located in Nigeria. The hospital is the main vascular center serving three contiguous states with an estimated population of over 9 million people.[12] Data were obtained from the case files of patients including their biodata, mechanism of trauma, arteries involved, estimated ischemia time, method of evaluation, degree of arterial injury, type of repair, complications, and outcomes. Other non-vascular but associated long bone and soft tissue injuries were co-managed by the orthopedic, and plastic surgeons, respectively. Follow-up was for at least 12 weeks after surgery with majority of the patients lost to follow-up beyond this time. The study focused on major extremity arteries, and a viable limb was defined as successful revascularization without complications such as chronic pain and Volkmann's contracture.

Statistical analysis was performed using the statistical package for social sciences version 16 (Armonk, New York, IBM Corp., USA). The Student's *t*-test was used to compare the continuous variables and the Chi-square or Fischer's exact test for categorical variables. $P < 0.05$ was considered statistically significant.

Results

A total of 36 patients were managed for 40 extremity arterial injuries involving 37 different limbs (there were 3 patients with radial and ulnar arterial injury in the same limb and one patient with axillary and femoral arterial injuries). Thirty-two of the 36 patients (88.9%) were males while females accounted for just 11.1% with ages ranging between 6 and 58 years and a mean age of 28.4 ± 10.3 years [Table 1].

Table 1: Patient and vessel characteristics, mode of injury, and injury interval

	Frequency (%)
Sex	
Male	32 (88.9)
Female	4 (11.1)
Age (years)	
Mean age	28.4±10.3
Range	6-58
Preoperative method of evaluation	
Hard clinical signs present	34 (91.9)
Soft clinical signs present	23 (62.2)
Pulse oximetry used	3 (8.1)
Doppler scan	14 (37.8)
Angiography	2 (5.4)
Interval from injury to presentation (h)	
<6	12 (33.3)
6-<12	11 (30.6)
12-<18	3 (8.3)
18-<24	2 (5.6)
≥24	8 (22.2)
Artery involved	
Upper limb arteries	23 (57.5)
Subclavian	1 (2.5)
Axillary	1 (2.5)
Brachial	9 (22.5)
Ulnar	5 (12.5)
Radial	7 (17.5)
Lower limb arteries	17 (42.5)
External iliac	1 (2.5)
Common femoral	4 (10.0)
Superficial femoral	5 (12.5)
Deep femoral	1 (2.5)
Popliteal	5 (12.5)
Posterior tibial	1 (2.5)

Up to 38.9% of the patients lived in our city while 61.1% resided in cities ranging between 30 and 300 km from the hospital.

Gunshot injuries were the most common cause of arterial trauma in our series (37.8%), followed by assault with knives, machetes, or other nonmissile injuries (27%). Motor vehicular and motorcycle accidents accounted for a combined seven cases (18.9%) in our series [Figure 1].

The brachial and femoral arteries were the most commonly injured vessels (n = 9, 22.5% each) followed by the popliteal artery (n = 5, 12.5%) while four patients (11.1%) had multiple arteries injured, in which scenario, the ipsilateral ulnar and radial arteries were the likely combination 75% of the time. There was a slight preponderance of the right-sided vascular injury compared to left-sided ones (1: 0.89). There were more upper limb arterial injuries (n = 23) than lower limb involvement (n = 17).

Associated nonvascular injuries were seen in 69.4% of the patients (n = 25); the most common of which was long bone fractures either alone or in combination with nerve injuries (n = 19, 52.8%) [Figure 2] followed by nerve injuries alone in three cases (8.3%).

The mean time from arterial injury to the presentation in the accident and emergency department was 20.4 h. On the other hand, six patients with posttraumatic arterial pseudoaneurysms presented approximately 10 days (235.2 h) after the initial trauma following the second episode of hemorrhage or an expanding swelling. Only 12 patients (33.3%) presented within 6 h of injury [Table 1].

The median time to revascularization for acute injuries was 5.4 h (range 1.6–408 h) while for patients with pseudoaneurysms, it was about 5 days.

About 91.9% of the patients presented with at least one hard sign of arterial injury [Table 1]. Transcutaneous pulse oximetry was used as part of evaluation in three patients while 14 patients (37.8%) had a Doppler scan during evaluation. Angiography was done in two patients (5.6%).

Complete arterial transections were the most common type of injuries occurring in 27 (67.5%) injuries [Table 2], followed by pseudoaneurysms (15%) and partial transection (12.5%). The patients classified as partial transections all presented acutely within 24 h while those with pseudoaneurysms presented after the 5th day with expanding pulsatile arterial swelling following an initial usually partial transection. Two patients had an intramural thrombus only.

Direct end-end anastomosis was the most common type of repair (45%), followed by reversed saphenous vein interposition grafts (22.5%), ligation (10%), lateral repair, and synthetic interposition graft using woven polytetrafluoroethylene (7.5% each), thrombectomy (5%), and bypass grafting [Table 3].

The limb salvage rate was 64.9% with about a quarter of the patients requiring an amputation [Table 2]. Excluding

Table 2: Degree of injury and repair outcome

	Frequency (%)
Degree of injury	
Partial transection	5 (12.5)
Complete transection	27 (67.5)
Pseudoaneurysm	6 (15.0)
Intramural thrombus	2 (5.0)
Complications of surgery	7/37 (18.9)
Graft thrombosis	2
Wound infection	2
Graft infection	1
Disseminated intravascular coagulopathy	1
Compartmental syndrome	1
Outcome of repair	
Viable limb	24 (64.9)
Nonviable limb leading to amputation	9 (24.3)
Chronic pain	1 (2.7)
Volkman's ischemic contracture	1 (2.7)
Death	2 (5.4)

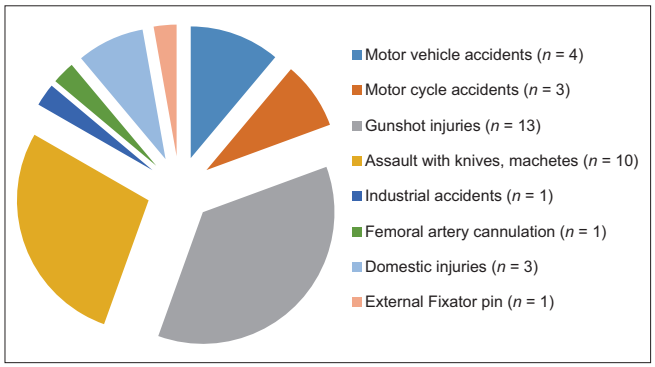

Figure 1: Mechanism of trauma

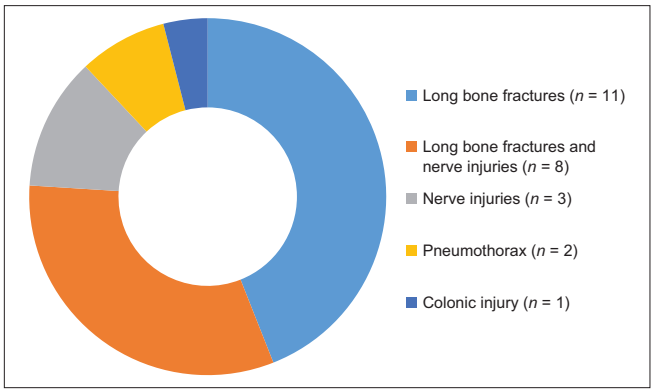

Figure 2: Associated injuries

Table 3: Type of arterial repair

Artery	Type of repair						Total
	Ligation	Lateral repair	Direct end-to-end anastomosis	Venous interposition graft	PTFE interposition graft	Thrombectomy	
Subclavian	0	0	0	0	1	0	1
Axillary	0	0	1	0	0	0	1
Brachial	0	0	5	2	0	2	9
Ulnar	1	1	3	0	0	0	5
Radial	2	0	4	1	0	0	7
External iliac	0	0	0	0	1	0	1
Common femoral	0	0	1	2	1	0	4
Superficial femoral	0	0	3	0	2	0	5
Deep femoral	0	1	0	0	0	0	1
Popliteal	0	1	1	3	0	0	5
Posterior tibial	0	1	0	0	0	0	1
Total	3	4	18	8	5	2	40

PTFE=Polytetrafluoroethylene

Table 4: Relationship between limb viability and ischemic time among patients with extremity arterial trauma[#]

Ischaemic time (h)	Viability of limb		Total (%)	Statistical comparison
	Viable (%)	Nonviable (%)		
0-11.99	10 (90.9)	1 (9.1)	11 (100)	LR=8.543
12-23.99	6 (40)	9 (60)	15 (100)	df=2
>24	2 (40)	3 (60)	5 (100)	*P*=0.014
Total	18 (58.1)	13 (41.9)	31 (100)	

[#]Excluding six patients with pseudoaneurysms. LR= Likelihood ratio

Table 5: Relationship between postoperative complications and limb viability in the 37 limbs

Complications	Viability of limb		Total (%)	Statistical comparison
	Viable (%)	Nonviable (%)		
Yes	2 (28.6)	5 (71.4)	7 (100)	LR=4.802
No	22 (73.3)	8 (26.7)	30 (100)	df=1
Total	24 (64.9)	13 (35.1)	37 (100)	*P*=0.028

LR= Likelihood ratio

patients who had pseudoaneurysms, the limb salvage rate fell to 58.1%. Mortality rate was 5.4% while 1 patient each had chronic pain and Volkmann's contracture.

The limb ischemic time was the most important predictor of viability [Table 4]. Limb salvage rate of patients with acute arterial injury who had surgery within 12 h of injury was 90.9%. With longer limb ischemic times, the percentages dropped to 40% between 12 and 24 h and 40% after 24 h. This was excluding patients with pseudoaneurysms who all had viable limbs postoperatively

In addition, Table 5 shows that the occurrence of postoperative complications had a significant relationship with the viability of the limb after revascularization. The complications noted included surgical site infection (n = 3, 42.8%), graft thrombosis (n = 2, 28.6%), and disseminated intravascular coagulation (n = 1, 14.3%). One patient had multiple complications including compartmental syndrome, surgical site infection, and hematoma collection.

Discussion

Our result confirms arterial trauma as primarily a disease in young males similar to other regions of the world[10,13-17] with gunshot injuries being the most common cause as has been shown in other parts of Nigeria and the developing world.[10,14,16,18] Khan, however, reported road traffic accidents as the most common cause of arterial injuries in his study[13] while in the study by Perkins in a major British trauma center, stab wounds were the most common.[17] The relatively high crime rates in the period under study in Southwest Nigeria probably accounted for the gunshot injuries and assault by knives recorded by us in this series.

In our study, the most commonly injured artery was the brachial arteries accounting for 22.5% of arterial injuries similar to that reported by De Silva[19] although Thomas,[10] Khan[13] and Krishnan[3] noted in their report that the lower limb vessels were more commonly involved. The femoral vessel in Thomas *et al*. (51.2%) and popliteal artery in Khan *et al*. (41.7) were the most commonly injured vessels.[10] The reason for predominance of the upper limb arterial injuries in other studies is unknown however an explanation in our study may be due to the attempt by our patients using their upper limbs to defend themselves from the gunshots and knife stabs and prevent injuries to the trunk. This is more so noting that we had a high gunshot injuries and knife stabs in our series compared to motor vehicular accident.

We recorded associated injuries in 67.6% of our patients similar to Aduful and Hodasi[15] in Ghana (71.1%).

The most common associated injury were bone fractures (n = 11, 27.5%) in our study. In contrast, all the arterial injuries in Thomas *et al*.[10] were isolated injuries in his study. Hafez in his study[7] demonstrated that compound fractures were associated with low limb salvage rates although we did not demonstrate this in our study.

Only about one-third of our patients presented within 6 h of injury with 63.9% presenting within 12 h. This was less than what was reported by Khan in his study where 79.2% presented within 8 h of injury[13] and much lower than 91.8% of patients who reached hospital within 12 h of injury reported by Firas.[14] Topal *et al*. in their retrospective study noted that the time range for presentation was 30 min to 10 h.[18] Several factors account for the relatively late presentation of patients at our hospital; chief of which is the lack of a proper prehospital ambulance service to transport injured victims from the site of injury, coupled with the fact that a number of patients stay more than 3 h away, having, therefore, to arrange for private transport to the hospital. There are also delays in referring patients from the peripheral centers following late diagnosis of possible vascular injuries.

The median time to revascularization in our study of 5.4 h with all ischemic limbs being revascularized between 1.6 and 24 h except for one patient who had surgery at 408 h. Silva in his study also noted a median revascularization time of 5.5 h.[19] Several factors prevent prompt revascularization of injured limbs in our hospital but probably, the most important is that only one anesthetic team covers the emergency department, taking in all the emergencies presenting in the casualty department. They are thus forced to stratify the patients they take in to surgery preferring life-saving to limb-saving surgeries. Sometimes other logistic problems such as inadequate power supply may contribute to delays in revascularization times.

In the presence of hard signs, we would not engage in extensive investigations in our hospital because this tends to unnecessarily prolong limb ischemic times; In addition, many patients are unable to afford these investigations. This may account for the low usage of Doppler scans and computed tomography (CT) angiography. Aduful and Hodasi in Accra[15] also related the low use of Doppler and angiography (25% of patients) in vascular trauma to the inability of patients to pay for services in his center. In contrast, up to 96% of the patients in the series by Perkins, who had blunt vascular trauma and 40% of patients who had penetrating vascular trauma had a CT angiography at a major British trauma center.[17]

In contrast to Faris, who reported partial injuries to be the most frequent type of arterial injuries (55.1%), complete transection of the artery was the most common type of injury in our series (67.5%) although this did not appear to be significant in predicting the outcome of revascularization in our study (P = 0.223). A larger sample size may be more sensitive in identifying this correlation as the trend from our study showed that patients with partial injuries tended to have higher rates of limb salvage postoperatively (76.9%) compared with those who had complete injuries (58.3%) from our study. Hafez *et al*., in his study, noted complete arterial transections versus partial injuries as one of the factors that determined the outcome of revascularization.[7]

Direct end-to-end anastomosis was the most frequent type of repair (45%) as also reported by Faris (63.26%),[14] but unlike Kahn where venous interposition graft (53.1%) were the most frequent type of repair. The type of repair done did not correlate with the outcome of surgery.

The most common complications were surgical site infections accounting for 3 out of 7 complications similar to the report by Shakir,[14] who also noted infectious complications as the most frequent types of complications postoperatively.

The limb viability rate for the acute trauma of 58.1% was higher than that reported by Khan (41%). Similar to Khan, however, limb viability rates were 40% when the presentation was more than 12 h.

The limb ischemic time and presence of postoperative complications in the operated limb were the factors associated with outcomes of revascularization. With ischemic times >12 h, the limb salvage rate for acute arterial injury fell from above 90% to 40%. Interestingly, from our study, patients with acute trauma who had limb ischemic times >24 h still had a 40% limb salvage rate, supporting the argument for delayed revascularization as has been mentioned by other authors.[3] Other factors which may influence outcomes from literature include the presence of combined above and below knee injuries, compartment syndrome at presentation and compound fractures.[7]

Conclusion

We conclude that arterial injuries are more common in young males with gunshots injuries being the major cause in our environment. Management of extremity arterial injuries still poses a major challenge in a developing country like ours with prolonged ischemic time being a major challenge due to delayed presentation. Even with prolonged ischemia, limb salvage rates of up to 40% are achievable with revascularization up to 24 h after onset of ischemia.

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Conflicts of interest

There are no conflicts of interest.

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