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Management and Outcome of Traumatic Peripheral Vascular Injuries in A Nigerian Teaching Hospital

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1. Abstract

1.1. Background: Peripheral vascular injuries are common in Nigeria. Appropriate and timely treatment averts loss of life or limb.

1.2. Methods: Retrospective analysis of 42 consecutive patients who had 50 vascular injuries was done. Other patients with vascular injuries whose medical records were incomplete were excluded from the study.

1.3. Results: The median age was 26.5 years ± 6.5 with male: female ratio of 7.4:1. About 55% of the vascular injuries resulted from machete cuts, while 16.67% was due to gunshot wounds, and knife stabs in 7.14%. Glass cut and broken bottle cut accounted for 7.14%, RTA in 4.76. There were 37 actively bleeding peripheral vascular injuries (16 arterials and 21venous), 4 pseudoaneurysms (3 leaking/bleeding), 7 neck venous injuries. Treatment included repair in 88.0% and ligation in 10.0%. The repair methods included lateral arteriorrhaphy and venorrhaphy (50.0%), end to end anastomosis (20.0%), patch angioplasty (10.0%), reversed autogenous long saphenous vein graft (6.0%), and one aneurysmorrhaphy. Ligation was done for four venous injuries in the limbs and one ulnar artery injury in the distal forearm after Allen's test had confirmed adequacy of arterial blood supply to the whole hand by the radial artery. Five patients were excluded from the analysis because three of them presented at more than 72 hours after injury with obvious gangrenous limb and the remaining two died from exsanguinations and hypovolaemic shock before presentation.

1.4. Conclusion: Eighty-seven percent patients survived without long-term complications, 6.4% patients had limb amputation, 4.3% patients died, and 2.1% patient had chronic oedema of the affected limb.

2. Introduction

Peripheral vascular injury involving arteries, veins or both can result from both blunt and penetrating traumas to the extremities. It occurs in about two percent of civilian injuries and eight percent of wartime injuries [1]. All series that included the age and sex in analysis have documented preponderance of males and young adults both in wartime and non-wartime [1-7]. Mechanisms of penetrating injuries include gunshot, stab, cut or laceration and shrapnel penetration [1, 4, 8]. Mechanism of blunt injuries includes road traffic accident, blast and fall [1, 4, 5]. Presentation is commonly in emergency with many patients presenting as poly-traumatised needing immediate and extensive resuscitation with damage control surgeries to save life and limb [1]. Common associated injuries include haemothorax, lung lacerations, splenic injury, kidney injury, laryngeal injury, small bowel and large bowel perforations and various limb and spine fractures along with splinter injuries to various parts of the body [1, 7]. The concomitant injuries should not distract the emergency room physician from the peripheral vascular injury which can present with hard signs such as active bleeding, rapidly expanding haematoma, pulselessness, limb ischaemia, pseudoaneurysm, thrill and bruit [3]. The six Ps of limb

ischaemia (pain, paraesthesia, paralysis, pulselessness, pallor and poikilothermia) may not all be present in all cases of limb ischaemia. Some patients with vascular injuries present only soft signs of pulse deficit, neurological deficit, paleness of extremity and non-expanding haematoma. The presentation may depend on extent of injury to artery or vein which may be in form of transection, laceration, contusion/intimal flap, thrombosis, spasm, arterio-venous fistula, aneurysm, pseudo-aneurysm or emboli [9].

Evaluation of patients with peripheral vascular injuries follows the Advanced Trauma and Life Support (ATLS) protocol. Physical examination alone has been used successfully to diagnose peripheral vascular injuries especially where hard signs are present [8]. In patients with suspected peripheral vascular injuries with soft signs and or proximity injuries, diagnosis of vascular injuries has been substantiated with use of various investigative and imaging modalities such as Ankle-Brachial Index (ABI), Arterial Pressure Index (API), duplex ultrasonography, Doppler ultrasonography, computed tomographic arteriography, magnetic resonance angiography, conventional arteriography, etc [6, 10-13]. Treatment of peripheral vascular injuries must be timely and appropriate in order to prevent loss of limb and life [3, 5, 14]. Pre-hospital treatment usually involved measures to arrest active bleeding which include limb elevation, compression dressing, application of tourniquet about eight cm proximal to injury point, packed dressing of open wound, haemostatic dressing and direct compression [15]. The definitive treatment of vascular injury in hospital is emergency and should be done within the golden hour to limit the warm ischaemia time [14]. Following wound exploration, the principles of vascular repair must be strictly adhered [3, 16]. These include adequate exposure of the injured vessel(s), proximal and distal control with snares or vascular clamps, regional heparinization with 15-20ml of 50 IU/ml heparin, and distal embolectomy [3]. The available options of treatment for vascular injuries include lateral arteriorrhaphy/venorrhaphy, patch angioplasty, end-to-end anastomosis, interposition graft, by-pass graft, extra-anatomic bypass graft and resection/ligation [16]. Adjunctive treatment like fasciotomy is necessary in patients with suspected or confirmed compartment syndrome [17]. Where there is associated displaced bone fracture, reduction and stabilization must be done during the revascularization surgery so that the fragment of bone will not injure the repaired vessel.

Outcome of treatment of peripheral vascular injury varies from complete recovery, survival with limb salvage, survival with amputation, survival with complications and death. Factors of prognostication include duration of time from injury to presentation and treatment, development of compartment syndrome, Mangle Extremity Severity Score (MESS), injury severity score, severity of limb ischaemia and the magnitude of associated injuries [1, 3, 10, 16]. MESS $\geq$7 is associated with irreversible necrosis that would necessitate amputation. MESS inputs extent of damage to bone and soft tissue, level of ischaemia, shock and age of the patient. It is reported that severity of tissue ischaemia does not only depend on the duration of injury but also on the level of arterial injury, extent of soft tissue damage and the efficiency of collateral circulation [1].

This particular study portrays our experience on the management of peripheral vascular injuries and outcome obtained in our first decade of practice.

3. Methods

3.1. Study Design: All consecutive patients with arterial and venous injuries were included in the retrospective study.

3.2. Ethical Approval: Approval was obtained from the institutional health research ethic committee.

3.3. Inclusion Criteria: All patients who presented alive with penetrating or blunt injury to the extremity with concomitant vascular injury were included in the study. Also included were all patients with penetrating injuries in the proximity to a limb artery.

3.4. Exclusion Criteria: All brought-in-death cases and extremely late presentation with established limb gangrene were excluded from the analysis.

3.5. Research Process: Data on patients' characteristics and clinical and management parameters including outcome of treatment were collated for analysis. Age, sex, duration from injury to presentation, duration from injury to treatment, vital signs, cause of trauma, use of tourniquet/duration, symptoms and signs of vascular injury, associated injuries, investigative modalities with results, treatment offered including fasciotomy, and outcome of treatment in terms of survival of patient, limb salvage, amputation and complications were noted.

3.6. Data Analysis: Data analysis was done with STATA version 10. Categorical variables were summarized using frequencies and percentages.

4. Results

There were 42 patients treated for 50 vascular injuries with age ranging from 2 to 52 years. Another five patients were excluded from the analysis because three of them presented at more than 72 hours after injury with obvious gangrenous limb while two died from exsanguinations and hypovolemic shock before evaluation for peripheral vascular injury. The median age was 26.5 + 6.5 years. There were 37 (88.1%) males and 5 (11.9%) females giving male: female ratio of 7.4:1. Most (69.0%) of the patients presented beyond the golden hour of 6-8 hours with only 31% presenting to our trauma Centre within 6-8 hours from the time of injury. There were five patients who presented extremely late with obvious limb gangrene in three of them and haemorrhagic shock and death before evaluation of the remaining two. These five were not included in data analysis. The causative events for vascular were machete cuts (54.76%), gunshot wounds (16.67%), and knife stabs (9.52%). Others include glass and broken bottle cuts (7.14%), RTA

(4.76%), and spontaneous rupture of varicose vein, iatrogenic and self-administration of intravenous drug in a drug addict accounting for vascular injury in 2.38% each (Table 1). The remaining 2.38% was due to broken intravenous cannula in the external jugular vein. Twenty-four (57%) of the patients presented with one or more hard sign of vascular injury: active bleeding (15), pulselessness (7), acute ischaemia (7), expanding haematoma (4), and vascular thrill and bruit (1). Eighteen [43%] presented with soft signs of vascular injury which included pulse deficit in the affected limb (12), neurological deficit with impaired pain and touch sensations and absence of active extension of the great toe (5), paleness of extremity (8), and non-expanding haematoma (4). All eight patients with proximity injuries had soft signs of vascular injury. Only two types of first aid measures were rampant in our patient population. These were compression dressing in 32 (76%) patients and tourniquet application in 10 (24%) patients.

Table 1: Causes of peripheral vascular injury

Cause of vascular injury	frequency	percent
Machete cut	23	54.57
Gunshot wound	7	16.67
Knife stab	3	7.14
Glass/ broken bottle cut	3	7.14
Road traffic accident	2	4.76
Spontaneous	1	2.38
Iatrogenic	1	2.38
IV drugs addict	1	2.38
Broken IV cannula	1	2.38
Total	42	100

Table 2 shows that there were 37 extremities vascular (16 arterials and 21venous) injuries, 4 pseudoaneurysms (3 leaking/bleeding), 7 neck venous injuries, one arterio-venous fistula and one case of broken cannula in the external jugular vein. Thirty-four (68%) of the injury occurred in the lower limbs, eight (16%) were in the upper limbs and neck respectively. Lower limb vessels were most affected (68%). Popliteal artery and branches; anterior tibial, posterior tibial and peroneal (10) and popliteal vein and tributaries (13) were most frequently injured. Femoral vessels were injured in 6 (12%) cases where the superficial femoral artery and superficial femoral vein were injured in all the cases. There were five cases of dorsalis pedis artery injury which presented as two cases of active pulsatile bleeding and three cases of leaking pseudoaneurysm. In the upper limb, the 16% of vessels injured were distributed as cephalic vein two cases and one case each of brachial artery and vein, antecubital vein, radial artery, ulnar artery, and axillary artery and vein which formed the only case of arterio-venous fistula diagnosed in the study. There were three injuries in the external jugular vein including a case of broken intravenous cannula, and two cases of internal jugular vein injuries. There were associated limb fractures in eight patients, muscle injury in 19 patients and nerve injury in five patients. Fasciotomy was done in only six cases of lower extremity vascular injury.

Table 2: Pattern of peripheral vascular injuries

Pattern	Frequency	Percent
Types of vascular injury		
Active bleeding in extremity		
Arterial	16	32
Venous	21	42
Pseudoaneurysm	4	8
Neck venous injury	7	14
Arterio-venous fistula	1	2
FB in external jugular vein	1	2
Total	50	100
Lower limb vessels		
Popliteal artery	4	8
Popliteal vein	6	12
Anterior tibial artery	2	4
Anterior tibial vein	2	4
Posterior tibial artery	2	4
Posterior tibial vein	2	4
Peroneal artery	2	4
Peroneal vein	3	6
Femoral artery	2	4
Femoral vein	4	8
Dorsalis pedis	5	10
Total	34	68
Upper limb vessel		
Brachial artery	1	2
Brachial vein	1	2
Antecubital vein	1	2
Radial artery	1	2
Ulnar artery	1	20
Axillary artery and vein	1	2
Cephalic vein	2	4
Total	8	16
Neck vessels		
External jugular vein	5	10
Internal jugular vein	3	6
Total	8	16

Physical examination was used in the diagnosis of all patients who presented with hard signs of peripheral vascular injury for immediate exploration and revascularization. Non-invasive inves-

tigation modalities which did not increase the waiting time were routinely utilized in all patients. These included finger/toe tip pulse oxymetry, hand-held Doppler ultrasonography, ankle-brachial index/arterial pressure index. Only patients with soft signs of peripheral vascular injury and proximity injury needed ultrasonography or angiography for diagnosis or exclusion of vascular injury. Treatment carried out included repair in 88% and ligation in 10%. The repair methods included lateral arteriorrhaphy/venorrhaphy (50.0%), end-to-end anastomosis (20.0%), patch angioplasty (10.0%), reversed autogenous long saphenous vein graft (6.0%), and an aneurysmorrhaphy (2.0%). Ligation was done for four venous injuries in the limbs and one ulnar artery injury in the distal forearm after Allen's test had confirmed adequacy of collateral blood supply to the whole hand by the radial artery. Intravenous cannula removal from external jugular vein was done for the one patient (2.0%) via venotomy (Table 3).

Table 3: Treatment and outcome of peripheral vascular injuries

Type of treatment	frequency	percent
Repair		
Lateral arteriorrhaphy/venorrhaphy	25	50
End to end anastomosis	10	20
Patch angioplasty	5	10
Reversed autogenous long saph vein graft	3	6
Aneurysmorrhaphy	1	2
Total	44	88
Ligation	5	10
Removal of foreign body	1	2
Outcome of treatment		
Complete recovery	41	87.2
Amputation	3	6.4
Chronic oedema	1	2.1
Dead	2	4.3
Total	47	100

Apart from the extremely late presented three patients that had lower limb amputation and two patients who died, there was no other mortality or amputation in the study. However, the patient who presented with bleeding from antecubital vein erosion after a long time of self-administration of intravenous narcotic drug had pre-intervention chronic oedema of the forearm and hand which persisted in the post-operative period.

5. Discussion

The current study has revealed the epidemiology of peripheral vascular injury in our civil setting. Forty-two patients sustained 50 vascular injuries in the five years studied giving yearly incidence of eight to ten. Previous studies have documented varying prevalence depending on some factors such as patients' volume, catchment area, status of centre and whether the studied region is on war conflict [1, 3, 4, 18]. Although the study by Oyebanji, et al had lower prevalence than the current study, those of Shalabi and Subramanian had higher prevalence respectively [3, 4, 18]. These differences may be due to varying level of civilization, criminality and war conflict in the various regions of the world studied. Previous studies in same institution revealed that vascular injuries accounted for 15% of cardiothoracic surgical emergencies and vascular pathologies constitute 10% of all cardiothoracic pathologies [19,20]. Young adults were more at risk, with male preponderance. All related studies whether at civilian or war times have shown the same pattern [1, 3-7]. Characteristically, the three-year study by Dhillan involved 46 patients who were all males [7]. This is basically because adult men are the ones that readily engage in both legitimate and illegitimate ventures where the injuries that may affect blood vessels occur. It is also males that are commonly involved in altercations where weapons may be used on the opponents. A far-reaching implication of this is that where many man-hours, limbs or lives are lost, the productivity of a state may be adversely affected and bread winning responsibility of the victims also affected. Most (54.76%) of our patients sustained vascular injury from machete cut, some of which being accidental during domestic activities and some as a result of assaults. In the series of de Silva [1], machete cut accounted for 26% of peripheral vascular injury. In this study, RTA accounted for 4.76% whereas in the study by Shalabi [4], it accounted for 50%. Gunshot wounds were the cause of vascular injury in 16.67% of our patients. Situations of gunshot included police brutality, assault and communal crisis. In the study of de Silva [1], during wartime, 17% of the peripheral vascular injuries were from gunshot wound. However, studies of Gomez and Frykberg on extremity vascular injury documented gunshot wounds as the cause in 91.7% and 85% respectively [6, 8]. The degree to which gunshot wounds cause peripheral vascular injury in non-wartime depend on the degree of liberalization of use of gun in the population. In Nigeria, vascular injuries have been reported from stray bullets from gunshots not targeted at the victims [21], Iatrogenic vascular injury has been recorded in another related study [22]. In our study, it resulted from attempt at establishment of temporary vascular access for haemodialysis via the femoral vein which had been reported earlier [23]. The contribution of other causes is similar to that in related studies except in the study by de Silva, et al where blast injury alone caused vascular injury in 41% of cases [1].

Majority (57%) of our patients presented with one or more signs that fitted the American College of Surgeons' hard signs of vascular injury [17]. In such patients, resuscitation was carried out alongside with definitive treatment. It was not necessary to further prolong the presentation-to-intervention time by carrying out imaging studies before wound exploration and vascular repair. However, in all patients, it was mandatory to assess and document peripheral arterial status via oxygen saturation testing using finger

or digit pulse oximeter, ankle-brachial index or arterial pressure index, amongst other clinical physical examination findings. In such cases, definitive diagnosis was established intra-operatively. Physical examination only before treatment has been found to be adequately accurate with specificity and sensitivity above 90% for the diagnosis of peripheral vascular injury [8]. However, in patients who presented with only ACS soft signs of vascular injury or proximity injury, management towards the vascular injury was initially conservative and the likely vascular injury was investigated with duplex, Doppler ultrasonography, computed tomographic angiography or magnetic resonance angiography where necessary. These modalities have been found in other studies to be accurate in excluding vascular injuries [6, 10-13, 16, 24]. None of our patients underwent conventional arteriography which is being vastly replaced by other imaging modalities [13]. The study of Johansen found non-invasive vascular tests to be safe, accurate and cost effective when compared with arteriography [12]. The spectrum of the vessels injured in our patients' cohort was similar to other series [1, 4, 5, 7, 18]. Our study also showed that involvement of lower extremity vessels was more than upper extremity vessels, and veins were also more injured than arteries as in previous studies [4, 5, 7].

The definitive treatment given to our patients was according to the vascular surgery treatment guidelines [25]. Vascular repairs were undertaken in 86.76%. These consisted of lateral arteriorrhaphy and venorrhaphy (19), end-to-end anastomosis (9), patch angioplasty (4), reversed long sapheneous vein grafting (2) aneurysmorrhaphy (1), and arterio-venous fistula repair (1). None of our patients received anatomic or extra-anatomic bypass grafting. Bleeding from lower extremity venous injuries and dorsalis pedis injuries was treated by ligation. Also, one ulnar artery injury in the distal forearm was ligated after Allen's test showed good collateral blood supply in the hand. All these modalities have successfully been utilised by vascular surgeons in management of peripheral vascular injuries [3, 4, 14, 17, 26]. Venous ligation may be risked with the complication of oedema which can be successfully managed by limb elevation [26]. Also, none of our patients was treated with temporary intravascular shunt or artificial prosthetic vascular graft which have been reported in other studies [18, 27]. The treatment of associated injury where present was not allowed to unnecessarily delay the treatment of vascular injury. Associated displaced long bone fractures were treated with reduction and external fixation under the same anaesthesia for vascular repair. Complicated associated injuries' treatment was delayed for revascularisation surgeries to save the limb or carried out concurrently with vascular repair. Same approach has been previously reported [2]. Tourniquet use was not observed to predispose to critical limb ischaemia even though some tourniquets were in place for up to ten hours or more. This may have been because the tourniquets were not tight enough to occlude arterial blood supply distally. The review by Passos, et al did not show any mortality or limb loss in any of the patients with peripheral vascular injuries who had pre-hospital or emergency room tourniquet application [15].

Concerning outcome of treatment, during the entire period of the study two (4.3%) patients with vascular injury died, three (6.4%) patients had limb amputation, and one (2.1%) had chronic oedema of the affected limb. Forty-one (87.2%) survived with no long-term complication. Outcomes from studies of peripheral vascular injuries have noted mortality rate ranging from 0-9.7% [1, 4, 5, 7, 14, 15] and amputation rate of 0-22.2% [1, 4, 5, 7, 14, 15]. Factors discovered to correlate with limb amputation and mortality include injury severity score, mangled extremity severity score, associated injuries, and duration from injury to presentation at trauma Centre [3, 5, 10, 28]

6. Conclusion

In our civilian setting, most of the peripheral vascular injuries resulted from machete cut commonly in assault situations. Most of the injuries were amendable to repair with 87.2% of patients surviving without long-term complications, 6.4% patients had limb amputation, 4.3% patients died, and 2.1% patient had chronic oedema of the affected limb.

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