Short-term results of percutaneous transluminal balloon angioplasty for a failing brachial arteriovenous fistula

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Purpose
The purpose of this paper is to review short-term results of percutaneous transluminal angioplasty (PTA) in treating a failing brachial arteriovenous access (AVF) in terms of safety, durability, and efficacy.
Patients and methods
This study was performed on 20 patients (12 men and 8 women). Full history taking, examination, and risk factors identification were performed. Fistulogram was done using a radial sheath to detect site and number of the stenotic segments, and accordingly appropriate balloon size was selected for treating the diseased segment(s). Outcome of the procedure was assessed by success rate (clinically, technically, and angiographyically) and so primary patency rate was measured. Also, all complications were registered during follow-up period of 6 months.
Results
Success rate (1ry patency) of AVF during the follow-up period was 90% in the first 2 days then decreased to 65% 6 months after the procedure, due to restenosis or occlusion. Regarding complications, one patient (5%) had an infected AVF that was ligated as it was beyond salvage, two patients (10%) had puncture site hematoma that was treated conservatively with good outcome, rupture AVF in one patient (5%) that was treated by AVF ligation (rupture at body of the AVF), and immediate thrombosis and inability to cross the site of tight stenosis or near total occlusion in one patients (5%) that led to immediate failure of the procedure (PTA). It was also observed that the success rate (1ry patency) tends to decrease in patients older than 60 years and in diabetic patients. This correlation was statistically significant (*P* value=0.017).
Conclusion
Patency of AVF can be maintained with continuous monitoring and follow-up. PTA for a failing AVF is an effective and safe mode of treatment with no need for temporary hemodialysis catheters insertion or creation of surgical wounds with its morbidities.

Keywords:
ESRD, failing arteriovenous fistula, percutaneous transluminal angioplasty

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Introduction

Good vascular access with high blood flow rates is the main modality for renal replacement therapy. The native arteriovenous fistula (AVF) is superior to grafts and catheters in terms of patency and lower complications rates [1]. Both AVF and arteriovenous graft (AVG) are essential for patients with end-stage renal failure (ESRD) on hemodialysis. AVF are the preferred one due to its longer patency rates. But sometimes AVG are the only feasible option in an elderly patient with no suitable veins [2,3].

Despite advantages of AVF over AVG using PTFE grafts, both types of accesses fail and lead to multiple hospital admissions for radiological and surgical interventions. Significant stenosis of the access is a frequent complication that requires multiple times of percutaneous transluminal angioplasty (PTA) to maintain access patency [2,4–6].

Because of the limited access sites for AVF creation and the relatively increased life expectancy of patients with ESRD, the old concept of forgetting a failing access and insertion of a temporary catheter till performing a new access had been changed.

The Dialysis Outcomes Quality Initiative (DOQI) guidelines recommend early detection and treatment of all hemodynamically significant fistula stenosis, both to avoid usage of a temporary catheter with all its complications and drawbacks and to extend the life span of each access as long as possible [7,8].

Usually, hemodialysis accesses are liable to failure due to thrombosis in the outflow vein or over/near the anastomosis, which necessitates semiemergent procedures but the overall outcome is unfavorable. So prophylactic interventions to treat hemodynamic problems to prolong access patency are crucial [9–11].

There are two types of access failure. One is early failure that occurs in access that fails to mature or fails within 3 months from starting dialysis. The other type is the late failure that occurs lately after 3 months from access construction or usage [12,13].

Many varieties of endovascular interventions include combination of venous and/or arterial angioplasty. Successful fistula maturation can be achieved in up to 92% of patients. Treatment of discrete stenotic lesions with PTA is the most apparent intervention that would be expected to increase fistula flow rates and leads to successful maturation [12,13].

This is a prospective study that aims to review the early results of endovascular intervention (PTA) for preservation of a failing brachial AVF.

Patients

After taking a written consent from patients approved by the ethical committee, 20 patients were enrolled in this study (12 men and 8 women). These patients were admitted in Aswan University Hospital and other vascular centers in Egypt in the period between January 2017 and January 2019. All patients had ESRD and were on regular dialysis.

Inclusion criteria

(1) Significant stenosis in the outflow vein more than 50% by duplex examination with no central venous stenosis.
(2) Weak thrill after 6 weeks from creation of the fistula that was examined clinically with nonmaturation of the fistula.
(3) Low flow through fistula on dialysis defined by KDOQI guidelines (access flow less than 600 ml/min or less than 1000 ml/min with a more than 25% decrease over a 4-month period.

Exclusion criteria

(1) Thrombosed fistula either primary (after creation of the fistula and before its use on dialysis) or thrombosis later after many dialysis sessions.
(2) Infected fistula.
(3) Aneuryismal dilation over the body of the fistula or over the outflow vein especially if there is skin change.
(4) Elderly patients more than 80 years old and patients with hypotension during dialysis sessions.
(5) Patients with allergy to contrast agent or patient refusal to enter the study.

Methods

Our patients were submitted to history taking including time of starting dialysis, duration of ESRD, cause of renal failure, history of any medical problems such as cardiac or chest diseases, diabetes, hypertension, smoking, allergy to dye, and history of any previous accesses before this access (its site and cause of its failure).

Examination includes full body examination and detailed examination for upper limb and access by feeling its distal pulsations, thrill over the body of the brachial AVF and over the draining vein, presence of infection, or skin changes over the AVF or over the draining vein.

Investigations

(1) Laboratory investigations that include complete blood picture, urea, creatinine, serum sodium and potassium, prothrombin time, international normalized ratio (INR), and fasting blood sugar.
(2) Radiological investigation done by radiologist that includes detailed duplex examination for this shunt including flow rates through shunt, presence of any stenosis either in artery near the AVF or anastomotic or in the draining vein with precise measuring of its diameter and its length.

Endovascular procedure

All procedures were performed in the angio-suite. Local anesthesia was given using xylocaine 2% at site of puncture. Radial artery access was used in most of the patients using a radial sheath or micropuncture set and 5000 IU of unfractionated heparin was injected through the sheath then flushed with normal saline, then the brachial AVF was imaged retrogradely through the radial sheath with detection of any stenosis in the brachial artery or in the anastomosis or in the draining vein or central veins. Technique of the procedure: after having the radial access, a hydrophilic 0.035 terumo wire was introduced through the sheath and advanced near the AVF,

then a guiding catheter (Bern) 5 French was introduced over the wire. The wire was removed and a fistulogram was made using a dye. All data including site and number of the stenotic segments were collected from fistulogram and accordingly appropriate balloon size was selected. The guiding catheter was removed after advancing the wire then a high pressure balloon was introduced over the wire after passing the wire through the stenotic segment. Then inflation of the balloon was done using an inflation device. A completion fistulogram using Bern catheter was done after the procedure to assess its success. Figure 1 shows pictures from our work. Outcome of the procedure was identified by clinical success, which means that patient can undergo three consecutive dialysis sessions by the treated fistula successfully. Technical success is detected by measuring the flow rate over the stenotic segment before and after intervention and detection of the increased flow rate to confirm technical success. This will be accompanied by feeling better thrill over AVF and the draining vein. Angiographic success means that there is less than 30% residual stenosis in the treated segment. Also, all complications that may occur at time of the procedure or later were followed up, such as hematoma formation, bleeding, infection, and/or rupture of the AVF. The outcome of the procedure was assessed at the same time of the procedure, within 2 days after (at time of patient discharge), then patients were followed up at 1 month, 3 months, and 6 months later.

Figure 1

(A) Radial artery access, (B) angiogram showing juxta-anastomotic and outflow vein stenosis, (C) balloon dilatation of stenosed segments and (D) completion angiogram after percutaneous translumi-nal angioplasty for the outflow vein.

Results

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. Data were fed to the computer and analyzed using IBM SPSS software package version 20.0 (IBM Corp, Armonk, New York, USA). The Kolmogorov-Smirnov, Shapiro, and D'agostino tests were used to verify the normality of distribution of variables. Comparisons between groups for categorical variables were assessed using χ^2 test (Fisher or Monte Carlo). Student's t-test was used to compare two groups for normally distributed quantitative variables. Cochran's test was used to analyze the significance between the different stages. Significance of the obtained results was judged at the 5% level.

In the present study, 20 patients were enrolled, 12 men and 8 women. Their ages ranged between 29 and 74 years with a median of 58 years. Their risk factors were diabetes mellitus (DM) in 45%, hypertension in 50%, and smoking in 50% of patients. Causes of renal failure were hypertension in 40% of patients, DM in 25% of patients, glomerulonephritis in 20% of patients, systemic lupus in 10% of patients, and unknown in 5% of patients. Regarding types of AVF, 14 patients (70%) had brachiocephalic AVF and 6 patients (30%) had brachiobasalic AVF. Indications for treatment were stenosis of the outflow vein more than 50% in 5 patients (25%), weak thrill after 6 weeks from creation of AVF in 7 patients (35%), and low flow through AVF on dialysis in 8 patients (40%). Duplex examination revealed stenosis in artery near AVF in 2 patients (10%), anastomotic stenosis in 8 patients (40%), or stenosis in the outflow vein and juxta-anastomotic in 10 patients (50%). Regarding complications, 1 patient (5%) had an infected AVF that was ligated as it was beyond salvage as patient was presented lately during follow-up, 2 patients (10%) had puncture site hematoma that was treated conservatively with good results, rupture AVF in 1 patient (5%) that ended by fistula ligation (rupture at body of the AVF), and immediate thrombosis and inability to cross the site of tight stenosis or near total occlusion in 1 patients (5%) that was managed conservatively with failure of the procedure (PTA) (Table 1).

Regarding success rate (1ry patency) of AVF during the follow-up period, it was 90% on day zero and the first 2 days then decreased till 65% at 6-month period due to restenosis or occlusion. For AVF, which were occluded during follow-up period, open surgical patch plasty for the venous outflow was performed due to financial issues with rePTA or another AVF was created if there were available sites for its creation (Table 2, Figs 2 and 3).

Also, it was observed that success rate (1ry patency) tended to decrease in patients older than 60 years and in diabetic patients. This correlation was statistically significant (Table 3).

Table 1 Distribution of the studied cases according to different parameters (*n*=20)

	No. (%)
Age (y)	
<60	11 (55%)
≥60	9 (45%)
Mean±SD	54.3±14.2
Median (Min.–Max.)	58 (29–74)
Sex	
Male	12 (60%)
Female	8 (40%)
DM	9 (45%)
HTN	10 (50%)
Smoking	10 (50%)
AVF	
Brachiocephalic	14 (70%)
Brachiobasilic	6 (30%)
Indication of treatment	
Stenosis of outflow vein >50%	5 (25%)
Weak thrill after 6 weeks from creation of AVF	7 (35%)
Low flow through AVF on dialysis	8 (40%)
Duplex examination	
Stenosis in artery near AVF	2 (10%)
Anastomotic stenosis	8 (40%)
Stenosis in the outflow vein and juxta-anastomotic	10 (50%)
Complications	
Hematoma	2 (10%)
Infection	1 (5%)
Rupture of AVF	1 (5%)
Thrombosis of AVF	1 (5%)

AVF, arteriovenous access; DM, diabetes mellitus; HTN, hypertension.

Discussion

Ideal hemodialysis access should be safe, durable, and easily accessed but unfortunately this is not applicable in real time so patients frequently require many procedures to maintain their accesses functioning. The factors that affect the durability of the access may be related to inflow problem in the feeding artery or outfow problem in the draining vein or related to technical operative errors. The most common problem that leads to access failure and thrombosis is stenosis of the feeding artery or in the draining vein [14,15].

Hemodialysis accesses should be evaluated continuously at the time of their creation and during access usage. Presence of pulse along the draining vein instead of palpable thrill indicates that there is proximal venous stenosis that necessitates an intervention. This intervention may be by open surgical procedure using patch plasty or by PTA. Until now there is no randomized prospective studied comparing open versus endovascular intervention in treating stenosis of AVF. In the United States of America, endovascular intervention for treating hemodialysis dysfunction had become the standard way of treatment instead of surgical intervention. As endovascular intervention is more rapid procedure with less hospital stay, with no surgical wounds and there is no need for temporary hemodialysis catheter insertion, so PTA is a better way for treating failing AVF. According to National Kidney Foundation policy, the choice of either open versus PTA for a failing shunt depends on the center expertise opinion [16–21], so after all these debates we aimed in this study to assess the efficacy of PTA for treating a failing brachial AVF, its durability, and comparing our results with other centers' results.

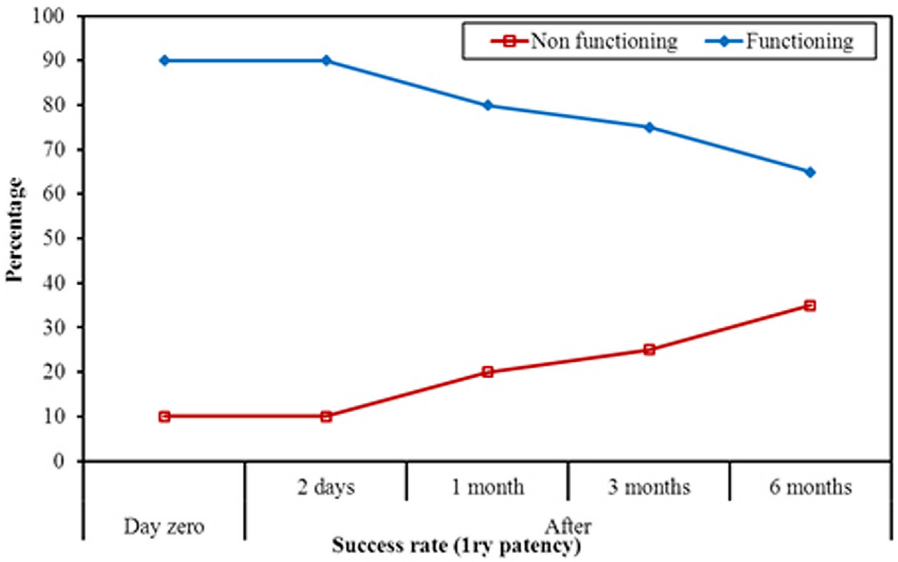
Aktas *et al.* performed a retrospective analysis of first-time PTA on 228 patients with a total of 330 stenotic areas; there were 129 men (56.6%) and 99 women (43.4%). Their mean age was 56.8±14.6 years. AVF types were brachiobasilic in 9 patients (3.9%), brachiobrachial in 1 patient (0.4%), brachiocephalic in 19 patients (8.3%), radiobasilic in 1 patient (0.4%), and radiocephalic in 198 patients (86.8%). Regarding

Table 2 Comparison between the different periods according to success rate (1ry patency)

Success rate (1ry patency)	Day zero	After				Q	*P*
		2 days	1 month	3 months	6 months		
Not functioning	2 (10%)	2 (10%)	4 (20%)	5 (25%)	7 (35%)	13.846*	0.008*
Functioning	18 (90%)	18 (90%)	16 (80%)	15 (75%)	13 (65%)		
P_1		1.000	0.215	0.063	0.002*		

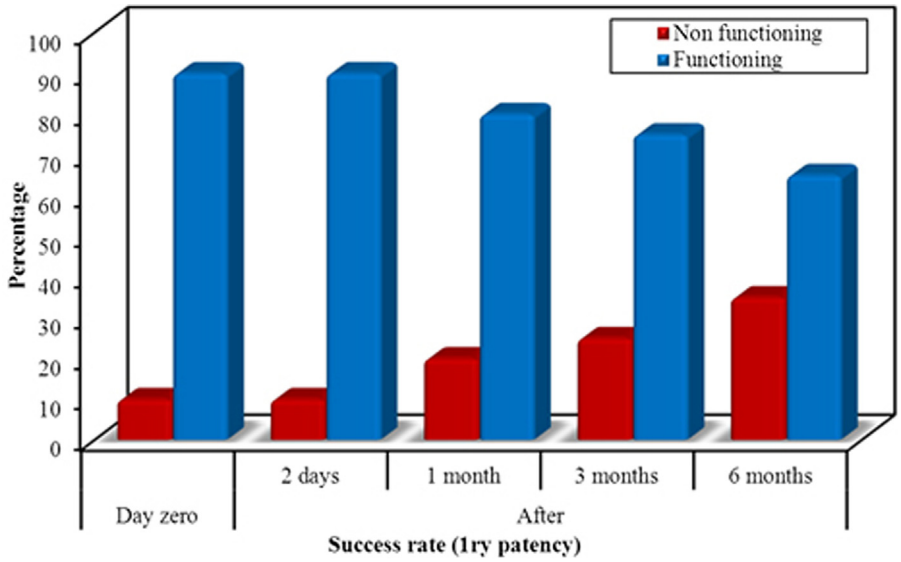
Q: Cochran's test, Sig. bet. Periods were done using post hoc test (Dunn's). *P*: *P* value for comparing between different periods. P_1: *P* value for comparing between day zero and each group. *Statistically significant at $P \leq 0.05$.

Figure 2



Line Chart showing the comparison between the different periods according to success rate (1ry patency).

Figure 3



Par chart compare between functioning and non function fistulae in different periods according to success rate.

Table 3 Correlation between success rate (1ry patency) at 6 months with age (years) and DM

	Success rate (1ry patency) 6 months		Test of sig.	*P*
	Nonfunctioning (*n*=7)	Functioning (*n*=13)		
Age (y)				
<60	1 (14.3%)	10 (76.9%)	χ^2=7.213*	0.017*
≥60	6 (85.7%)	3 (23.1%)		
Mean±SD	63.1±12	49.5±13.3	*t*=2.264*	0.036*
Median (Min.–Max.)	66 (38–74)	55 (29–68)		
DM				
No	1 (14.3%)	10 (76.9%)	χ^2=7.213*	0.017*
Yes	6 (85.7%)	3 (23.1%)		

P: *P* value for association between different categories. *t*, Student's *t*-test. DM, diabetes mellitus. *Statistically significant at $P \leq 0.05$.

risk factors, 142 patients (62.3%) were having DM. Location of stenosis was the anastomotic segment in 73 patients (32%), feeding artery in 25 patients (11%), draining fistula vein in 78 patients (34.2%), and juxta-anastomotic segment in 149 patients (65.4%).

Bountouris *et al.* performed PTA for a failing shunt on 159 patients. Their comorbidities were coronary artery disease in 67 patients (42%) and DM in 60 patients (38%). Regarding types of AVF, there were 81 radiocephalic AVF (51%), 56 brachiocephalic AVF (35%), other native vein in 3 AVF (2%), and prosthetic graft in 19 AVF (12%). Positions of stenosis in native AVF were anastomotic 29%, venous cannulation zone 49%, outflow vein 18%, and central vein 4%. Positions of stenosis in synthetic grafts were in arterial anastomosis 16%, graft 5%, venous anastomosis 58%, and outflow vein 21%.

Kitrou *et al.* performed retrospective study on 39 patients; 23 men (59%) and 16 women (41%) with a failing AVF. Patients underwent PTA for their failing hemodialysis accesses using paclitaxel-coated balloons. Twenty patients had native AVF and 19 patients had AVGs. Most of their lesions in their accesses were restenotic (64.1%).

Ahmed *et al.* performed PTA for a failing AVF for 15 patients; 8 men (53.3%) and 7 women (46.7%). Their ages were less than 40 years in 2 patients (13.3%), between 40 and 60 years in 9 patients (60%), and more than 60 years in 4 patients (26.7%). Regarding their comorbidities, 10 patients had DM (66.7%), hypertension in 9 patients (60%), and smoking in 3 patients (20%). The types of AVF were brachiocephalic in 9 patients (60%) and brachiobasalic in 6 patients (40%). Positions of stenosis were anastomotic in 6 patients (40%), juxta-anastomotic in 4 patients (26.7%), central venous stenosis in 3 patients (20%), and arterial stenosis in 2 patients (13.3%) [22–25].

In the present study, 20 patients were enrolled, 12 men and 8 women. Their ages ranged between 29 and 74 years with a median of 58 years. Their risk factors were DM in 45%, hypertension in 50%, and smoking in 50% of patients. Regarding types of AVF, 14 patients (70%) had brachiocephalic AVF and 6 patients (30%) had brachiobasalic AVF. Duplex examination revealed stenosis in artery near AVF in 2 patients (10%), anastomotic stenosis in 8 patients (40%), and stenosis in the draining vein and juxta-anastomotic in 10 patients (50%).

Aktas *et al.* observed within 6 months that early dysfunction was directly correlated with patient age (older age) and with the presence of DM. Also, in the current study, the same correlation (P value=0.017) was observed. Primary patency rates at 1 year, 2 years, and 3 years were 84.7%, 62.2%, and 23.7%, respectively, which is better than the current study results. This may be correlated with that patients' median age was less than the patients' median age of the current study. Also, they performed their study on larger number of patients. Primary patency rates in the study of Bountouris *et al.* at 6 month and 1 year were 61% and 42%, respectively, which is nearly equal to the current study in which primary patency at 6 months was 65%. Primary patency rates in the studies of Kitrou *et al.* and Yazar *et al.* at 6 months were 72.2% and 69.2%, respectively, which is better than the current study primary patency rate results. This may be correlated with their usage of drug-coated balloon that was not used in the current study. Success rate (primary patency) at 6 months in the study of Ahmed *et al.* was mostly 50% except in central venous stenosis that was 100%. Regarding complications, four patients (26.7%) had hematoma, two patients (6.7%) had access thrombosis, one patient (6.7%) had rupture AVF, and two patients (13.3%) had an infection. The results of this study are comparable with these results except that there were no cases with central venous occlusion or tight stenosis in the current study [22–26].

Conclusion

Patency of AVF can be maintained with continuous monitoring and follow-up. PTA for a failing AVF is an effective and safe mode of treatment with no need for temporary hemodialysis catheters insertion or creation of surgical wounds with its morbidities.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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