

## ORIGINAL RESEARCH

# Outcomes of open surgical interventions for pseudoaneurysms: A 5-year retrospective study at 2 referral hospitals in Addis Ababa, Ethiopia

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## Abstract

### Background

A pseudoaneurysm is a rupture in an arterial wall resulting from inflammation, trauma, or an iatrogenic mechanism. The epidemiology and treatment outcomes of pseudoaneurysms remain unclear in resource-limited settings, such as Ethiopia, where open surgical repair is the primary method of treatment.

### Methods

In this retrospective medical record review, eligible patients were those treated for pseudoaneurysms at 2 large hospitals in Addis Ababa from 1 January 2015 through 31 December 2019. Descriptive statistics were generated to characterize the patient population.

### Results

The medical records of 76 patients were reviewed. Most patients were male (n=63, 83%) and less than 31 years old (n=43, 57%). Trauma was the most common cause of pseudoaneurysm formation (n=63, 83%), with stab and gunshot wounds being the leading causes. Swelling (n=68, 89%), pain (n=62, 82%), and pulsatile mass (n=55, 72%) were the leading presenting symptoms. The most common vessel affected by pseudoaneurysm formation was the superficial femoral artery. All patients underwent open surgical repair; interposition grafting was performed for 24 patients (32%). Three patients underwent repeat surgery. The rate of surgical site infection was 22%. Significant intraoperative bleeding occurred in 6 of the index procedures (8%).

### Conclusions

In contrast to other settings, trauma was the most common cause of pseudoaneurysms in our study. Swelling, pulsatile mass, and pain were the predominant clinical presentations. Surgical site infections were common, and this finding warrants further investigation.

**Keywords:** pseudoaneurysm, trauma, open surgical repair, Ethiopia

## Introduction

Pseudoaneurysms arise when inflammation, trauma, or iatrogenic causes disrupt arterial wall continuity.<sup>[1]</sup> Pseudoaneurysms should be treated as surgical emergencies, as they can lead to life-threatening rupture and bleeding.<sup>[2]</sup> In trauma patients, the pathophysiologic processes underlying pseudoaneurysms usually involve expansile waves, projectile fragmentation, bone-induced vascular wall damage, or endothelial injury, leading to thrombosis.<sup>[3]</sup>

Pseudoaneurysms are often of iatrogenic origin, particularly in association with endovascular procedures or line

placements.<sup>[4]</sup> Trauma is a less common but still important cause of pseudoaneurysm. Traumatic pseudoaneurysms can occur anywhere in the body, and case reports and case series have described pseudoaneurysms in arteries of the arms and the legs, as well as in the aortic, subclavian, innominate, hepatic, superficial temporal, middle meningeal, and ophthalmic arteries.<sup>[5]-[11]</sup>

Few publications have reported on the percentage of vascular injuries associated with pseudoaneurysms; however, a recent review of major arterial injuries found that pseudoaneurysms were present in 43.0% of subclavian arterial injuries, 52.9% of aortic arterial injuries, and 58.6% of innominate arterial injuries.<sup>[12]</sup>

For decades, treatment for pseudoaneurysms has been primarily surgical. In Western settings, open surgical repairs for treating pseudoaneurysms are becoming uncommon, and treatment is increasingly based on less-invasive approaches, including thrombin injection, ultrasound-guided compression, and covered stents. In these settings, open surgical repair is primarily conducted if there is evidence of haemodynamic instability or an expanding haematoma, or if there is failure of less-invasive procedures.[13] Further, endovascular surgical techniques have been found to be effective for excluding pseudoaneurysms occurring in the vessels of the extremities, as well as in central vessels.[14] However, open surgical repair remains a commonly used approach for treating pseudoaneurysms in low-resource settings.[15],[16]

Few studies have reported on pseudoaneurysms in Africa. We speculated that, due to the infrequency of intravenous drug abuse[17] and endovascular procedures in Africa,[18] the most common cause of pseudoaneurysms in the African setting may be trauma. Given the low availability of minimally invasive surgical techniques in low-resource settings, open surgical repair remains an important approach for treating pseudoaneurysms. Ethiopia, like many other low-income countries, has few health facilities providing vascular surgery services, and even at facilities where such services are available, minimally invasive techniques are rarely offered. Therefore, open surgical repairs are paramount and deserve further study.

## Methods

### Study design and setting

We conducted a retrospective review of the medical records of all patients who underwent surgical procedures for pseudoaneurysm treatment from 1 January 2015 through 31 December 2019 at 2 referral hospitals in Addis Ababa, Ethiopia, namely, Tikur Anbessa Specialized Hospital (TASH) and Teklehaimanot General Hospital. Both referral hospitals provide elective and emergency vascular surgery services. TASH is the largest and oldest university teaching hospital in the country, with a bed capacity of 800, among which 150 beds belong to Department of Surgery. Teklehaimanot General Hospital has 25 inpatient beds allocated to surgical patients. A vascular surgery subspecialty service was started in 2013, and about 4000 patients are seen annually at the vascular clinics of both hospitals. Both study hospitals participate in a fellowship programme for vascular surgery in collaboration with the University of Wisconsin, USA, and Linköping University Hospital, Sweden. A variety of vascular surgical procedures are performed at both facilities, including abdominal aortic aneurysm repair, carotid endarterectomy, and lower extremity revascularization.

### Data collection and analysis

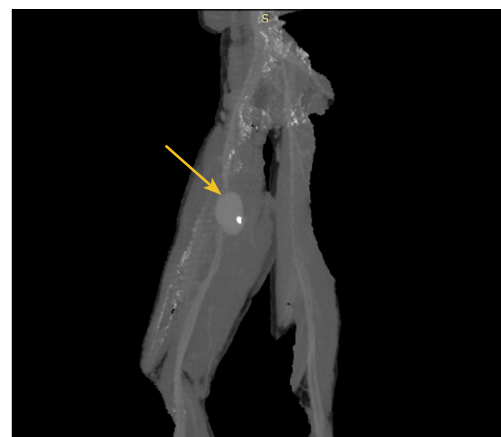
The study sample was obtained using nonprobability purposive sampling. Specifically, the medical records and operation theatre register notes of all consecutive patients who underwent surgical treatment for clinically or radiologically diagnosed pseudoaneurysms were evaluated, regardless of

the duration of illness, associated or presumed aetiological factors, age, or gender. A trained, clinically qualified research team member used a structured, paper-based questionnaire, to collect data on relevant variables, including patient demographics, presenting signs and symptoms, imaging findings, prognostic indications, type of surgery, intraoperative and postoperative complications, and surgical outcomes. All data were checked for completeness, and any missing variables prompted re-evaluation of patient medical records and notes in the operating theatre logbook.

Univariate and bivariate descriptive statistics were generated to characterize the patient population and evaluate the relationship among demographic factors, disease factors, and patient outcomes. All study data were entered into a database and analysed using SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA). Before starting data collection, ethical approval for this study was obtained from the institutional review board of the Department of Surgery, School of Medicine, College of Health Sciences, Addis Ababa University.

Most patients were referred for surgery from regional hospitals after attempts to control bleeding had failed. Pre-operative assessments and diagnoses were informed by clinical history, physical examination, and imaging studies, including ultrasonography and computed tomography (CT) angiography (Figure 1, Figure 2).

Regional or general anaesthesia was applied to all patients. In all cases, there was no discharge of blood, serous fluid, or pus from the skin covering the aneurysmal lesions. Intraoperatively, the patients were positioned according to the anatomic locations of the aneurysms. Povidone iodine was used as an antiseptic to prepare the skin, and standard draping methods were applied. Incision sites varied by pseudoaneurysm site. When necessary, heparin was given intravenously 2 minutes before occluding the artery proximal to the lesion. For each patient, proximal control of the pseudoaneurysm was undertaken by applying a vessel loop and vascular clamp; when accessible and feasible, distal control



**Figure 1.** Computed tomography angiogram of a 40-year-old man with a pseudoaneurysm in the right superficial femoral artery secondary to a gunshot injury



**Figure 2.** Computed tomography angiogram of a 39-year-old woman showing a huge pseudoaneurysm in the left common iliac artery with atherosclerotic changes on the right; it was successfully treated with a Dacron interposition graft

**Table 1.** Sociodemographic characteristics of patients treated for pseudoaneurysms at 2 tertiary hospitals in Addis Ababa, Ethiopia, January 2015 through December 2019 (N=76)

Category	n (%)
<b>Sex</b>	
Male	63 (83)
Female	13 (17)
<b>Age, years</b>	
<15	22 (29)
16-30	21 (28)
31-45	21 (28)
46-60	10 (13)
>60	2 (3)
<b>Marital status</b>	
Single	32 (54)
Married	27 (46)
Undocumented	17 (-)
<b>Region of residence</b>	
Oromia	20 (28)
Addis Ababa	32 (45)
Amhara	9 (13)
Afar	5 (7)
Gambella	2 (3)
Somali	3 (4)
Undocumented	5 (-)

was also applied. The operative technique was determined by several factors: the size of the defect in the arterial wall, the extent of defect in the circumference of the affected arterial wall, the anatomic site of the pseudoaneurysm, and the presence of collateral circulation. Reverse venous interposition grafting, using either the great saphenous vein, cephalic vein, or basilic vein (or, occasionally, synthetic grafts), was used for lesions that were longer than 1.5 cm. A lateral-wall venous patch was used if a lesion involved 25% or more of the circumference of the arterial wall. Primary repair was used if the circumference or length of the defect was too small to necessitate either interposition or patching. Ligation with or without excision, using nonabsorbable polypropylene sutures, was used for surgical management when the anatomy of the collateral circulation allowed its use—for example, for radial artery pseudoaneurysms, internal iliac artery pseudoaneurysms, or splenic artery pseudoaneurysms. Immediately postoperatively, distal pulses were evaluated clinically and with a handheld Doppler device. For almost all patients, surgical wounds were closed primarily because there were no clear clinical signs of infection. We did not send specimens obtained from intraoperative evacuation for culture and sensitivity testing for every patient because these investigations were not routinely available. If the evacuated clot was large, we used Penrose drains, which were usually removed after 48 to 72 hours if there was not significant drainage. Some patients, particularly those with groin incisions, developed postoperative wound infections that required opening for free drainage and debridement; vessels at the wound sites were always covered with soft tissues. Almost all patients were evaluated postoperatively by clinical examination and colour Doppler; all patients had good circulation and perfusion in the extremities.

## Results

In total, 76 patients underwent surgical treatment for pseudoaneurysms at the 2 hospitals over 5 years. Most patients were male (n=63, 83%), under the age of 31 years (n=43, 57%), and unmarried (n=32 of 59 patients with available data, 54%) (Table 1). Further, most patients were residents of Addis Ababa (n=32 of 71, 45%) or Oromia Region (n=20 of 71, 28%).

In total, 63 pseudoaneurysms (83%) were attributed to trauma, most of which involved penetrating injuries (n=52, 68). Stab injuries (n=35, 46%) caused close to half of the pseudoaneurysms, followed by gunshot wounds (n=16, 21%). Iatrogenic injuries (n=7, 9%) and inflammatory injuries (n=7, 9%) were the least common causes of pseudoaneurysms. Among pseudoaneurysms attributed to iatrogenic injuries, most were associated with central line placement (n=4, 5%) (Table 2).

Swelling of the affected extremity (n=68, 89%) was the most common presenting complaint among patients, followed by pain (n=62, 82%). In total, 55 patients (72%) had pulsatile localized masses upon examination. Seventy patients (92%) were evaluated using Doppler ultrasonography, 35 patients (46%) were evaluated using both Doppler ultrasonography and CT angiography, 4 patients (5%) were evalu-

**Table 2.** Trauma mechanisms among patients treated for pseudoaneurysms at 2 tertiary hospitals in Addis Ababa, Ethiopia, January 2015 through December 2019 (N=76)

Mechanism of trauma	n (%)
<b>Iatrogenic</b>	<b>7 (9)</b>
Central line placement	4 (5)
Dialysis fistula	1 (1)
Endovascular anastomosis site	2 (3)
<b>Blunt</b>	<b>10 (13)</b>
Road traffic injury	3 (4)
Fall	2 (3)
Assault	4 (5)
Other	1 (1)
<b>Penetrating</b>	<b>52 (68)</b>
Stab	35 (46)
Gunshot	16 (21)
Blast	1 (1)
Inflammatory	7 (9)

**Table 3.** Presenting complaints and diagnostic modalities associated with pseudoaneurysms treated at 2 tertiary hospitals in Addis Ababa, Ethiopia, January 2015 through December 2019 (N=76)

Category	n (%)
<b>Presenting complaint</b>	
Swelling	68 (89)
Pain	62 (82)
Ischaemic claudication	2 (3)
Gangrene	1 (1)
Pulsatile mass	55 (72)
Abdominal pain	3 (4)
<b>Diagnostic modality</b>	
Doppler ultrasonography	70 (92)
Computed tomography angiography	39 (51)
Clinical evaluation only	1 (1)

ated using CT angiography without prior Doppler scanning, and 1 patient underwent only a clinical evaluation (Table 3).

The arteries of the lower extremities, particularly the superficial femoral arteries (n=22, 29%), were the most common pseudoaneurysm sites (Table 4). Other frequently affected sites were the brachial arteries (n=9, 12%), the common femoral arteries, and the popliteal arteries (n=7,

**Table 4.** Pseudoaneurysm sites among patients treated for pseudoaneurysms at 2 tertiary hospitals in Addis Ababa, Ethiopia, January 2015 through December 2019 (N=76)

Artery	n (%)
<b>Neck</b>	
External carotid artery	1 (1)
Common carotid artery	6 (8)
<b>Thorax</b>	
Subclavian artery	4 (5)
Brachiocephalic artery	2 (3)
<b>Abdomen</b>	
Splenic artery	3 (4)
<b>Upper limb</b>	
Axillary artery	3 (4)
Brachial artery	9 (12)
Radial artery	3 (4)
Ulnar artery	2 (3)
<b>Lower limb</b>	
Common iliac artery	2 (3)
External iliac artery	2 (3)
Internal iliac artery	1 (1)
Gluteal artery	7 (9)
Common femoral artery	1 (1)
Profunda femoris artery	22 (29)
Superficial femoral artery	7 (9)
Popliteal artery	1 (1)

9%). Splenic artery pseudoaneurysms were diagnosed in 3 patients (4%), each of whom presented after an episode of acute pancreatitis accompanied by abdominal pain.

All 76 patients underwent open surgical procedures; no endovascular or hybrid techniques were performed. The most frequently performed surgical technique was interposition grafting (n=24, 32%), followed by primary defect repair (n=22, 29%). Eleven patients (14%) underwent surgical ligation of the affected artery to achieve pseudoaneurysm exclusion; 3 of these patients underwent splenic artery ligation with splenectomy, 3 underwent radial artery ligation, 2 underwent ulnar artery ligation, 1 underwent posterior tibial artery ligation, and 1 underwent profunda femoris artery ligation (Table 4).

All 76 patients underwent primary wound closure, which included passive drainage for a mean of 3±1 postoperative days. All patients underwent intraoperative Doppler scanning, but completion angiography was not performed because it was not available.

**Table 5. Surgical modalities and postoperative complications associated with pseudoaneurysms treated at 2 tertiary hospitals in Addis Ababa, Ethiopia, January 2015 through December 2019 (N=76)**

Category	n (%)
<b>Surgical modality</b>	
Venous patch	18 (24)
Primary repair	22 (29)
Interposition graft	24 (32)
Ligation	11 (14)
Above-knee amputation	1 (1)
<b>Postoperative complication</b>	
Surgical site infection	17 (22)
Deep venous thrombosis	2 (3)
Anastomotic pseudoaneurysm	1 (1)
Arterial thrombosis	1 (1)
Bleeding	1 (1)

The most common postoperative complication was surgical site infection, which was diagnosed in 17 patients (22%). Surgical site infections were treated with wound care, opening of the wound, debridement, and antibiotics. Most of the infected wounds (n=13, 17%) were allowed to close by secondary intention. Six patients had significant intraoperative bleeding requiring transfusion. Two patients were diagnosed with deep venous thrombosis. A few patients underwent second operations; these were for the management of postoperative bleeding (n=1), an anastomotic pseudoaneurysm (n=1), and arterial thrombosis (n=1) (Table 5).

## Discussion

Our detailed medical record review of patients who underwent surgical treatment for pseudoaneurysms during a 5-year period at 2 large referral hospitals in Ethiopia identi-

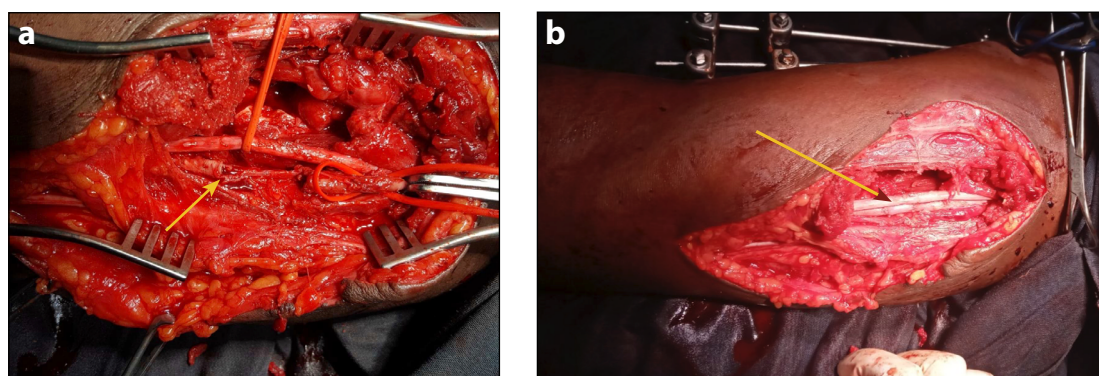
fied trauma as the most common cause of pseudoaneurysm formation. It was, therefore, not surprising that most patients were males and under 31 years old. Trauma as the primary cause of pseudoaneurysm formation has been observed in multiple studies conducted in a variety of settings.[19]-[22]

We speculate that the predominance of trauma as a cause of pseudoaneurysm formation in Ethiopia reflects social and medical conditions in the local context. Among the trauma-related conditions observed in our study, the majority were penetrating injuries. In contrast with our study, a review of studies examining the management of traumatic arterial pseudoaneurysms identified blunt trauma as the most common cause of pseudoaneurysm formation, accounting for 57% of cases.[23]

In line with findings from other studies investigating pseudoaneurysms,[16],[22],[23] swelling and pain were common presentations among our study patients. Although bleeding is a commonly reported presentation, we did not find any documentation of preoperative bleeding in our medical record review. We speculate that before being referred to our hospitals' surgical departments, trauma patients may have frequently received treatment to control bleeding at local health facilities. Occasionally, bleeding might have stopped spontaneously.

Doppler ultrasonography and/or CT angiography were conducted for all but 1 patient in this study. In their review of traumatic limb pseudoaneurysm management, Raheirantenaina et al.[23] reported conventional angiography to be the most common investigation ordered. In recent studies, CT angiography and Doppler ultrasonography have been reported as more frequently undertaken for vascular injury diagnoses.[24] We found that the most common pseudoaneurysm site was the femoral arteries, followed by the brachial arteries (Figure 3). This finding aligns with those of Raheirantenaina et al.,[23] who identified the brachial and femoral arteries as among the most common sites of pseudoaneurysm.

Open surgical repair was the only treatment approach for pseudoaneurysms in the study hospitals, as well as in Ethiopia in general. We found that interposition grafts and



**Figure 3. Brachial artery pseudoaneurysm – (a) excised and prepared for interposition graft placement; (b) after venous interposition graft repair**

primary repairs were the most commonly performed procedures, followed by ligation with exclusion. Similar treatment approaches were reported in a case series from the US in which 9 patients who presented with traumatic brachial pseudoaneurysms were treated by saphenous vein interposition grafting.[25] In our review, 3 patients with splenic artery pseudoaneurysms were treated by ligation and splenectomy, which has been reported in other settings.[26]

Finally, surgical site infections were documented for nearly a quarter of patients following treatment. This rate was substantially higher than the 7% reported in a US study of 949 patients treated for penetrating trauma.[27] Our findings regarding surgical site infections suggest that wound care and the sterility of surgical practice might have been inadequate, but further studies are needed to identify the causes of postoperative infections in our setting. Aside from the surgical site infections, only 5 other patients experienced postoperative complications, including 2 who had deep venous thrombosis (subsequently treated with anticoagulants), and 3 who required reoperation for bleeding, recurrent thrombosis, and anastomotic site pseudoaneurysm formation, respectively. Klocker and colleagues[28] reported 152 patients who underwent venous interposition grafting, 7% of whom developed graft occlusion as complications. Similarly, Mitchell and Thal[29] found that 8.3% of patients experienced graft occlusion following venous interposition grafting. In our study, only 1 patient had postoperative thrombosis, which required a second operation leading to a better outcome. Overall, few patients in our study required repeat interventions, and outcomes following the second operations were favourable, with no amputations required.

## Conclusions

Pseudoaneurysms are common. According to our findings, in Ethiopia, unlike other settings, pseudoaneurysms are frequently caused by trauma. We found that patients with pseudoaneurysms frequently presented with a combination of swelling, pain, or pulsatile mass formation overlying respective affected sites. Doppler ultrasonography, which is available at specialized surgical centres in Ethiopia, has an acceptable level of accuracy and was successfully used to diagnose pseudoaneurysms in most of the patients included in our medical record review, although some patients required further imaging. In our resource-limited study setting, open surgical repairs, encompassing a variety of techniques, achieved a high rate of success. However, the high prevalence of surgical site infections following pseudoaneurysm treatment is concerning and warrants further investigation.

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