Feasibility and intermediate-term outcome of catheter-directed thrombolysis in management of acute nontraumatic viable and/or marginally threatened lower limb arterial thrombosis

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Introduction
Although catheter-directed thrombolysis (CDT) has been shown to be an effective method to salvage the ischemic limb resulting from acute thrombotic occlusion and bypass graft thrombosis, bleeding complications remain a major problem of this treatment.
Aims
To evaluate the success rate, the patency rate, the limb salvage rate, and possible complications of CDT therapy in patients presented with acute nontraumatic unilateral lower limb ischemia.
Patients and methods
CDT was offered to patients with acute lower limb ischemia (ALI) who presented to Vascular Surgery Emergency Department at Cairo University hospitals in the period between May 2018 and December 2018. We only included patients with unilateral ALI with viable or marginally threatened limbs (Rutherford class I and class IIa).
Results
During the period from May 2018 till December 2018, we received 20 patients (12 males and eight females) who were admitted with acute unilateral lower limb ischemia, in whom CDT was done. The mean age of patients was 54.25±9.2 years (range, 36–73 years). Complete thrombolysis had been achieved in 14 (70%) cases, whereas in six cases, it was unsuccessful (30%), of which three (15%) cases had incomplete thrombolysis and in the other three (15%) cases thrombolysis failed. Above-knee amputation had been carried out to one of the failed thrombolysis cases, representing 5% of the total number of patients. All cases with successful thrombolysis have achieved 6-month follow-up with patent treated arteries (patency rate, 100%). Two (10%) patients died during the period of follow-up, both of them had successful thrombolysis and died within the first 4 weeks owing to medical problems unrelated to thrombolysis procedure (cardiac problems).
Conclusion
Thrombolysis remains a safe and effective alternative to surgery for treating ALI.

Keywords:
acute lower limb ischemia, thrombolysis, tissue plasminogen activator

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Introduction

Acute lower limb ischemia (ALI) remains a challenge even with the recent advances in vascular surgery field over the past decade with still significantly high risk of limb loss and mortality. Currently, endovascular revascularization has appeared as a novel strategy in patients with ALI with a viable or marginally threatened limb (Rutherford class I and class IIa) [1]. Advantages of successful thrombus lysis include the ability for a more accurate localization of the underlying disease 'culprit lesion' by angiography, and thus, a more directed and potentially more definitive therapeutic approach [2]. Although catheter-directed thrombolysis (CDT) has been shown to be an effective method to salvage the ischemic limb resulting from acute thrombotic occlusion and bypass graft thrombosis, bleeding complications remain a major problem of this treatment [3].

Aim

This study was designed to evaluate the efficacy and safety of CDT by recombinant tissue plasminogen activator in patients with nontraumatic ALI. The aim was to evaluate the success rate, the patency rate, the limb salvage rate, and possible complications of CDT therapy in patients presented

with early stages of acute nontraumatic lower limb ischemia.

Patients and methods

CDT was offered to patients experiencing ALI who presented to Vascular Surgery Emergency Department at Cairo University hospitals in the period between May 2018 and December 2018. After obtaining an ethical approval from the local health authorities inside the hospital. The thrombolysis procedure with its possible complications, benefits, and risks and other alternative interventions were all explained to the patients and their relatives and a written informed consent was obtained. We only included patients with unilateral ALI with viable or marginally threatened limbs (Rutherford class I and class IIa) due to *in situ* acute thrombosis of an axial native artery distal to the aortic bifurcation, in-stent thrombosis, or infrainguinal bypass graft thrombosis. We excluded patients with nonviable or immediately threatened limbs (Rutherford class IIb and class III) and patients with ALI due to arterial embolism as detected from history (like sudden onset of ischemia pain, a known cardiac embolic source, past history of arterial embolism, and absence of prior history of intermittent claudication) or from clinical examination (like presence of atrial fibrillation or other types of cardiac arrhythmias, normal pulse, and Doppler examination in the unaffected limb).

We also excluded any patient with a known contraindication to thrombolytic therapy, such as patients with age more than 80 years, recent cerebrovascular insult within the last 2 months, active bleeding disorders, recent gastrointestinal bleeding (<10 days), head injury within the last 3 months, major surgery or trauma within the last 10 days, uncontrolled essential hypertension (>180 mmHg systolic or >110 mmHg diastolic), intracranial tumors, recent ocular surgery, hepatic cell failure (particularly those with hepatic coagulopathy), bacterial endocarditis, and pregnant patients. Being basically a feasibility study, our inclusion and exclusion criteria were largely based on the most recently available evidence from the current literature [4].

Preprocedure preparation

Arterial duplex scanning was done for all patients immediately after presentation to emergency department to confirm diagnosis, and patients were urgently admitted to undergo thrombolysis procedure on the next day. Therapeutic dose of parenteral anticoagulation (e.g. enoxaparin 1 mg/kg subcutaneous, twice daily) was started immediately after admission, and a loading dose of clopidogrel (300 mg) was given the night of the procedure.

The procedure

All procedures were done in the angiography suite of the Vascular Surgery Department. The patients were in the supine position, and both groins were prepared as usual using an antiseptic solution (povidone-iodine 10%), and then local anesthetic was given (lidocaine 2%). Based on the preprocedural duplex findings, femoral access was either ipsilateral antegrade (in lesions involving the mid to distal femoropopliteal arteries) or contralateral retrograde (in lesions of the iliac arteries, common femoral artery or proximal superficial femoral artery and in obese patients). A 6-Fr sheath (11 cm) was advanced and then systemic heparin administration with initial dose of 80 IU/kg through the sheath was given with further 5000 IU for every 1 h. Initial diagnostic angiography of the target limb was done using an appropriate 4 or 5 Fr catheter (e.g. Bernstein Catheter;, Cordis, Miami, Florida, USA). Delayed imaging up to 30 s with large contrast volumes was needed to opacify the tibial runoff vessels, which were classified based on angiographic findings into either cases with single run-off or cases with multiple run-offs. Once the occlusion was delineated, wire-traversal test was done by probing the occlusion with a soft floppy tip guide wire using a 0.035-inch 260-cm standard angled tip Terumo guide wire (Terumo Inc., Tokyo, Japan). If this standard workhorse guide wire traverses the thrombosed segment easily, then the clot is likely to respond well to thrombolysis. The guide wire was then advanced through the occluded part into a run-off vessel and then a multiside hole infusion catheter 4 or 5 Fr (according to vessel size) 90 cm length (like: Fountain infusion system with Squirt; Merit Medical Systems Inc., Malvern, Pennsylvania, USA), with an infusion segment length of 50 or 20 cm (according to occlusion length), was introduced over the guide wire, which was exchanged for the occluding wire that was provided with the infusion catheter (according to the manufacturer's instruction for use) to occlude the end hole of the catheter; therefore, the infused thrombolytic agent exited the catheter only through the infusion side holes (within the thrombus). Correct placement of the catheter and the occluding wire were checked angiographically. Sheath and infusion catheter were secured in position by skin silk sutures. We have used alteplase (Actilyse; Boehringer-Ingelheim, Ingelheim am Rhein, Germany) as the only thrombolytic agent in our study. Forceful injection

of an initial loading dose of the thrombolytic agent (10 ml) was then performed. After that, the patient was transferred to intermediate care unit where continuous thrombolytic injection was done using squirt pump or sometimes an electronic syringe pump at a rate of 1 ml/h over 24 h. Heparinized saline was infused in the side port of the introducer sheath at a rate of 500 IU/h using a syringe pump throughout the thrombolysis period. During CDT, the patients were kept in the intermediate care unit at the angiography suite and were constantly monitored for the following:

(1) Heart rate and blood pressure measurements (every 30 min).
(2) Frequent access site evaluation.
(3) Serial hemoglobin and hematocrit level assessment (every 3–4 h).

A completion angiography was then performed after 24 h for the following:

(1) To assess thrombus lysis status to determine the need for continuation or ending of thrombolytic therapy.
(2) To repositioning of the infusion catheter.
(3) To determine the culprit lesion and management by balloon angioplasty or stenting whenever needed.

Vessel recanalization was considered successful when direct noninterrupted contrast flow was obtained angiographically in the treated vessel. Patients were transferred to the in-patient wards after the end of thrombolysis procedure where the arterial sheath was routinely removed 2–6 h after last heparin dose, and digital compression was held proximal to the skin puncture site for 15–20 min. Mobilization was delayed for 6–12 h. On the next day after the thrombolysis, auxiliary procedures for foot care were done in the form of ulcer debridement, toe amputations, or foot wound dressings with administration of systemic culture-based antibiotic therapy as dictated by the clinical condition of each patient. Patients were discharged only after clinical improvements as evidenced by resolution of the limb ischemic symptoms with regain of pulse, local limb warmness, distal limb edema, disappearance of rest pain, and improvement of capillary refill with absence of any complication from the thrombolytic procedure like major bleeding requiring blood transfusion or surgery, intracranial hemorrhage, lower limb compartment syndrome, distal embolization, access site complications (bleeding or hematoma), or contrast-induced nephropathy. Follow-up duplex ultrasound assessment was routinely done before discharge to objectively document the arterial patency and improvements in ankle peak systolic velocities. Medications were prescribed to the patients including aspirin 150 mg/day for life, clopidogrel 75 mg/day for at least 6 weeks, and atorvastatin 20 mg once daily. Oral anticoagulation with vitamin K antagonists followed the short course of LMWH therapy and continued for a minimum of 6 months after discharge with necessary dose titration made to obtain international normalized ratio values of 2–3.

Follow-up protocol

Clinical follow-up was done once a week for the first 2 weeks and then on monthly basis for the next 6 months after the procedure. It included follow-up of pulse examination, Doppler flow signal, evaluation of the claudication pain and rest pain, evaluation of wound or amputation site healing, or resolution of infection.

Statistical analysis

The statistical methods that were used in this study included the range, the mean, and *P* level for statistical significance. Statistical workup was performed using MedCalc, version 15.8 (Medcalc Software, Ostend, Belgium).

Results

During the period from May 2018 till December 2018, CDT was offered to 20 patients (12 males and eight females) who were admitted in the Vascular Surgery Department in Kasr Al Aini teaching hospitals presenting with mild to moderate acute unilateral lower limb ischemia. The mean age of the patients was 54.25±9.2 years (range, 36–73 years). The demographic and clinical data for all patients are shown in Tables 1 and 2.

Patients were classified according to duration of the ALI symptoms into two groups: group A with symptoms duration less than 14 days, including 11 (55%) cases, and group B with symptoms duration more than 14 days, including nine (45%) cases. For group A, CDT was achieved in eight (72.73%) of 11

Table 1 Age and sex distribution

Sex	Age distribution		
	Number	Mean±SD	Percentage
Male	12	53.08±7.32	60
Female	8	56±11.24	40
Total	20	54.25±9.20	100

Table 2 Clinical and pathological features of patients

Clinical characteristic	*n* (%)
Diabetes mellitus	13 (65)
Hypertension	6 (30)
Ischemic heart disease	5 (25)
Smoking	12 (60)
Renal impairment	0
Previous history of claudication	16 (80)
Etiopathological causes of the acute limb ischemia	
Acute *in situ* thrombosis of a native axial artery	16 (80)
In-stent thrombosis	2 (10)
Thrombosis of infrainguinal bypass graft	2 (10)
The affected arterial segments	
Ilio-femoral segment	4 (20)
Femoro-popliteal segment	16 (80)

Table 3 The effect of acute limb ischemia duration on thrombolysis success

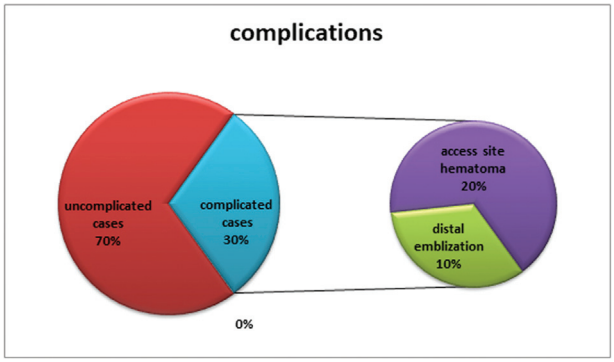
	<14 day		>14day
Complete thrombolysis			
n (%)	8/11 (72.73)		6/9 (66.67)
χ^2		0.55	
P		0.2	

χ^2, χ^2 test value.

patients, whereas for group B, complete thrombolysis was achieved in six (66.67%) of nine patients, and there was no statistically significant differences between the two groups ($P>0.2$), as shown in Table 3.

Complete thrombus removal had been achieved in 14 (70%) patients, whereas in six cases, it was unsuccessful (30%) of which three (15%) cases had incomplete thrombolysis, and in the other three (15%) cases, thrombolysis failed completely. Above-knee amputation had been carried out to one of the failed thrombolysis cases, representing 5% of the total number of patients. There was a statistically significant difference ($P<0.001$) between the numbers of successful cases compared with unsuccessful procedures. As for the three incomplete thrombolysis cases, in the first case, the target limb was clinically compensated, so the patient was continued on medical treatment; in the second case, popliteal embolectomy was done just after the incomplete thrombolysis procedure and pedal pulse was restored; and in the third patient, popliteal embolectomy was done one day after the procedure and pedal pulse was also restored. For the three failed thrombolysis cases, one patient underwent surgery for femoro-lower popliteal bypass that was carried out one day after the failed thrombolysis procedure and pedal pulse was restored after surgery, another patient underwent above-knee amputation one day after thrombolysis owing to distal embolization and

Figure 1



Complications rate during the study period.

muscle infarction, and the other patient had undergone surgery for femoro-upper popliteal bypass graft one day after the thrombolysis and pedal pulse was also restored. Wire-traversal test result was positive in 18 (90%) cases and was found negative in two (10%) cases. In patients with positive wire-traversal test result, 13 (72.22%) cases achieved complete thrombolysis whereas in patients with negative wire-traversal test, only one (50%) case achieved complete thrombolysis. As for the distal run-off vessels, 15 (75%) cases had single run-off and only five cases had multiple run-offs. In patients with single run-off, nine (60%) of 15 cases achieved complete thrombolysis, whereas in multiple run-offs patients, all cases achieved complete thrombolysis. Culprit lesion was found in 11 of 14 cases after complete thrombolysis, and all of them were managed by balloon angioplasty only without stenting. Regarding procedural complications, access site hematoma occurred in four (20%) patients, where none of them needed surgical intervention or blood transfusion, and distal embolization occurred in two (10%) patients, where one of them had undergone above-knee amputation, whereas the other patient had undergone surgery for popliteal embolectomy. We have not noticed any signs of contrast-induced nephropathy in any patient after intervention. There was neither major systemic bleeding nor a troublesome retroperitoneal hematoma encountered in any patient during the course of the study. Figure 1 shows the complications rate during the study period.

All cases with successful thrombolysis have achieved 6-month follow-up with patent treated arteries (patency rate: 100%). Two (10%) patients died during the period of follow-up; both of them had successful thrombolysis and died within the first 4 weeks owing to medical problems unrelated to thrombolysis procedure. Mortality rates during the study period are shown in Fig. 2. In 20 patients enrolled in the study, the actually ischemic lower limb was saved in 19 (95%) patients

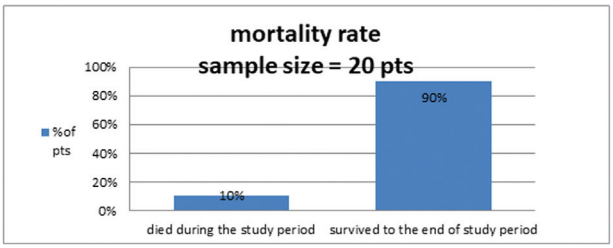
with above-knee amputation done for only one case owing to distal embolization, which occurred during the thrombolysis intervention. Figure 3 shows one of cases with successful thrombolysis.

Discussion

The 2007 Trans-Atlantic Inter Society Consensus revised consensus opinion defines ALI as any sudden decrease in limb perfusion that causes a potential threat to limb viability. In 1997, the Society for Vascular Surgery/International Society for Cardiovascular Surgery suggested a scoring system for ALI cases [1], which can be seen in Table 4.

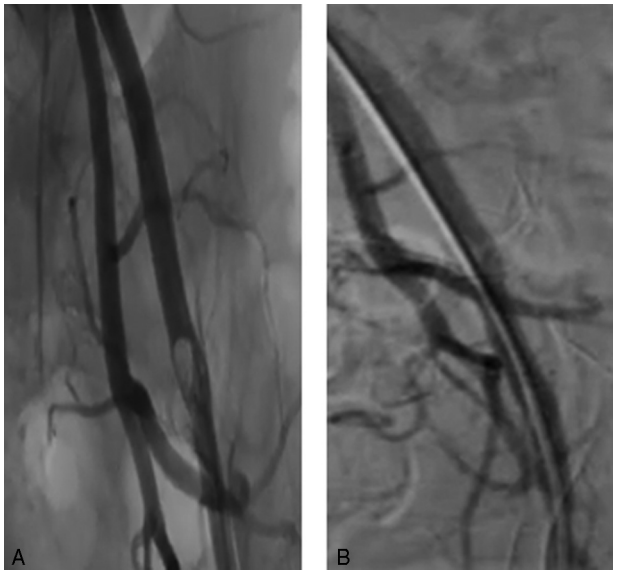
ALI can result from many underlying causes such as a sudden obstruction in the arterial flow to the extremity owing to arterial embolism or *in situ* intra-arterial thrombosis, bypass graft thrombosis, acute aortic dissection, popliteal artery entrapment syndrome, cystic adventitial disease, lower limb vascular trauma, phlegmasia cerulea dolens, ergotism, hypercoagulable states, and iatrogenic complications related to cardiac catheterization, or other endovascular procedures. Intra-aortic balloon pump, extracorporeal cardiac assistance, as well as vessel closure devices can also be potential causes for sudden decrease in arterial perfusion in the limb [6]. Embolic events result in a greater degree of ischemia than acute thrombosis [1]. The embolus usually lodges in the affected limb that is previously healthy with no prior collateral circulation; on the contrary, an *in situ* thrombosis occurs in vessels with prior, gradual atherosclerotic stenosis that has stimulated the formation of collateral vessels. The presence of these collateral channels helps to reduce the severity of acute ischemia symptoms when the atherosclerotic stenosis progresses to sudden total occlusion of the arterial segment [7]. Profound paralysis with complete loss of all sensations indicates an irreversible stage of ischemia, and the patient may be best treated with swift primary amputation [8]. Thrombotic occlusions can occur in any segment along the arterial tree of the lower extremities but most commonly involve the segment of superficial femoral artery [9]. Nowadays, with the recent decline of the incidence of cardiac valvular diseases from rheumatic fever, and with the growing use of oral vitamin K antagonists in patients suffering from atrial fibrillation, the proportion of ALI due to cardiac embolic sources has markedly declined [9].

Figure 2



The mortality rate during the study period.

Figure 3



(a) An initial angiography showing *in situ* thrombosis of the left external iliac artery in patient presenting with acute left lower limb ischemia. (b) The results after successful thrombolysis.

Table 4 Society for Vascular Surgery/International Society for Cardiovascular Surgery acute limb ischemia classification [5], 'modified from the classification of Rutherford *et al.* [1]'

Category	Suggested treatment	Sensation loss	Paralysis	Arterial Doppler	Venous Doppler
I	Not immediately threatened. Time to investigate	None	None	Audible	Audible
IIa	Prompt treatment need for salvage	Minimal (toe) or none	None	Often inaudible	Audible
IIb	Immediate treatment needed for salvage	More than toes associated with rest pain	Partial	Usually inaudible	Audible
III	Irreversible – primary amputation	Profound, anesthetic	Profound/ rigor	Inaudible	Inaudible

In the 1960s and the 1970s, balloon-catheter thrombectomy was first introduced by Fogarty, and since then, it had become the cornerstone of therapy for any patient with ALI [10]. In this study, we were aiming mainly to evaluate the efficacy of CDT for treatment of patients with ALI (Rutherford class I and class IIa). We have included 20 patients with either *in situ* acute thrombotic occlusion and infrainguinal bypass graft thrombosis. Technical success rate of 70% was achieved. In 2011, a study was conducted by Kashyap *et al*. [2], who reported a technical success rate of 82%. In another 2014 study by Byrne *et al.* [11], technical success rate was 78.3%.

There was no significant difference between technical success in our study and the other preceding similar studies [2,11–13], although our percentage was slightly lower than in the other studies which could be attributed to the small sample size. Technical failures were encountered in six (30%) cases, where surgical revascularization was needed in four cases, whereas in one patient, medical therapy in the form of anticoagulation was sufficient in preventing limb loss, and in the last case, amputation was inevitable. In the study by Kashyap *et al.* [2], technical failure was encountered in 23 (18%) cases, five cases underwent surgical revascularization, three cases continued on medical therapy in the form of anticoagulation which was sufficient in preventing limb loss, and early amputation was needed in 11 limbs. During our study, cases with technical failures were managed by subsequent surgical intervention, indicating that a failure of thrombolysis or unsatisfactory thrombolysis result does not necessarily prevent a successful surgical intervention or lead to amputation.

Regarding mortality rates, two patients died within the first month after the procedure (10%) owing to cardiac problems. In the study by Kashyap *et al.* [2], seven patients died during the first month after the thrombolysis (6%), where four of them died after they had an amputation for the target limb, whereas in Byrne *et al.* [11], the overall 30-day mortality rate was 4.8%, with systemic bleeding being the most common cause of early postprocedure mortality. In our study, death was mainly owing to medical problems not related to the thrombolysis itself, whereas in the other similar studies, it was directly related to the procedure [4,14,15]. Moreover, we have not encountered any major bleeding complications.

In predicting the success of thrombolysis therapy, much attention was directed toward the duration of the acute ischemia symptoms and its effect on the final outcome. It seems logical that a fresh thrombus will respond more favorably to thrombolytic therapy than an old thrombus. This concept was recognized by the initial findings of the STILE trial [16]. Patients with symptoms duration of less than 14 days, when treated with thrombolytic therapy, had lower rates of amputation, shorter hospital stays, and improved amputation-free survival at 6 month when compared with patients with relatively prolonged symptoms. Plate *et al.* [13] findings also support this conclusion.

In our study, according to duration of ALI, no statistically significant difference ($P>0.2$) was observed in outcome of thrombolysis when comparing between patient with symptoms less than 14 days and patients with symptoms more than 14 days. We have observed that patients with ALI symptoms lasting more than 14 days were excluded in other studies [2,11,12].

During our study, wire-traversal test result was objectively positive in 18 (90%) cases and negative in two (10%) cases. In cases with positive wire-traversal test result, 13 patients have achieved complete thrombolysis, representing 72.22%, whereas in cases with negative wire-traversal test result, only one patient achieved complete thrombolysis, representing 50%. We have noticed a significant increase ($P<0.001$) in the incidence of complete thrombolysis in patients with positive wire-traversal test result. Similarly, Plate *et al.* [13] realized a trend toward better thrombolysis effect with a positive wire-traversal test result; successful thrombolysis was observed in 80% of patients with positive wire-traversal test result versus 63% in those with negative wire-traversal test result. Moreover, a positive wire-traversal test result was found as indicative for successful thrombolysis in other recent similar studies [14].

Regarding complications that we encountered, four (20%) cases had access site hematoma; however, there were no major bleeding complications. Distal embolization and clot extension occurred in two (10%) patients: one of them had undergone amputation, whereas popliteal embolectomy was done to the other.

In the study by Kashyap *et al.* [2], the incidence of access site hematoma was 11% and of clinically relevant major systemic bleeding requiring transfusion was 8%, including one patient who developed intracranial hemorrhage, whereas in the study by Byrne *et al.* [11], the incidence of major systemic bleeding was

5.2%, being the most common known cause of 30-day mortality with distal arterial embolization occurring in ~6% of cases where adjunctive CDT and/or surgical management was required. We noticed that the incidence of access site hematoma in our patients was higher than other studies, despite the low rate of major bleeding complications compared with them. This could be attributed to the protocol for thrombolysis duration during our study, which did not exceed 24 h, whereas in other studies, they continued thrombolytic therapy for up to 3 days [2,11–13]. The main concern that has driven us to limit the infusion time to 24 h was to try to avoid the occurrence of a major systemic bleeding requiring blood transfusion, which could put the patients at risk. This was intended to produce the balance between achieving efficient lysis effect and avoiding the major bleeding complications to overcome the pitfalls that happened in the preceding studies and subsequently limited the widespread use of thrombolysis in ALI. The occurrence of groin hematomas was not considered a major bleeding complication if it did not require blood transfusion, caused pressure necrosis of the overlying skin, or persisted for more than 10–15 days after conservative treatment with or without secondary infection [4], problems which did not happen in any case in the study. Most similar studies in endovascular interventions consider groin hematomas directly related to inadequate manual compression after the procedure but not a direct complication from the procedure itself [4,14].

Our rate of early amputation was less than other studies because cases presented with profound ALI (Rutherford class IIB) were excluded, as they needed emergent surgical revascularization. In other studies, cases with profound ALI (Rutherford class IIB) were included as in Kashyap *et al.* [2] (8.5%) and Byrne *et al.* [11] (20.1%).

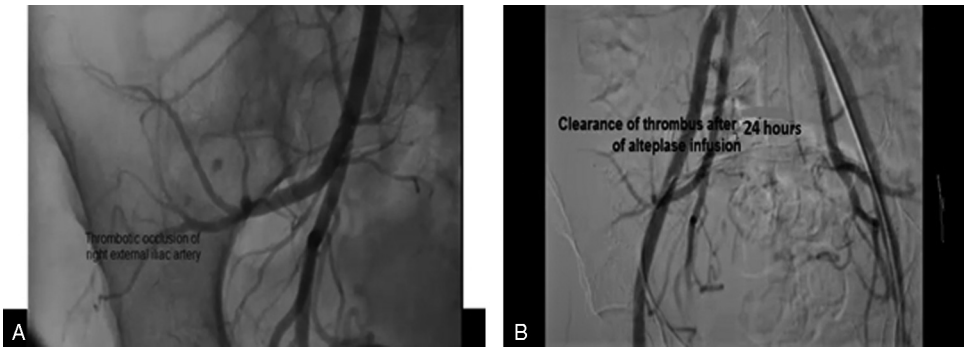
Over 6 months after the hospital discharge, patients were scheduled for follow-up at outpatient clinic to evaluate primary patency, and it was found that all patients with successful thrombolysis remained with patent treated arteries for the whole follow-up period. In the study by Byrne *et al.* [11], mean follow-up period was 15.2 months and the primary patency rate was 54 and 41% at 12 and 24 months, respectively, whereas in Kashyap *et al.* [2], primary patency rate at 12 and 24 months was 50.1 and 37.7%, respectively. We have achieved 95% limb salvage rate, whereas in Kashyap *et al.* [2], it was74.6% at 12 months and 68.8% at 24 months. However, because our follow-up period is relatively short compared with the others, we cannot compare our results with them.

In our study, we have used the CDT, but another recent novel method of thrombolysis is currently in use by other centers but not available at our institution at that time, which is the percutaneous mechanical thrombectomy. Percutaneous mechanical thrombectomy can be recommended in cases of ALI of Rutherford stage IIb who are at high surgical risk because CDT is time consuming intervention and could sometimes result in clinical deterioration and/or compartment syndrome [5]. Percutaneous mechanical thrombectomy is not recommended for the treatment of ALI involving the iliac, the common femoral, and the profunda femoris artery. The advantage of mechanical devices, however, lies in their ability to rapidly dissolve the major part of the thrombus with consequent reduction in the duration of limb ischemia and increase in the exposure of the residual thrombus and distal vessels to pharmacologic thrombolytic agents [5].

Another novel method in the way for endovascular management of ALI is the vacuum-assisted percutaneous aspiration thrombectomy with the Penumbra Indigo Mechanical Thrombectomy System (Penumbra, Alameda, California, USA). Recently published results from the multicenter PRISM study assessing the Indigo system (utility of a power aspiration-based extraction technique as an initial and secondary approach in the treatment of peripheral arterial thromboembolism: results of the multicenter PRISM trial XTRACT study) have showed that total or near total revascularization was achieved in 87.2% of patients immediately after the procedure [17].

This study faced several important limitations: first, the sample size was small, and second, the follow-up period was relatively short, as we found difficulty in conducting longer periods of follow-up owing to lack of patient compliance. The relatively small sample size is attributed to many reasons like the study was originally based as a feasibility study to assess possibility of CDT in some groups of patients with ALI and we did not mainly aimed to compare with other studies; the high costs of the procedure including the thrombolytic agents and the infusion catheter has limited the number included in the study in view of the limited available resources and absence of external funding; and lastly, the study was targeting primarily the patients with early-stage ALI, whereas most patients who presented to the

Figure 4



Thrombosis of the right external iliac artery that has been treated by catheter-directed thrombolysis showing clearance of the thrombus.

emergency department at our institution were actually in late stages (being a tertiary care and referral center) mostly owing to delay in timely diagnosis at the outside primary care centers. Even some patients diagnosed at our center refused to be included in the study for fear of complications of the thrombolytic agents after reading the consent form.

Figures 3 and 4 show some cases that have been treated by CDT technique. We believe that in the future studies, long-term follow-up for at least 24 months will be necessary to determine the real durability of this type of intervention, but at that stage, we wanted only to emphasize the feasibility of this technique in management of early stages of ALI, to be taken later on into consideration as an additional technique at our therapeutic armamentarium.

Conclusion

The results of this study reconfirm the recent concept that CDT can be a safe and effective alternative to surgery for treating ALI. Thrombolysis did not lead to a high rate of major systemic bleeding complications as often feared. Moreover, failure of catheter thrombolysis does not necessarily prevent a successful surgical intervention nor lead to amputation.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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