Stump pressure measurement as a predictor of limb salvage in infected femoral artery pseudoaneurysms in recreational drug abusers

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Introduction
The management of infected femoral pseudoaneurysms due to local injury after drug injection is a challenging debatable armamentarium.
Patients and methods
Twenty patients presented with infected pseudoaneurysm of the femoral artery due to recreational drug injection. Measurement of stump pressures (SPs) in the femoral arteries intraoperatively was done in all patients after ligation.
Results
All patients were men with a mean age of 36.9 years. The mean SP was 54.85 mmHg. SP was less than 60 mmHg in eight patients in whom transobturator bypass was mandatory to be performed. SP was at least 60 mmHg in 12 patients who underwent ligation without any trial of subsequent revascularization.
Conclusion
SP measurement in the superficial femoral artery is a good indicator for the need of revascularization after femoral artery ligation in patients with infected femoral pseudoaneurysms due to recreational drug injection.

Keywords:
infected, pseudoaneurysm, revascularization, stump pressure

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Introduction

Treatment of infected femoral artery pseudoaneurysms (IFAPs) due to local drug injection is a challenging, debatable issue. The continuous rise in the number of recreational drug abusers has resulted in an increased incidence of this problem [1].

IFAPs represent a devastating complication in patients with inadvertent drug injection. The treatment is difficult and controversial. Ligation only without revascularization may lead to future intermittent claudication and limb amputation. Arterial reconstruction with a synthetic or venous conduit is also limited due to contamination of the field and nonviability of venous conduits [2].

Patients and methods

This is a prospective study that included 20 patients presented to the Vascular Surgery Emergency Department in Kasr-Al Aini Hospital with IFAPs due to inadvertent recreational drug injection between January 2016 and January 2017.

Methods

Demographic features in all patients, modes of presentation, the side of involvement, type of substance abuse, cultures from wounds, blood culture, and wall biopsy were collected.

Measurement of stump pressures (SPs) in the femoral arteries intraoperatively was done in all patients after ligation, and if it is found to be more than 60 mmHg, no revascularization procedure would be done and patients would be observed for signs of acute ischemia and revascularization would be considered in such cases only and if the SP is less than 60 mmHg after ligation, revascularization would be considered from the start.

The SP is measured using an intra-arterial cannula (18 G) that is connected to an extension line (20 cm long, 0.9 mm outside diameter and 0.6 mm inside diameter). The extension line is connected to a standard arterial transducer, which is connected to an electronic patient monitor. The entire tubing is filled with sterile, heparinized (20 U/ml) saline solution. The arterial transducer is calibrated, and the entire system is standardized to zero hydrostatic pressure at the level of the arteries.

The components of an intra-arterial monitoring system can be considered in three main parts:

(1) The measuring apparatus.
(2) The transducer.
(3) The monitor.

The measuring apparatus consists of an arterial cannula connected to a tubing containing a continuous column of saline which conducts the pressure wave to the transducer. The advantage of this system is that a patient's SP is constantly monitored beat-by-beat, and a waveform (a graph of pressure against time) can be displayed. The plastic portion of the intra-arterial cannula is inserted into the distal artery to measure the SP. Postoperatively, all patients receive systemic intravenous antibiotics injection (ceftriaxone 1 g, intravenous, twice daily, and metronidazole 500 mg, intravenous, three times daily), till the results of the culture and sensitivity are available.

All reconstructions were performed in extra-anatomical iliofemoral bypasses. Daily dressings of open wounds and checking for ischemic insult were carried out.

Results

There were 20 patients in this study with IFAPs due to parenteral drug injection. All patients were men with a mean age of 36.9 heroin was the drug used in all cases.

Of the 20 cases, and after a virology scan, 12 cases turned out to be hepatitis C virus (positive), and three cases had turned out to be hepatitis C virus (positive), and hepatitis B virus (positive).

Fifteen (75%) patients were presented with painful pulsating sensation and swelling (Figs 1 and 2); four (20%) patients presented with active bleeding due to ruptured femoral pseudoaneurysms and one (5%) patient presented with pain at the site of injection. Of all 20 patients, only four (20%) had a pus discharging sinus.

Ten (50%) patients had right lower limb involvement and the other 10 (50%) had left lower limb involvement.

The injured artery was the common femoral artery (CFA) and its bifurcation in 100%. The common femoral vein (CFV) and superficial femoral vein (SFV) were ligated in six (30%) patients due to their affection.

Regarding the SP measured in the femoral artery intraoperatively after ligation in mmHg, the mean SP was 54.85 (range 28–65).

SP was less than 60 mmHg in eight patients who underwent transobturator iliofemoral bypass from the start.

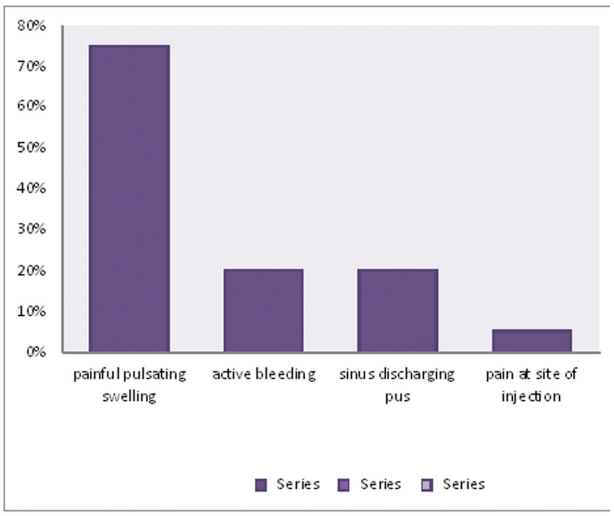
SP was at least 60 mmHg in 12 patients who underwent ligation without revascularization and only one patient suffered from acute ischemic insult after ligation of the femoral vessels for whom transobturator iliofemoral bypass was done.

On 6 months follow-up, regarding the SP, we found that for patients with SP of less than 60 mmHg, seven patients out of eight cases had limb loss, while in patients with SP of at least 60 mmHg, two patients

Figure 1

A male patient presented with painful pulsating sensation and swelling with pus discharging sinus.

Figure 2



Percentage of recreational drug users with infected femoral artery pseudoaneurysms with different presentations.

out of 12 had limb loss, with a resultant *P* value of 0.024, which is statistically significant.

In 11 patients, ligation of CFA, SFA, and profunda femoris artery with or without ligation of CFV and SFV was done with extensive tissue debridement.

In the other nine patients, transobturator iliofemoral bypass was done using synthetic grafts. Out of the nine extra-anatomical iliofemoral bypasses, eight procedures were done as a primary revascularization procedure after measuring the SP in the SFA (<60 mmHg) and only one case was done following ligation of the femoral vessels due to acute ischemia in which the SP in the SFA was 60 mmHg.

On the follow-up of patients who underwent ligation of the CFA and its bifurcation, nine (81.8%) patients have mild claudication, one (9%) patient had above-knee amputation, after 4 months due to gangrene and fixed color change in the left lower limb (Fig. 3) (SP in the SFA was 65 mmHg during ligation) and one (9%) patient died from a secondary hemorrhage following ligation.

Only one patient suffered from acute ischemia following ligation of the CFA and its bifurcation (SP in the SFA was 60 mmHg) in which transobturator bypass was done as a revascularization procedure immediately after ligation (Fig. 4).

On the follow-up, he had above-knee amputation.

On the other hand, those who underwent transobturator bypass (Fig. 5), three (33%) patients were complicated by graft occlusions in which SP in the femoral artery were (50, 48 and 28 mmHg), and the first two patients had above-knee amputation, while the third had hip disarticulation.

One (11%) patient was complicated by a secondary hemorrhage from the extra-anatomical bypass graft, in which SP in the femoral artery was 42 mmHg; ligation of extra-anatomical bypass graft and graft removal was done and the patient had above-knee amputation 1 week later.

Five (55%) patients were complicated with graft infection, in the form of pus collections surrounding the course of the graft in which SP in the femoral arteries were (40, 56, 50, 60, 48 mmHg), ligation of extra-anatomical bypass graft, graft removal, and drainage of collections were done.

During the follow-up, four patients out of the five with infected grafts had above-knee amputations in which the SP in the femoral arteries was (40, 50, 48, 60 mmHg), while the other patient had only mild to moderate claudication.

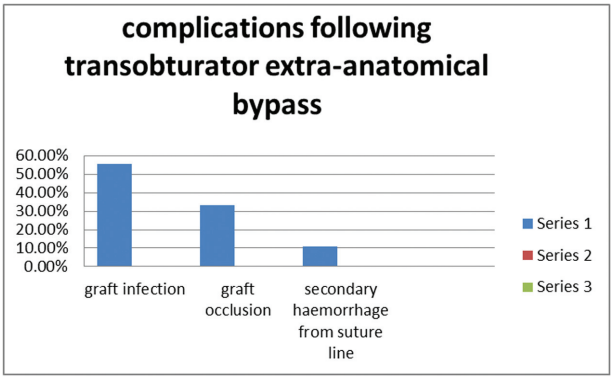
Figure 3

A male patient with gangrene and fixed color change in the left lower limb 4 months after ligation of femoral vessels and excision of infected femoral artery pseudoaneurysm due to parenteral drug injection.

Figure 4

A male patient with transobturator iliofemoral bypass due to acute ischemia after ligation of the femoral vessels and excision of infected femoral artery pseudoaneurysm due to parenteral drug injection.

Figure 5



Percentage of patient complications following transobturator extra-anatomical bypass.

The 6 months patency rate of the transobturator bypass was 66% (Table 1).

Regarding the results of culture and sensitivity (Table 2 and Fig. 6), wall biopsy and blood culture,10 patients were positive for methicillin-sensitive staphylococcus (MSSA) 50%; six patients were positive for methicillin-resistant staphylococcus (MRSA) 30%; two patients were positive for streptococci 10%; and two patients had mixed growth 10% including *Pseudomonas aeruginosa* and *Pseudomonas anaerobic*.

On follow-up:

Two patients out of 10 with MSSA infection had limb loss (20%).
Five patients out of six with MRSA infection had limb loss (83, 3%).
One patient out of two with streptococcal infection had limb loss (50%).
No limb loss was observed in patients with other mixed growth infection.

Discussion

IFAP is a severe complication in recreational drug abusers, with difficult, arguable, and irrelevant management. If left untreated, IFAPs can lead to hemorrhage, sepsis, limb loss, and even death [3].

Therapeutic options reported in the literature include: primary repair, immediate interposition grafting, extra-anatomical bypass, ligation–excision alone, and delayed revascularization, and some authors may use more than a single option [4].

In this study, 75% of patients presented with painful pulsating sensation and swelling, 20% presented with active bleeding, 5% presented only with pain at the site of injection.

In comparison with a study carried out by Majeed *et al.* [5], 70% of patients presented with pulsating swellings, 76% presented with pain and tenderness at the site of drug injection, and 15% presented with bleeding from aneurysmal sites.

Simple incision and drainage to any swelling over the course of femoral vessels may lead to unexpected catastrophic bleeding or even circulatory shock and death.

So, any swelling around the great vessels in a well-known drug abuser should be considered as IFAP till

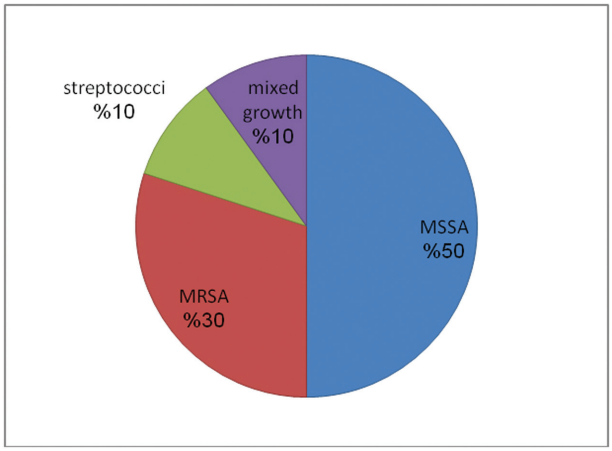
Table 1 Characteristics of male patients with infected femoral artery pseudoaneurysms related to parenteral drug abuse

Variables	Absolute frequency
Age (years)	
20 to <30	2
30 to <40	11
40 to <50	5
≥50	2
Presentation	
Painful pulsating swelling	15
Ruptured pseudoaneurysms (active bleeding)	4
Pus discharging sinus	4
Pain at the site of injection	1
Stump pressure (mmHg)	
20 to <30	1
30 to <40	0
40 to <50	4
50 to <60	3
≥60	12
Type of surgery	
Excision of aneurysms and ligation of femoral vessels	11
Transobturator bypass	9
Amputations required following	
Excision of aneurysms and ligation of femoral vessels	1
Transobturator bypass	8

Table 2 Results of intraoperative tissue culture and wall biopsy of femoral pseudoaneurysms

Culture results	Number of limbs (*n*=20)
Methicillin-sensitive staphylococcus aureus	10
Methicillin-resistant staphylococcus aureus	6
Streptococci	2
Mixed growth	2

Figure 6



Percentage of microorganisms found on the wound culture and sensitivity, wall biopsy, and blood culture.

proven otherwise. Urgent referral to a vascular surgeon for best management is mandatory [1].

High-quality evidence on the best management of IFAPs is still debatable. Clinicians should depend on several and multiple heterogeneous case series [6].

The use of SP as a predictor for ligation or reconstruction of IFAPs in the lower limb is lacking in the literature, and still considered as a debatable armamentarium; however, it has been used as a predictor for arterial sufficiency in the upper limb. This was obvious in a study carried out by Nunley *et al*. [6], where they used SP as a predictor of arterial sufficiency in arterial injuries of the forearm.

Moreover, SP is a reliable factor as a determinant for good hemispheric collateral circulation in case of ligation of internal carotid artery under certain conditions, for example, tumors of the carotid or high-lying carotid pseudoaneurysms [6].

Ehrnefeld *et al*. [7] recommended an internal carotid artery SP of less than 50 mmHg as the most reliable predictor of neurological outcome and selective shunting in patients undergoing carotid endarterectomy under general anesthesia.

Based on this point of view, we measured the SP in the SFA, following ligation in the current study to select which patient will benefit from revascularization as it is an important factor to predict the insufficiency of collateral blood flow. As the mean SP that is needed to salvage the lower limb is lacking in literature, we used a SP more than that used in cases that mandate ligation of the carotid artery as a baseline added by 10 mmHg, that is, 60 mmHg.

In the current study, eight cases with an SP of less than 60 mmHg underwent transobturator bypass from the start.

SP was at least 60 mmHg in 12 patients who underwent ligation without revascularization and only one patient suffered from acute ischemia following ligation of the femoral vessels to which transobturator bypass was done.

Seven patients out of eight with SP of less than 60 mmHg experienced limb loss and two patients out of 12 with SP of at least 60 mmHg had limb loss.

In the current study, nine (45%) patients are managed using extra-anatomic transobturator bypass through noninfected tissue planes with resulting high rate of infection (five patients out of nine cases, 55%).

Four patients out of the five with infected grafts had above-knee amputation following ligation of the bypass grafts.

Due to multifactorial reasons, that is, high virulence of organisms, septicemia in such patients and their tendency to reinject themselves at the graft sites, and the risk of graft reinfection is still not low and attention to methods of revascularization and wide debridement of the infected tissue planes should be in mind with a tissue culture performed to guide antibiotics therapy [8].

Failed revascularization due to graft occlusion was observed in three (33%) patients; two of them had above-knee amputation while the third one had a hip disarticulation.

One (11%) patient was complicated by secondary hemorrhage, ligation of extra-anatomical bypass graft and subsequent graft removal were carried on and the patient eventually had above-knee amputation.

In the current study, 11 cases from the start experienced ligation of the CFA, SFA, and profunda femoris artery with or without ligation of CFV and SFV with extensive tissue debridement.

On follow-up, nine (81.8%) patients had mild claudication, one (9%) patient had above-knee amputation, and one (9%) patient died from a secondary hemorrhage following ligation.

In comparison with a study conducted by McElroy *et al*. [9] on 60 cases, 12 cases underwent reconstructive surgery while 48 patients underwent ligation. Reconstructive surgery showed more postoperative complications on follow-up, (50% graft occlusion and 17% amputation above the knee versus 8% amputation rate after ligation). They concluded that in all cases, surgical management should include ligation of the aneurysm, debridement of necrotic tissue, and packing of the open wound to allow healing by secondary intention. At the time of surgery, the surgeon can select which patient will benefit from a reconstruction, based on the degree of the initial infection and the segment of the involved femoral artery.

However, their study included a large number of patients (60 vs. 20 patients in our study), but they

did not use the SP as a predictor to select which patient will benefit from revascularization. In our study, we reached the same conclusion evidenced by the use of a predicting factor like the SP measurement.

In comparison to a study done by Reddy *et al.* [10], on 54 patients with IFAPs who were managed surgically with 11% amputation rate and no mortality, 26 aneurysms were ligated and excised without further amputation.

However, of the 28 aneurysms involving the common femoral bifurcation, 18 required triple ligation and excision that led to six amputations. Six of the 28 aneurysms were reconstructed with autogenous saphenous vein grafts, three by prosthetic grafts, and one by primary anastomosis. No amputations were recorded following vascular reconstruction. However, all synthetic grafts eventually developed septic complications that mandated a graft removal [10].

They recommended ligation and excision for single artery segment aneurysms and immediate autogenous reconstruction for selected common femoral bifurcation lesions. This approach tends to be safe and may reduce the amputation rate and graft complication rates. Extensive uncontrollable wound sepsis may contraindicate revascularization. Under such circumstances, they estimated a 33% risk of amputation when the common femoral bifurcation is excised [10].

In the same study, other methods of revascularization were used namely, for example, primary repair, immediate autogenous interposition grafting which was not used in our study due to a high rate of infection.

However, primary repair of native vessels is usually thought to be the best choice if the infection is limited, it is not advocated by some surgeons due to extensive damage of the arterial wall which will lead to secondary hemorrhage [11].

Arora *et al.* [3] performed arterial ligation for six patients. There was no amputation rate recorded after the operation and the only complication was mild claudication experienced after 18 months.

In a study carried out by Cheng *et al.* [12], no significant difference in the amputation rate between the ligation and the delayed reconstruction operations (in cases of acute ischemia) and early reconstruction was observed.

On the other hand, Al-Zahrani *et al.* [13] recommended early reconstruction of all major vessels, when possible, based on the current advances both in the antibiotic industry and in vascular surgery. Consequently, they believed that reconstruction was the best method to save patient's limbs. However, long-term prognosis, in their experience, was poor and unpredictable.

Kaiser *et al.* [14] and Levi *et al.* [15] recommended reconstruction of vessels to manage an infected pseudoaneurysm due to the lower rate of postoperative claudication pain. These two studies had a low number of patients (two and eight, respectively).

Regarding the results of culture and sensitivity, in the current study, we found that 10 patients were positive for MSSA (50%); six patients were positive for MRSA (30%); two patients were positive for streptococci 10%; and two patients had mixed growth (10%) including pseudomonas aeruginosa and anaerobes.On follow-up, two (20%) patients out of 10 with MSSA infection had limb loss; five patients out of six with MRSA infection had limb loss (83, 3%); one patient out of two (50%) with streptococcal infection had limb loss; no limb loss was observed in patients with other mixed growth infection.

This may be attributed to the virulence of the organisms.

Albert *et al.* [16] obtained blood culture from 34 patients with infected femoral pseudoaneurysms, and found that 50% were positive for MSSA; 11.7% were positive for MRSA; 23.5% showed mixed growth; and 14.7% showed no growth. However, they did not point out a relation with the percentage of limb loss.

Finally, this study concludes that the best management of all IFAPs in recreational drug users is the ligation of the involved artery, the main complication in this group being intermittent claudication in nine patients which is more acceptable than complications like amputation and gangrene.

And this was consistent with the study done by Reddy *et al.* [10], who found that ligation and excision of the IFAP is safer and has reduced amputation and graft complications rates.

Ligation is good management for IFAPs because it is easy, cost-effective, and safe if the SP is more than 60 mmHg. Early reconstruction is not recommended, since there is an extended infection in the location of the pseudoaneurysm.

Moreover, infection of the artificial graft is also not uncommon.

Because of the recreational drug user's tendency to reuse femoral sites for further drug administration, the arterial reconstruction may be in jeopardy of recurrent infection. Consequently, ligation is a good management of IFAPs in recreational drug users.

Conclusion

SP measured in the SFA is a good indicator for the need of revascularization as it is an important factor to predict the insufficiency of collateral blood flow. Transobturator bypass using synthetic graft has high rate of complications in this study due to graft infection even if placed deep and away from the infected site due to several factors including septicemia affecting these patients and the high virulence of organisms.

Ligation is a good management for IFAPs because it is easy, cost-effective, and safe if the SP is more than 60 mmHg and because of the poor results of transobturator bypass in this group of patients and ligation should be done in a healthy segment of vessels that hold ligature to avoid secondary hemorrhage.

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Conflicts of interest
There are no conflicts of interest.

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