Failing arteriovenous access: endovascular option

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Objective
Hemodialysis access is considered the lifeline for patients with end-stage renal disease. So, maintaining it is extremely crucial for these patients. This study is designed to show the rule of percutaneous intervention to maintain their access.
Patients and methods
It is a prospective study conducted in Beni Suef University hospital from June 2016 to January 2018 on 20 patients with failing arteriovenous (AV) access. They were subjected to endovascular ballooning to relieve stenosis of their access and/or outflow vein. Efficacy, represented by technical success and clinical success, and complications of the procedure were assessed.
Results
The study revealed that 80% of the patients had technical success. However, 60% of the patients had their symptoms improved and succeeded to maintain their dialysis access. No major complications were attributed to the intervention. There was a strong association between lesions of total occlusion and technical failure.
Conclusion
Percutaneous treatment of dysfunctional or failing autologous dialysis fistulas can successfully and safely extend functional lifespan. Attention should be paid to lesions of total occlusion as they are difficult to cross and subsequently balloon dilatation.

Keywords:
dysfunctional arteriovenous access, endovascular, failing

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Introduction

Owing to the increasing prevalence of hypertension and diabetes, the number of patients with end-stage renal disease (ESRD) is steadily growing all over the world, with an estimated prevalence of 8–16% [1]. Patients with ESRD should be subjected to one of the following action to save their life: peritoneal dialysis (6.4%), renal transplant (29.3%), and hemodialysis (HD) (64.2%) [2]. Therefore, most patients with ESRD depend on maintenance HD to maintain their life. A well-functioning dialysis vascular access (VA) is essential to provide adequate dialysis treatment. However, creating a long-living dialysis access is considered a challenge [3]. Therefore, VA for HD patient has been considered to be their lifeline [4]. Three types of HD VA are currently known: native arteriovenous fistulas (AVF), arteriovenous (AV) grafts, and central venous catheters [5]. Native (autologous) AVFs are recommended as first-line VA in all guidelines [6]. It remains the gold standard as it has lower morbidity and mortality in addition to lower costs and prolonged longevity [5]. With endovascular era, salvage failing AVF or graft via endovascular procedure is a new option to prolong their longevity and maintain their function. The current study is designed to test the efficacy of percutaneous transluminal angioplasty (PTA) in salvage of AV HD access, detection of complications that may be associated with this intervention, and detection of variables that would influence the outcome of endovascular intervention for failing AVFs.

Patients and methods

This was a prospective study conducted on 20 patients in Beni Suef University hospital from June 2016 to January 2018. It included 20 patients with ESRD already on regular HD and presented with failing AVF. Follow-up was maintained for 6 months after intervention. Patients included in this study were subjected to PTA to salvage their failing AVFs.

Inclusion criteria

Patients enrolled into this study were patients with dysfunctional AV access as evidenced by one or more of the following clinical criteria and verified by presence of duplex hemodynamically significant stenosis or

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occlusion: decreased or absent thrill and increased pulsatility over the fistula, difficulty in cannulation, ipsilateral arm edema and/or collateral venous pathways suggestive of a central venous stenosis, high venous pressure during dialysis or prolonged needle sites bleeding after dialysis, development of persistent marked limb swelling, and decreased HD flow rate in accordance with the protocol appropriate for the specific type of HD machine.

Exclusion criteria

The following were the exclusion criteria: the presence of cellulitis overlying the VA or evidence of infection within the graft or native fistula, a stenosis associated with a newly created AV access (<30 days), a stenosis associated with a pseudoaneurysm, patients having severe allergy to contrast agents, and patients with huge aneurysmal dilatation or showing signs of impending rupture (skin changes).

Ethical considerations

The study was approved by the ethical committee of the Faculty of Medicine, Beni Suef University. The participants were informed of the purpose of the study and its consequences and confirmed of the confidentiality of data before taking a written consent.

Clinical examination, demography, and comorbidities

Demographic and clinical data including age, sex, and the presence of other medical comorbidities were obtained. The upper limb was inspected for scars of previous access operations, aneurysmal dilatation, perivenous hematoma, and for edema and dilated veins on the shoulder and the chest wall, indicating central venous occlusion or stenosis. The AVF was evaluated for quality and propagation of thrill over it, the presence of aneurysmal dilatation, status of the overlying skin, and the presence of external compression by hematoma.

Duplex examination

Duplex scan protocol was implemented for each patient including the anastomotic site, visualization of the feeding artery from the level of the subclavian artery down to the radial and ulnar arteries, and the draining vein up to the level of subclavian and innominate veins, including the perivascular space for compressing or communicating hematoma. Doppler/duplex also gave an idea about the peak systolic velocity across the stenotic lesions (the peak systolic velocity at and before the location of any narrowed areas). If the peak systolic velocity ratio was three times or more, it indicates significant stenosis. A stenosis was also considered significant if the PSV was greater than 375 cm/s or narrowing of 50% or more of the diameter at gray scale (B-mode).

Standard technique

The procedure was performed under local anesthesia of the puncture site (2% lidocaine hydrochloride). An appropriately sized radial sheath (usually 6 F) is advanced over a guide wire into either the venous or arterial limb of the fistula. Transradial access is the accepted access in this study (the radial artery should be punctured at least 2–3 cm distal to the venous anastomosis to allow sufficient distance for sheath insertion and anastomotic interventions). However, some cases were done using the transvenous access. Heparin (5000 IU) was given. A diagnostic angiography was performed. A guide wire is then passed through the sheath and is advanced up to the level of the central veins. Usually a 260-cm 0.035-angled hydrophilic guide wire was introduced through the sheath over a 5- or 4-French selective Bern catheter. Crossing the lesion is aided by both catheter-wire manipulation and external arterial or venous digital compression. A 6.0–8.0-mm balloon is introduced till the site of the lesion and then inflated on a high pressure up to 6–14 atm several times, usually for 3–5 min at a time until the stricture is dilated. Difficulties to dilate the lesion were overcome by using a higher pressure balloon or noncompliant balloon, longer duration of inflation, aided by compression from outside, changing the balloon site, and using shorter balloon. Fistulogram is done till the central veins to ensure the patency and to exclude any residual stenosis. In cases of residual stenosis, repeat the dilatation using high-pressure inflation and long duration. Removal of the sheath at the end of the procedure followed by manual compression was done.

Interventional data were reviewed and recorded, including technical success and major intraoperative complications.

Postintervention complications were reviewed and recorded to assign possible postoperative complications.

Postinterventional surveillance and medications

Patients were advised to come for follow-up visits, including physical examination and duplex scan if required to evaluate the anatomy and hemodynamic status of the fistula in outpatient clinic weekly to ensure that the fistula is well functioning. More frequent visits might be asked if needed. Postinterventional medications included low-dose aspirin 75–150 mg/day (ASA) and oral antibiotic tablets.

Assessment guidelines

Primary end point included technical success (anatomical success), which is restoration of at least more that 70% of lumen diameter, and clinical or functional success, which is improving the fistula function (hemodynamic parameters) and disappearance of limb abnormalities attributed to fistula dysfunction. Secondary end point included complications related to the intervention done.

Statistical analysis

Analysis of data was performed using SPSS 17 (statistical package for scientific studies; SPSS Inc., Chicago, Illinois, USA) for Windows. Description of quantitative variables was in the form of mean, SD, whereas description of qualitative variables was in the form of numbers and percentage. Data were explored for normality using Kolmogorov–Smirnov test of normality. Comparison between qualitative variables was carried out by χ^2-test. Fisher's exact test was used instead of χ^2-test when one expected cell or more were less than or equal to 5. Binary correlation was carried out by Pearson's correlation test. Results were expressed in the form of correlation coefficient (r) and P values. All statistical tests were performed at a significance level of 5% (P=0.05).

Results

A total of 20 patients with ESRD were subjected to the study. According to age, the mean age of patients was 51.5±3.5 years, with a range of 53 years and a minimum of 30 years and a maximum of 83 years. Other demographic features are presented in the Table 1.

Table 1 The demographic features of the patients

	n (%)
Age	51.5±3.5
Sex	
Male	14 (70)
Female	6 (30)
Hypertensive	12 (60)
Diabetes	4 (20)
Valvular heart disease	4 (20)

Table 2 The characteristics of fistula

	n (%)
Type of AVF	
Brachiocephalic	8 (40)
Radiocephalic	6 (30)
Brachiobasilic	6 (30)
Age of fistula	
>1 year	16 (80)
<1 year	4 (20)
Side of AVF	
Right	6 (30)
Left	14 (70)

AVF, arteriovenous fistulas.

The characteristics of fistula are shown in Table 2 as follows:

Presentation

The main presenting feature of the dysfunctional AV access was demonstrated. However, a lot of patients presented with more than one group of manifestations that occur simultaneously. In this study, 20% of patients (n=4) had upper limb edema with pain on dialysis, 10% of patients (n=2) had persistent bleeding following vein puncture and 70% of patients (n=14) had insufficient dialysis as shown in Table 3.

Types of lesion

In this study, access stenoses were found in 80% of patients (n=16), and total occlusion was found in 20% of cases (n=4) (Figs 1–11).

Table 3 Presentation of the patient

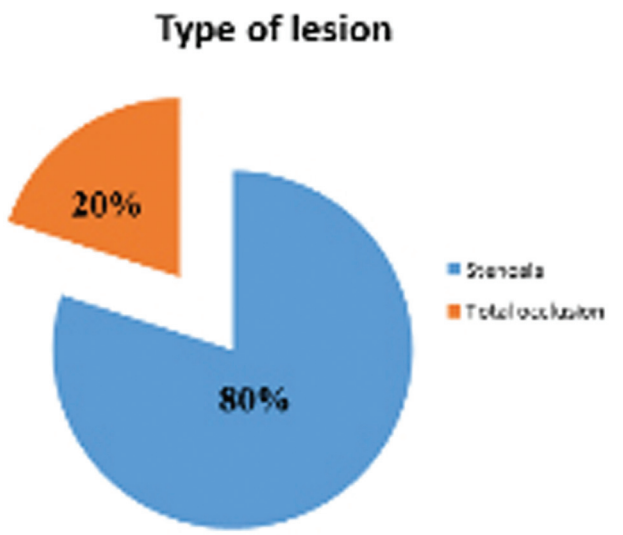
Presentation	*n* (%)
UL edema with pain on dialysis	4 (20)
Persistent bleeding following vein puncture	2 (10)
Insufficient dialysis	14 (70)

UL, upper limb.

Figure 1

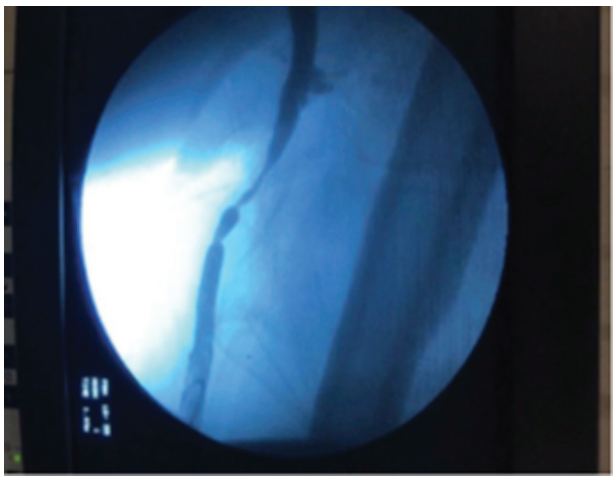
A case of upper limb edema.

Figure 2



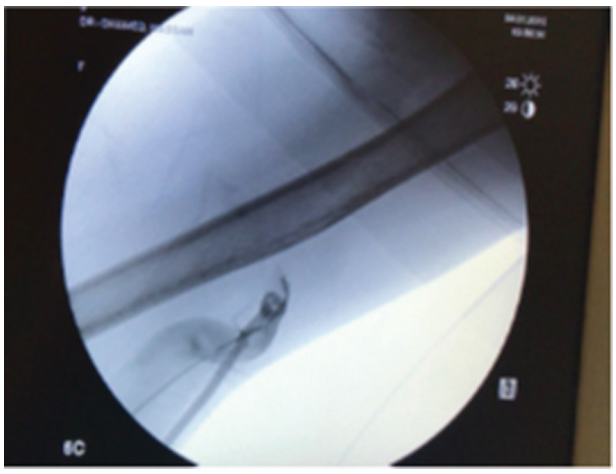
Distribution of type of lesions of arteriovenous fistulas.

Figure 3



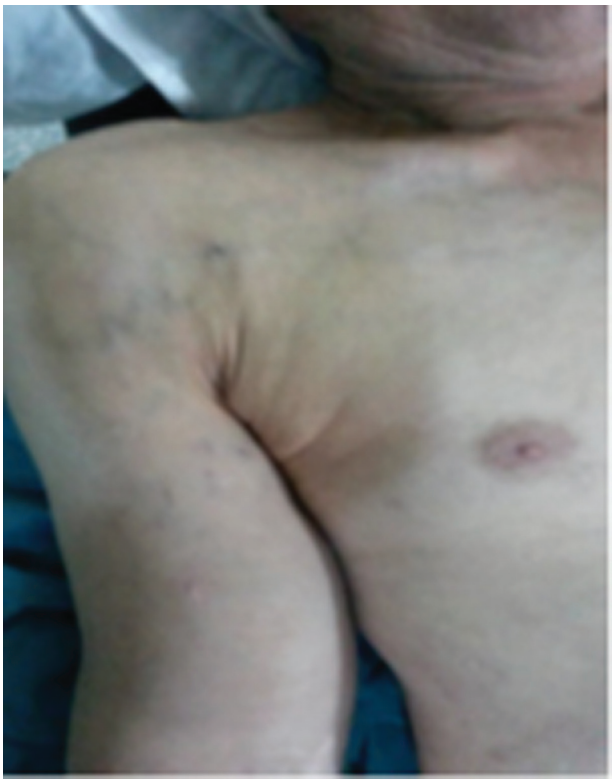
Stenotic lesion at basilic vein.

Figure 4



Totally occluded cephalic vein.

Figure 5



Dilated tortuous chest wall veins as an indicator of central venous lesion.

Site of stenosis

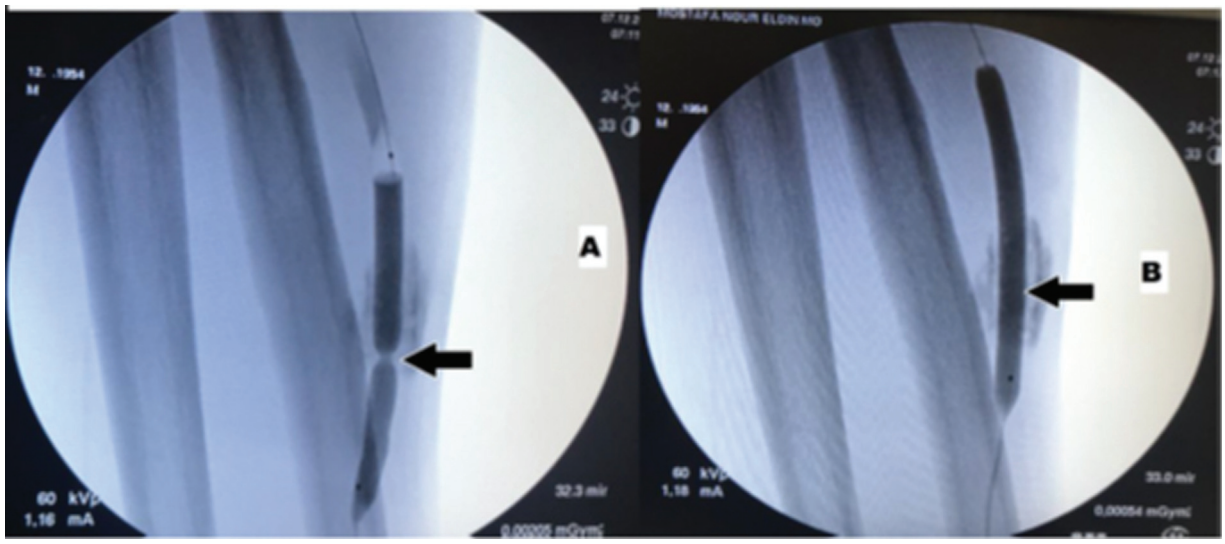
In this study, regarding site of stenosis, 40% of patients (*n*=8) had Juxta-anastmotic stenosis, 50% of patients (*n*=10) had needling segment stenosis, and 10% of patients (*n*=2) had central vein stenosis:

(1) Intervention:all cases were underwent percutaneous transluminal balloon angioplasty.
(2) Endovascular access in this study was done in 20% of patients (*n*=4) via transvenous access and 80% of patients (*n*=16) through transradial access.

Outcome

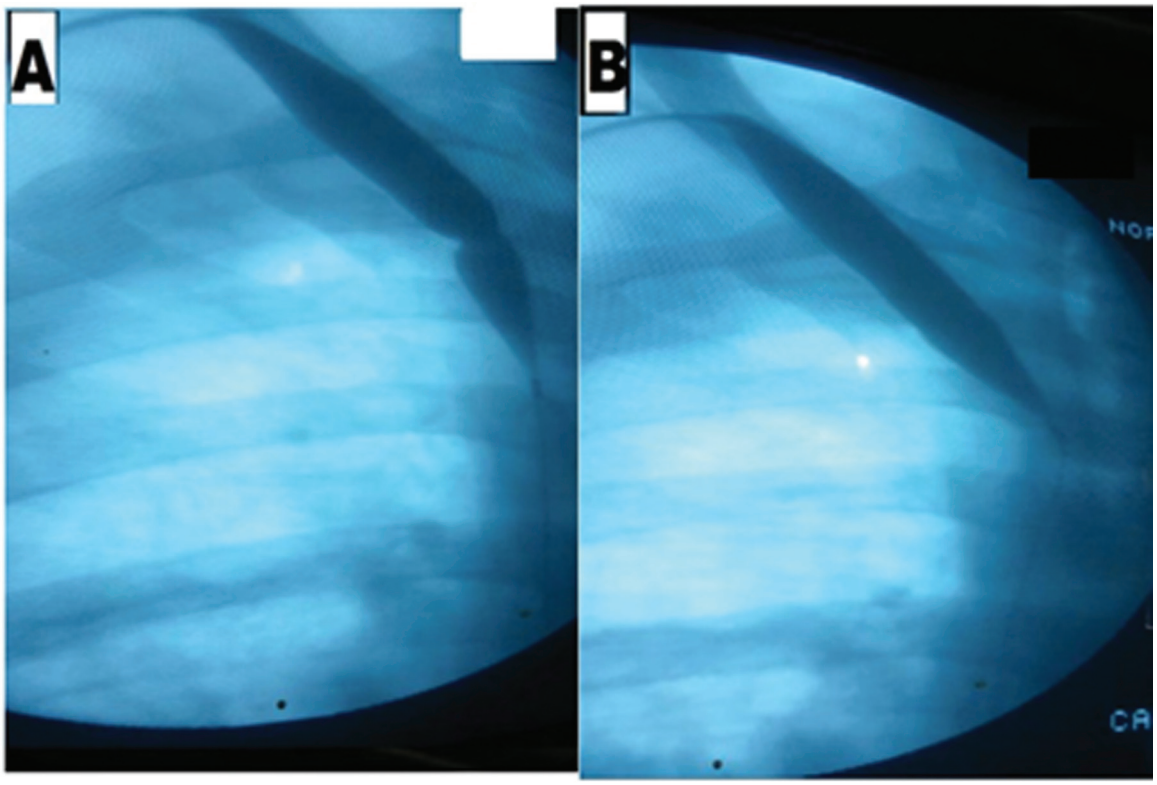
(1) Technical success: in this study, 80% of patients (*n*=16) had technical success and 20% of patients (*n*=4) had failed technical success.
(2) Clinical success: in this study, 60% of patients (*n*=14) had clinical success and 40% of patients (*n*=6) had failed clinical success.
(3) Complications: regarding the type of complications, 20% of patients (*n*=4) had minor venous perforation with extravasation of contrast.
(4) Correlation between variables and outcome: statistically, a correlation between different variables and outcome was done to show any association. At the end, the following were

Figure 6



Balloon angioplastic dilatation of stenosed needling segment of arteriovenous fistulas. (a) Wasting of balloon at stenotic segment while (b) its dilatation.

Figure 7



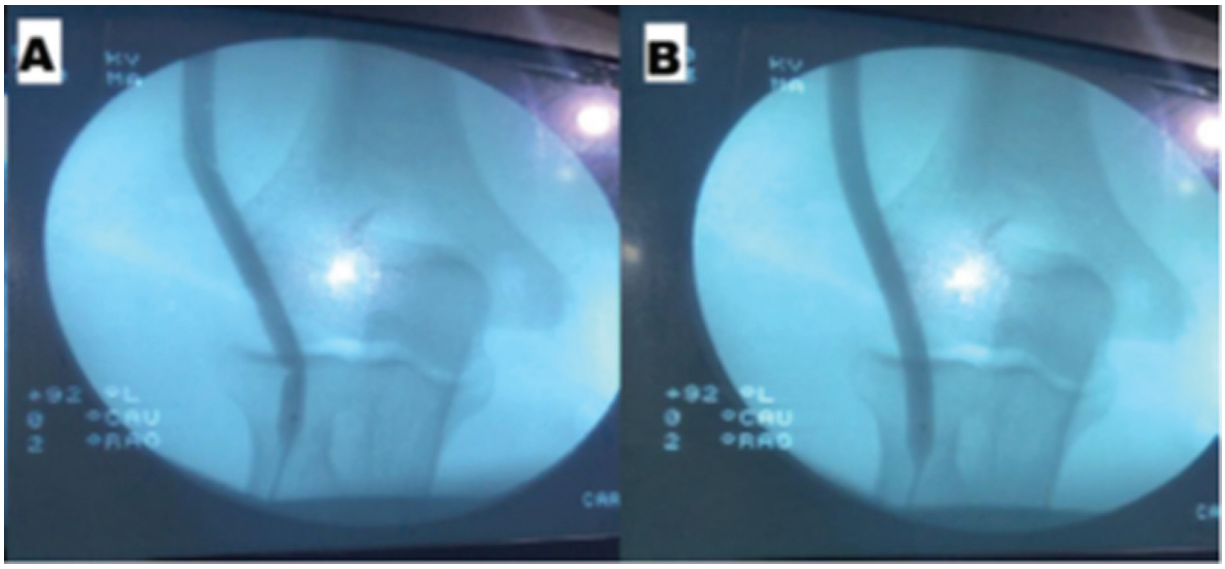
Balloon angioplastic dilatation of stenosed central vein. (a) Wasting of balloon at stenotic segment while (b) its dilatation.

concluded: there is a nonsignificant difference or correlation between outcome (including technical success, clinical success, and complications) and patients' variables. There is a significant association between type of lesion and technical success (P=0.000). There is a significant association between type of lesion and clinical success (P=0.001).

Discussion

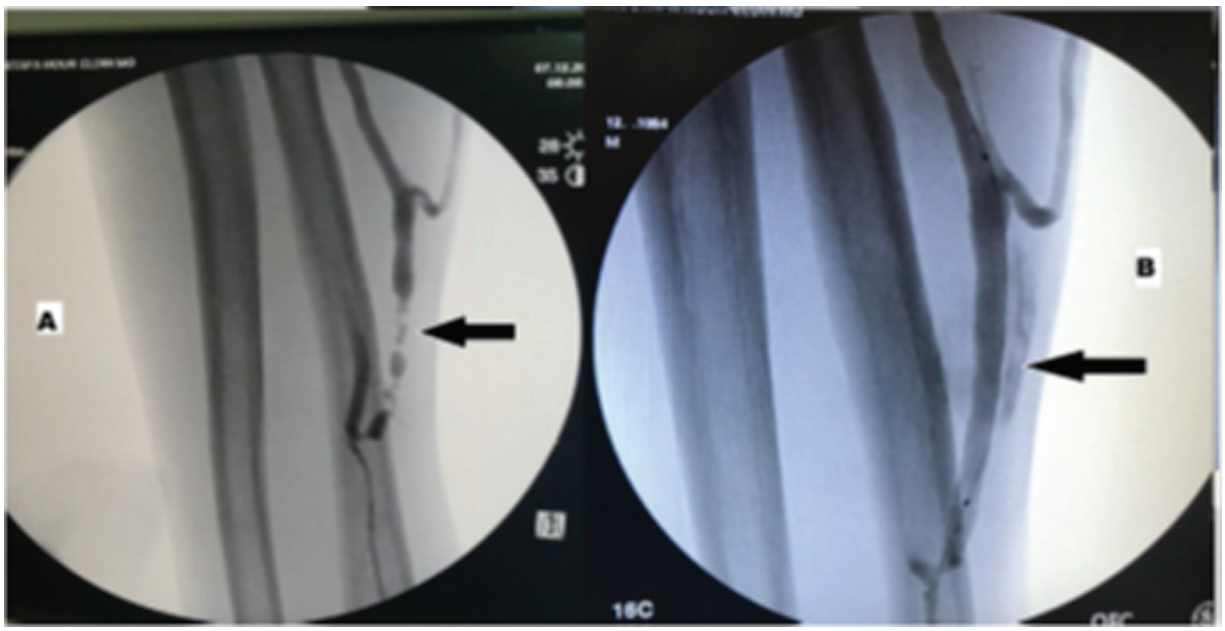
The increasing number of patients with ESRD made the need for reliable VA essential [7]. Therefore, a well-functioning and reliable VA is referred to as the lifeline for these patients [8]. However, dysfunctional dialysis access is threatening and alarming for incoming fistula failure [9]. Therefore, during the past 15 years,

Figure 8



Balloon angioplastic dilatation of stenosed needling segment of arteriovenous fistulas. (a) Wasting of balloon at stenotic segment while (b) shows its dilatation.

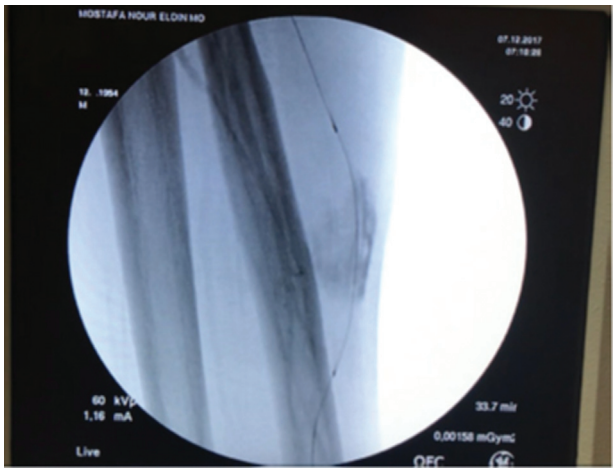
Figure 9



Technical success in dilating juxts anastomotic arteriovenous fistulas stenosis. (a) The lesion while (b) postinterventional angiography. Arrows point to site of lesion.

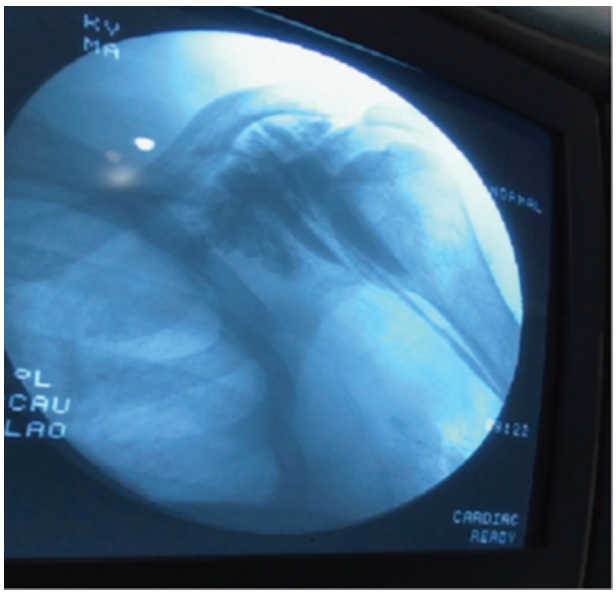
endovascular techniques have been developed for treating and salvaging AVF stenosis [10]. It was supposed that PTA is a safe and effective procedure for treatment of dialysis fistula dysfunction, which prolongs the lifespan of the fistula [9]. A prospective study was designed to show the efficacy and safety of PTA in salvage of AV HD access, as well as detection of complications that may be associated with this intervention and detection of variables that would influence the outcome of PTA for failing AVFs. Reviewing these results shows that PTA is an effective method for salvage of dysfunctional AVF. However, there are some predictors of poor outcome after PTA listed as type of lesions. It is proved that total occlusion of the AVF circuit is a strong indicator of PTA failure technically and clinically. Regarding procedural complications, the results show that complications during PTA occurred in 20% of patients (n=4) who had minor venous perforation with extravasation of contrast, which were self-

Figure 10



Extravasation of contrast at cephalic vein owing to minor perforation.

Figure 11



Extravasation of contrast at level of axillary vein owing to minor perforation.

limited with no need for intervention. Moreover, the results showed no association between patient's variables and complications. Concerning the outcome of our procedure, we discussed it as immediate technical success during the intervention and clinical success after PTA with follow-up of each patient for one year. We also considered intervention complications as an outcome parameter. Similarly, Le *et al*. [11] and also Reffat and Hussein [12] considered postintervention outcome to be technical and clinical success and also periprocedural complications. However, Reffat and Hussein [12] had performed a follow-up for 3 months after intervention and Le *et al*. [11] had a mean follow-up of 14.6±11.4 months after intervention. Moreover, Heye *et al*. [13], Aktas *et al*. [14], and Kim *et al*. [15] considered postintervention outcome to be technical and clinical success and also periprocedural complications. The follow-up period was of 3 years, and also they analyzed patency as primary, secondary, and assisted primary patency [13–15]. Regarding patients' characteristics, we found that patients' variables (age, sex, presentation, and comorbidities) are not associated with technical success. Similarly, Heye *et al*. [13], Aktas *et al*. [14], and Reffat and Hussein [12] agreed with our results that patient's variables are not associated with technical success. By contrast, Le and colleagues and Kim and colleagues did not analyze patient's variables with technical success [11–15]. Regarding AVF characteristics, we found that AVF variables (age of fistula, side, type of AVF, and type of lesion) are nonsignificantly associated with technical success. However, there is a marked statistical association between total occlusion and technical success and subsequently clinical success (P=0.000 and 0.001, respectively), with all the four cases presented with totally occluded venous segment had procedural failure. Heye *et al*. [13] and Aktas *et al*. [14] also found that the initial grade of stenosis was inversely proportional to the technical success which means that there was a linear effect of the initial stenosis grade on the technical success: the higher the stenosis grade, the smaller the success probability (P=0.044 and 0.039, respectively) [13,14]. Concerning the role of PTA in salvage failing AFV, our outcome parameters show that technical success was 80% (n=16) and clinical success was 60% (n=14). However, our technical success was close to the results of Heye *et al*. (84.4%) [13]. In contrast, Aktas *et al*. [14] had technical success of 96.3% of overall stenosis (without occlusion) and first-year patency rate of 84.7%. In addition, Reffat and Hussein had technical success of 93.8%, whereas clinical success and 3-month patency was 81.3% of cases. Moreover, Le and colleagues had technical success of 88% and clinical success and 1-year patency of 83% of cases [11,12]. These variations in patency might be owing to having included larger patient groups and patients with nonmatured AVF to assist their maturation. In this study, patients who had synthetic dialysis, composite grafts, or autogenous fistulas that were already thrombosed for a long period were excluded from our study. All interventions were done by the same team members in our facility with the same equipment and angiosuite. Data were collected in a prospective manner and analyzed in a limited time frame. Patients were followed for 1 year to ensure patency of their access and its clinical improvement. However, this study had important limitations that

should be known: the absence of a control group and the relatively small number of patients. However, making a control group for these patients is very difficult, as there is no standard agreed upon treatment modality, except for creation of a new access. Based on the relatively small sample size of the study cohort, this study likely may not detect the effect of certain risk factors and procedural characteristics on outcome. In addition, most lesions were peripherally situated, with only two cases with central vein stenosis. Furthermore, the anatomical variables (degree and length of stenosis) that could be associated with post-PTA patency were not assessed. Technical failure is associated with total occlusion of the outflow access vein. However, the thrill was also preserved owing to the presence of small collateral vein not amenable to intervention. So, further patient selection should pay attention to the original path of the outflow vein and not only preserved thrill to predict technical difficulties and outcome. On the contrary, Heye and colleagues, Aktas and colleagues, Le and colleagues, and Kim and colleagues had limitation regarding their studies of being retrospective in design. Patients were referred from various centers, making follow-up difficult. Because of the retrospective nature, there were no well-defined criteria for the abandonment of VA and any flow data associated with post-PTA patency in these studies. Therefore, there might be selection bias in these cohorts, as the decision to no longer proceed with PTA differed according to the preference of the surgeon, remaining HD VA options, and relative risks and benefits of additional PTA and new surgical access creation [11–14]. Although Reffat and Hussein [12] did their study in a prospective manner, they had a limitation of small number of cases, and they did not analyze the effect of patients' variables on clinical success. In addition, they had a short time period of follow-up [12]. After all, technical success of PTA in HD AVF is influenced by the initial grade of stenosis and the presence or absence of total occlusion at any point of AVF circuit. However, we recommend further studies with increased number of patients for better assessment of clinical and anatomical variables, as well as divide lesions and types of dialysis access into subgroups to assess the influence of PTA on each group, and finally make use of newly developed equipment to salvage and overcome total occlusive lesions.

Conclusion

Percutaneous management of dysfunctional or failing autologous dialysis fistulas can successfully and safely extend functional lifespan. A substantial improvement in patency through additional interventions illustrates the need for close surveillance in these patients. In our study, the variables examined, which included location of stenosis, age of fistula before first intervention, and diabetes, did not influence the clinical success outcome. Technical failure is associated with total occlusive lesion of AVF.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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