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Etiology and Surgical Management of Penetrating Arterial Trauma of Limbs in Toamasina

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Abstract

Background: The prevalence of penetrating arterial trauma of limbs remains unknown in Toamasina. Their management remains a challenge due to lack of protocol and late in admission of victims. The aim of this study was to describe etiology and surgical management of penetrating traumatic arterial injuries of limbs in Toamasina. **Material and Methods:** This was a retrospective and descriptive study for 6 years period (from 1st January 2017 to 31th December 2022) performed at Vascular Surgery Unit of Morafeno Teaching Hospital in Toamasina, Madagascar, including all patients who underwent surgery due to penetrating traumatic arterial injuries of limbs. Demographics, circumstance of accident, symptomatology, characteristics of arterial injury, surgical procedures and outcomes were analyzed. **Results:** Thirty-five cases of penetrating arterial trauma of limbs were recorded. The most victims were young (mean age = 31.27) male (96.43%). Arterial injuries were due to stab wounds in 85.17% of cases. The most common symptoms were bleeding (89.12%) and pulseless (46.73%). Most patients (82.85%) used tourniquets to control the bleeding before admission. Lesions were laceration (34.28%), transection (48.57%) and avulsion (17.14%). Arterial injuries were located in upper extremities in 20 cases (71.42%). The most involved vessels were the brachial artery (45.71%) and radial artery (34.28%). Surgical procedures were end-to-end anastomosis (45.71%), lateral arteriorraphy (25.71%), interposition of reverse saphenous vein graft (17.14%) and ligation (8.57%). Primary amputation was performed for 1 patient after delayed acute ischemia (2.85%). There was no death among patients who underwent surgery. The overall limb salvage rate was 97.14%. **Conclusion:**

Stabs were the most common etiology of penetrating arterial injuries in Toamasina. Surgical results were satisfactory despite the late in admission of majority of victims.

Keywords

Artery, Vascular Injury, Limbs, Surgery, Trauma

1. Introduction

In Sub-Saharan African countries, vascular trauma is the most common cause of death and amputation. Vascular surgery is sometimes performed by both general surgeons due to lack of vascular surgeons in these countries. The prevalence of civilian vascular trauma is estimated at 4.5 cases per year in Sub-Saharan African countries [1]. In Antananarivo, vascular injuries account for 5.28% of reason for hospital admission in Vascular Unit [2] and trauma remains the leading reason (33%) of surgical procedures of limbs in Antananarivo [3]. The poverty and insecurity increased the risk of vascular trauma in Toamasina. However, the management of vascular trauma remains a challenge in low-income countries such as Madagascar due to delays in timing of admission for majority of victims. In addition, there is not any guideline available in management of victims of vascular trauma in Toamasina. The aim of this study was to describe etiology and surgical management of penetrating traumatic arterial injuries of limbs in Toamasina.

2. Materials and Methods

This study was performed in Morafeno Teaching Hospital in Toamasina, located in East region of Madagascar. It's one of referral hospitals for vascular surgery in Toamasina. We conducted a retrospective and descriptive study among patients admitted to hospitalisation after penetrating arterial injuries due to trauma happened in Toamasina, an East region of Madagascar. This study included all victims of trauma of limbs which underwent surgical arterial repair due to the presence of penetrating arterial injuries, for 6 years-period (from 1st January 2017 to 31th December 2022) performed at Vascular Surgery Unit in Morafeno Teaching Hospital. Data were collected from patients' folders stored in Vascular Surgery Unit, including all prehospital gestures, the preoperative management during admission at Emergency Unit, the surgical procedures and postoperative management. Demographic data, mechanism of injury, prehospital haemostasis gesture, clinical signs, type and location of arterial injury, associated injuries, surgical treatment and outcomes were analyzed. Data were recorded with Microsoft excel 2016, then analyzed with SPSS 21.0 software.

3. Results

Thirty-five cases of penetrating traumatic arterial injuries were recorded. The

most victims were young, and the average age was 31.27 years old, ranging from 16 to 43 years. There was a male predominance (91.42%) with sex ratio of 10.66. Penetrating arterial injuries were due to stabs in 88.57% and gunshots in 11.42% (Table 1). Patients had a history of using improvised tourniquets (57.14%), compression bandages (31.42%) and skin suture (11.42%) to control the bleeding before their admission into hospital. The most common symptoms were external bleeding (68.57%), expanding and pulsatile hematoma (31.42%), pulse absents (88.5%) and paresthesia (91.42%). Lesions were lacerations (34.28%), transections (48.57%) and avulsions (17.14%). Arterial injuries were located in upper extremities in 22 cases (62.85%) and in lower extremities in 13 cases (37.14%). The most involved vessels were brachial artery (45.71%) followed by femoral artery (28.57%) (Table 2). There were associated injuries observed in some victims like soft tissue damage (34.28%), venous injuries (54.28%), nerve injuries (8.57%) and bone injuries (11.42%). In admission, all victims received medical treatment like painkill, antibiotics and massive crystalloid fluid perfusion to manage hemodynamics before surgery. Surgical arterial repair was performed between 6 to 12 hours after arterial trauma in more than half of cases (51.42%) (Table 3). Only nine victims (25.71%) underwent surgical repair before 6 hours after arterial trauma. Surgical procedures were end-to-end anastomosis (45.71%) (Figure 1), lateral arteriorrhaphy (25.71%), interposition of saphenous vein graft (17.14%) (Figure 2) and ligation (8.57%). Primary amputation of leg was performed for 1 patient (2.85%) after irreversible acute ischemia with large soft tissue damage. Two patients (5.71%) died during hospitalization due to polytraumatism after gunshots. The survival rate and the limb salvage rate were respectively 94.28% and 97.14%.

Table 1. Gender, circumstance of accident, control of bleeding before admission and clinical signs.

Gender/circumstance of accident/control of bleeding before admission/clinical signs		Frequencies (n = 35)	Percentage (%)
Gender	Male	32	91.42
	Female	3	8.57
Circumstance of accident	Stabs wounds	31	88.57
	Gunshots wounds	4	11.42
Control of bleeding before admission	Improvised tourniquets	20	57.14
	Compression bandage	11	31.42
	Skin suture	4	11.42
Clinical signs	External bleeding	24	68.57
	Expanding and pulsatile hematoma	11	31.42
	Cold extremities	32	91.42
	Skin wound	35	100
	pulse absents	31	88.5
	paralysis	4	11.42

Table 2. Characteristics of arterial injuries.

Characteristics of arterial injuries			Frequencies (n = 35)	Percentage (%)
Type of arterial injuries	Laceration		12	34.28
	Transection		17	48.57
	Avulsion		6	17.14
Location and involved vessels	Upper extremities (n = 22)	Brachial artery	16	45.71
		Radial artery	5	14.28
		Ulnar artery	1	2.85
	Lower extremities (n = 13)	Femoral artery	10	28.57
		Tibial artery	2	5.71
		Fibular artery	1	2.85
Associated injuries	Soft tissues damage		12	34.28
	Venous injuries		19	54.28
	Nerves injuries		3	8.57
	Bones injuries		4	11.42

Table 3. Delay between trauma and surgical procedures, surgical repair and outcomes.

Delay between trauma and surgical procedures/surgical repair and outcomes		Frequencies (n = 35)	Percentage (%)
Delay between initial trauma and surgical procedures	<6 hours	9	25.71
	6 - 12 hours	18	51.42
	12 - 24 hours	5	14.28
	>24 hours	3	8.57
Surgical repair	Lateral arteriorrhaphy	9	25.71
	End-to-end anastomosis	16	45.71
	Interposition of saphenous vein graft	6	17.14
	Ligation	3	8.57
	Primary amputation	1	2.85
Outcomes	Survival	33	94.28
	Mortality	2	5.71
	Limb salvage	34	97.14
	Amputation	1	2.85

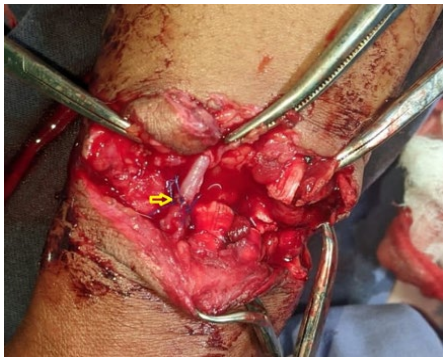

Figure 1. Peroperative image of end-to-end anastomosis.

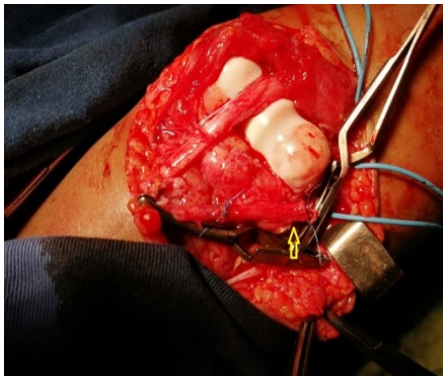

Figure 2. Peroperative image of reverse saphenous vein graft interposition.

4. Discussion

Penetrating arterial injuries due to trauma are a usual situation in Sub-Saharan African countries, contrasting in advanced countries where incidence of vascular trauma is extremely low, accounting 1.8% of trauma admission [4]. The true prevalence of arterial trauma remains unknown in Sub-Saharan African countries because most of victims mostly died before the admission in hospital. In Ethiopia, penetrating trauma are responsible for 89.4% of vascular injuries of extremities [5]. In addition, penetrating arterial injuries were usually underreported in Sub-Saharan African literature because all cases published by researchers included just only all patients who underwent surgery without patients who died before admission. So, these cases didn't represent the true prevalence of arterial traumatic injuries of limbs in these countries.

Most research published a high prevalence of penetrating arterial trauma in young male people. This predominance of young people was seen in different African studies that the average age was 28 years in Nigeria [6], 27 years in Ethiopia [5] and 31 years in our study. Male predominance is still observed in most research in African countries and in advanced countries with a rate of 90% in Iran [7], 85% in Nigeria [8] and 85 in Texas [9]. This predominance of youth male could be explained by the high level of activity and mobility of the male gender that exposes

them to various risk of trauma.

In advanced countries, penetrating arterial trauma of extremities was commonly due to road traffic accidents, but it was usually due to stabs or gunshots in Sub-Saharan African countries. This situation was observed in the study of Khan *et al.* and in the study of Thakur *et al.* that the rate of road traffic accidents was respectively 53% and 92% [10] [11]. In contrast, the most common causes of penetrating arterial injuries in Sub-Saharan African countries were gunshot wounds in South African study of Le Roux *et al.* (72%) [12] and in Tunisian study of Daly *et al.* (39%) [13]. Other studies showed a similar result of our study in the predominance of stabbing in circumstances of accident like the study of Nkomo *et al.* (65%) [14] and Daly *et al.* (53%) [13]. The predominance of gunshots and stabbings in Sub-Saharan African countries could be explained by the high rate of insecurity and banditism act related to poverty in population.

Most people used an impovised tourniquets (57%) and compression bandages (31%) to control the external bleeding before admission of victims. This situation was mostly observed in other African studies such in study of Nkomo *et al.* [14] and Fokou *et al.* [15]. Our result showed a similar result in the study of Fokou *et al.* with the predominance of using of compressing bandages (46%) and tourniquets (41%) [15]. The lack of medical transportation in low-income countries makes people to improvise something to stop the bleeding before the admission of victims. Tourniquets can be used to control hemorrhage before admission or before vascular control during surgery.

The diagnosis of penetrating arterial trauma of limbs is usually simple with the presence of hard signs of vascular trauma such as pulsatile bleeding, expanding and pulsatile hematoma, cold extremities and pulse absents. There is no role for routine imaging in penetrating arterial trauma of extremities. External pulsatile bleeding is the leading sign observed in most studies, accounting for 57% in our study, 78% in the study of Fokou *et al.* [15]. But our result contrasts with the study of Krüger *et al.*, which absence of pulses (48%) is the leading sign of penetrating arterial trauma of limbs [16]. The presence of signs of acute ischemia of limb depends on quantity of external bleeding and time of using tourniquets before admission.

Type of arterial injuries are different according to studies. It usually depends on circumstances of accident and energy of trauma. Stabs with their low-energy trauma are responsible for laceration or transection, but gunshots are responsible for arterial avulsion due to high-energy of trauma. Transection is the most common type of arterial injury seen in our study (48.57%), followed by laceration (34.28%). Other African studies showed a similar result in the leading of transection in degree of injury, such as in study of Onakpoya *et al.* (67%) [6] and Nkomo *et al.* (46%) [14]. Other non-African studies showed too the predominance of transection like the study of Franz *et al.* (31%) [17].

Traumatical arterial injuries could be located in upper extremities or in lower extremities. This study showed a predominance of upper extremities (62%). Some

studies showed a similar result with predominance of upper extremities in the location of arterial injuries. Upper extremities accounted respectively 73% and 57% in the study of Nkomo *et al.* [14] and Onakpoya *et al.* [6]. Brachial and femoral arteries were the most commonly involved vessels, as published by some researchers. Our study agrees with the literature in the predominance of brachial artery (45%) followed by femoral artery (28%). Some authors published the same result like Krüger *et al.* with brachial artery (41%) followed by femoral artery (30%) [16]. However, some studies showed a contrasting result, like predominance of tibial artery (29%) [18].

Associated injuries were still observed in some studies of traumatic arterial injuries like venous injuries, nerve injuries and bone injuries. Venous injuries are the most common associated injuries observed in our study (54%), in the study of Krüger *et al.* (31%) [16] and in the study of Hussein *et al.* (35%) [19]. Nerve injuries took usually second place among additional injuries, accounting for 29% in the study of Krüger *et al.* [16] and 26% in the study of Hussein *et al.* [19]. Some authors found a predominance of bone injuries associated with arterial injuries, such as Adeoye *et al.* (31%) [18] and Shakeri *et al.* (86%) [18]. These associated injuries sometimes need additional surgical repair to restore the right anatomical structure and functions of extremities. This situation could explain the extension of the surgical repair duration.

In low-income countries, the surgical management of penetrating traumatic arterial of limbs was usually late due to prolongation of admission in most victims, related to lack of medical transportation. In this study, half of victims underwent surgery between 6 to 12 hours after their initial vascular trauma. In the same way, other African studies showed too the delayed of time of presentation among victims of arterial trauma of extremities, such as the study of Gebregiorgis *et al.* that most of victims (42%) were admitted after 24 hours after the initial trauma [5] and the study of Onakpoya *et al.* which the majority of victims (63%) admitted 12 hours after the accident [6]. Adeoye *et al.* found that 55% of victims underwent surgery between 4 - 6 hours after vascular trauma [8]. The delayed of surgical management in our study could be explained by firstly, the lack of medical transportation and secondly by the poverty in population. In addition, most people can't afford to pay the hospital costs in case of emergency. After vascular trauma, most of the victims needed again more time to search money or find another solution before admission to hospital.

Surgical revascularization must be done early to prevent ischemia of limb and to avoid risk of amputation. Surgical arterial repair depends on type of arterial injuries. Lacerations require usually simple lateral arteriorrhaphy to restore arterial vascularization. However, transections need end-to-end anastomosis to establish continuity of arterial segment. Lateral arteriorraphy and end-to-end anastomosis remain the most common surgical repairs in Sub-Saharan African studies. Our study showed a predominance of end-to-end anastomosis (45%) followed by lateral arteriorrhaphy (25%). Some authors found a similar result, such as Nwafor

et al. whose study presented 30% of arteriorraphy and 27% of end-to-end anastomosis [1] and Adeoye *et al.* with 31% of end-to-end anastomosis followed by lateral repair (25%) [8]. The loss of arterial segment requires usually an interposition of vein to restore the continuity. Establishing the continuity of arterial segment by using reverse saphenous vein was the most common situation seen in low-income countries such Madagascar. It could be explained by availability of saphenous veins in emergency situation.

Although making salvage of limbs is one of aim of surgical management of penetrating arterial trauma of extremities, the outcome was variable and depended on type and/or mechanism of injury, the delay between accident and surgical repair and collateral blood supply. The rate of limb salvage was 97% in our study. Some studies showed a contrasting result, such as the study of Onakpoya *et al.* with a lower rate (64%) of limb salvage [6] and the study of Gebregiorgis *et al.* with 71% of limb salvage [5]. The hospital mortality rate was extremely lower than before admission accounted usually under 10% in Sub-Saharan African countries, like the studies of Adeoye *et al.* (6%) [8] and Hussein *et al.* (6%) [19]. In Western country, researchers found a lower rate of mortality than in African studies such as Altoijry *et al.* and Cho *et al.* with respectively 5% and 3% of hospital mortality rate [20] [21].

5. Limitations

The retrospective nature and the small size of the population studied constitute the main limitations of our study. This population of study was underestimated because it included only all patients who underwent surgical repair of penetrating arterial injuries.

6. Conclusion

Stabs were the most common cause of penetrating traumatic arterial injuries in Tamatave. Restoring the arterial flow to the distal extremity within six hours after the initial trauma remains the important key to keep off the limbs from the risk of amputation. But it's usually difficult to perform the surgery at the right time because of late in admission of victims.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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