Dysfunctional stenotic hemodialysis arteriovenous fistulae: Effect of percutaneous transluminal angioplasty

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Abstract

Purpose: To study effect of percutaneous transluminal balloon angioplasty (PTA) on dysfunctional stenotic arteriovenous fistulae (AVF).

Methods: Between June 2008 to January 2010, 22 patients with dysfunctional stenotic hemodialysis native AVF for whom technically successful PTA were done, were enrolled in the study. AVF dysfunction was shown by a decrease in blood pump flow (Qb) below prescribed level (300-350 ml/min), a decrease in access blood flow rate (Qa) below 400 ml/min and a decrease in urea reduction rate (URR) below 65%. AVF stenoses were diagnosed by duplex ultrasound study and significant stenoses (more than 50% of luminal diameter) were treated by PTA.

After PTA, measurements of Qb, Qa, and URR were done and were compared to pre-intervention levels.

All AVF were kept on access surveillance program and primary patency rates were assessed at 1, 3, 6 and 12 months.

Results: PTA was associated with improvement of AVF hemodynamics as shown by returning of Qb to the prescribed levels with a significant increase by mean of 76(± 26) ml/min (P<0.001) and a significant increase of Qa by mean of 407 (± 92) ml/min (P<0.001) compared to pre-intervention levels. Also PTA was associated with improvement of adequacy of dialysis as shown by a significant increase of URR by a mean of 24.6(± 6.1) % (P<0.001) compared to pre-intervention levels. Primary patency rates of AVF were 95.4%, 68.2 %, 45.4% and 22.7% at 1, 3,6 and 12 months, respectively. Also, primary patency rates were significantly superior in less severe stenoses compared to more severe stenoses with 6 months patency rate of 66.7% versus 20%, respectively (P=0.029).

Conclusion: PTA is an effective and safe procedure in the treatment of dysfunctional stenotic haemodialysis native AVF. When successful, it improves AVF haemodynamics, adequacy of dialysis and primary patency rates at short and intermediate terms. Our findings also support the importance of hemodialysis access surveillance programs for early detection of AVF stenosis causing access dysfunction and the pre-emptive PTA which improves access survival.

Key words: Hemodialysis, AVF, stenosis, PTA.

Introduction:

Most patients with end stage renal failure still spend an appreciable amount of time on haemodialysis either as definitive treatment or awaiting for transplants. Permanent haemodialysis access is best provided by a native arteriovenous fistula (AVF).[1]

Satisfactory blood flow through AVF is essential for adequate haemodialysis. This is only possible when the AVF blood flow is at least 400-500 ml/min.[2]

Stenosis is a common complication of AVF which can lead to subsequent thrombosis and failure.[3,4] The use of AVF surveillance

programs and pre- emptive repair of detected defect has been shown to improve AVF survival.[1,3,5] Previously, this required reoperation and re-formation of the fistula, interposition graft or vein angioplasty but with the advent of endovascular techniques, many stenoses can now be treated by percutaneous transluminal balloon angioplasty (PTA).[1,6,7]

The aim of this study was to study effect of PTA on dysfunctional stenotic haemodialysis native AVF.

Materials and methods:

Study design:

This study was a single center prospective study. Patients were recruited from haemodialysis unit of Al-Ahssa Hospital (a tertiary referral center in the eastern area of Saudi Arabia). In the period between June 2008 to January 2010, 29 patients with dysfunctional native and virgin upper limb haemodialysis AVF with significant stenosis (>50% reduction of luminal diameter compared with an adjacent non-stenosed segment)[1,8] were attempted for PTA. Patients who were converted to open surgery because of technical failure, were lost to follow-up, were transplanted or died were excluded from the study. After applying the inclusion and exclusion criteria described above ,7 patients were excluded from the study : 3 patients were converted to open surgery and were considered as technical failure (one patient due to failure to manipulate the lesion with guide wire , one patient due to rupture of the vein with major leak, and one patient due to vein thrombosis), 2 patients were transplanted, one patient was transferred to other center and lost to follow-up, and one patient died. Finally, a total of 22 patients with 22 significantly stenotic dysfunctional native AVF for whom technical successful PTA were done, were included in the study. Baseline demographic and clinical characteristics were collected including age, gender, prevalence of diabetes mellitus, prevalence of hypertension and symptomatic cardiovascular disease (coronary artery, cerebral or peripheral vascular disease). Characteristics of the lesions were also collected including haemodialysis access age, type and side together with number, location, length and degree of stenoses. The study was approved by Hospital Ethical Committee and all allocated patients gave informed consent.

Access surveillance:

Access surveillance program was based on physical examination abnormalities, prescribed blood pump flow rate (Qb), access blood flow (Qa) measurement and dialysis adequacy measured by urea reduction rate (URR).

Qb was monitored during each haemodialysis session. The prescribed Qb ranged from 300 to 350 ml/min, and Negative Arterial Pre-pump Pressure (NAP) alarm was set at -250 mmHg. Qa was measured quarterly by ultrasound dilution technique with transonic HD01 monitor (Sono Ace 9900 Prime ,Korea).

URR was measured by the following equation: URR= predialysis urea - postdialysis urea /predialysis urea x 100 or as prescribed by others with the result of 65% or more denoting adequate dialysis.[1,9]

Haemodynamic access dysfunction and or inadequate dialysis were the indication of duplex ultrasound study of the access: hemodynamic dysfunction was demonstrated by a decrease of Qb below the prescribed levels prompting continuation of dialysis due to high NAP on at least 2 consecutive hemodialysis runs and or a decrease of Qa less than 400 ml/min, and inadequate dialysis was demonstrated by a decrease in URR below 65%.[1,9] Duplex Ultrasound study was done using multibeam 3D ultrasound system(Sono Ace 9900 Prime, Korea) and any significant stenosis (more than 50% of luminal diameter)[1,10] was localized.

The pre- PTA, Qb and Qa , post-PTA, Qb and Qa, and changes of Qb and Qa were measured and analyzed . In addition the pre-PTA, URR, post PTA,URR and changes in URR were measured and analyzed.

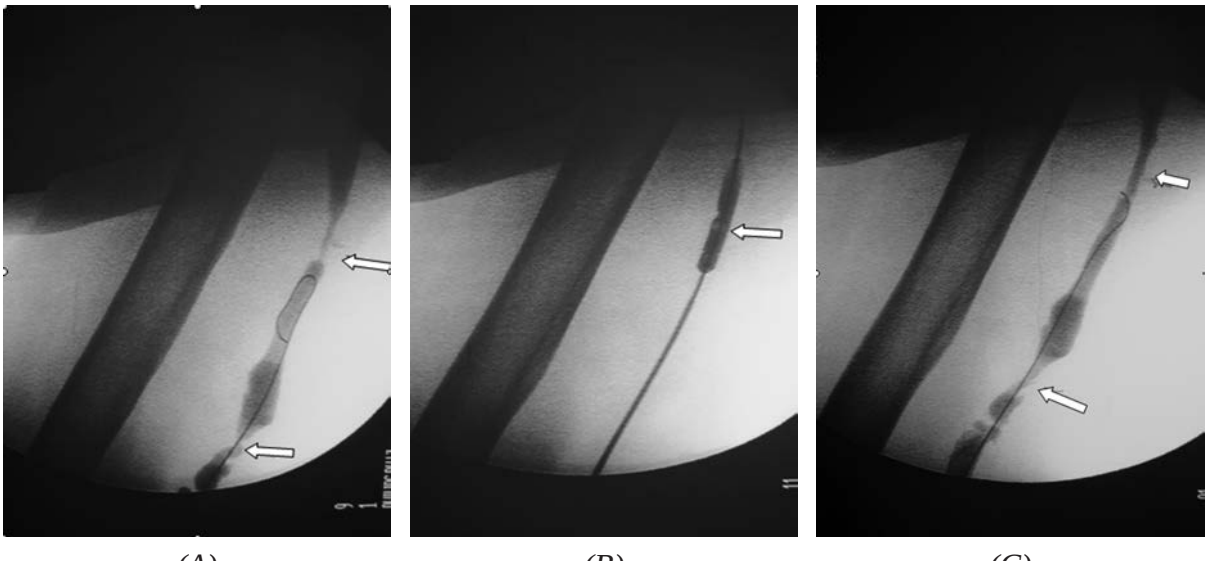
Technical description:

All cases were done at operating theater using mobile C-Arm Flouroscopic device (Philips BV Libra, Holland) under local anesthesia as day care cases. AVF was cannulated by the Seldinger technique. Before PTA, an intravenous dose of 5000 IU of heparin was administered. A 6-French vascular sheath was inserted into the lumen. Diluted contrast was injected under fluoroscopy to localize the

stenotic lesion **Figure(1A,2A)**. Intervention was performed if the lesion was greater than 50 % of luminal diameter. Hydrophillic guide wire (Angioflex TM, Kimol, England) was then introduced into the AVF and manipulated under fluoroscopic guidance to cross the lesion followed by balloon catheter (Synergy balloon dilatation catheter, Boston Scientific, Ireland) and inflated via inflator device (Dolphin System D'Inflation Device, Sedate, France) to 10 to 12 atm for 60 seconds **Figure(1B,2B)**. Completion venography was performed after dilatation and the procedure was considered anatomically successful if less than 30% of residual stenosis was recorded[1,10] **Figure(1C,2C)**. Other significant stenoses were dealt with by the same manner, if there were. In only 2 patients, a nitinol self expandable stent (Smart, Cordis, France) was deployed in the area of the lesion: in one patient due to vein perforation with significant leakage and in another patient due to residual stenosis more than 30 % despite of repeated dilatation.[10] After initial PTA, all AVF remained under access surveillance program mentioned before and all re-stenoses were treated again by PTA.

Statistical analysis:

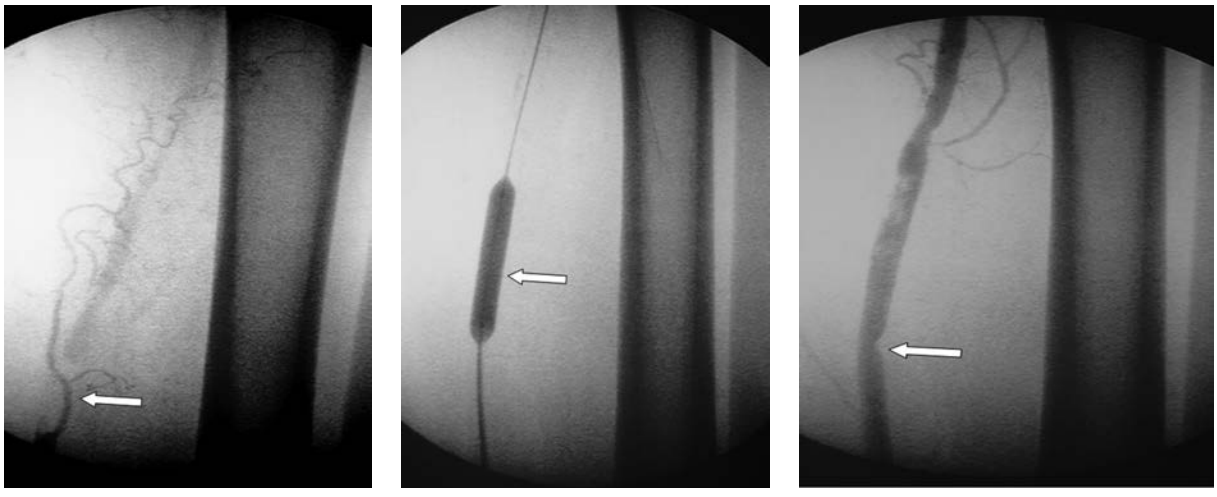
Analysis was performed according to intension -to- treat principle. Data were statistically described in terms of mean and standard deviation (± SD). Comparison of the studied groups was done using the student's t test. The chi-squared test was used to compare categorical variables. A probability value (P-value) less than 0.05 was considered significant. Data were collected and tabulated using Microsoft excel version 7 (Microsoft Cooperation, NY, USA) and analyzed using SPSS for windows (statistical package for the social science, version II, SPSS, Inc, Chicago, IL. USA).



(A) *(B)* *(C)*

Figure (1): PTA for left brachio-cephalic AVF stenoses.

(A) Cephalic vein shows, proximal 60% stenosis (lower arrow) and distal 90% stenosis (upper arrow), (B) Guidewire manipulated through the lesion and balloon catheter inflated at site of distal stenosis (arrow), (C) Completion venography after PTA shows successful dilatation of both proximal (lower arrow) and distal (upper arrow) stenoses with <30% stenosis.



(A) *(B)* *(C)*

Figure (2): PTA for left brachio-basilic AVF stenosis.

(A) Basilic vein shows 99% stenosis at Its proximal part (arrow). Notice faint opacification of the vein distal to stenosis (critical stenosis), (B) Guidewire manipulated through the lesion and balloon catheter inflated at site of the lesion (arrow), (C) Completion venography after PTA shows successful dilatation of the lesion with < 30% stenosis (arrow).

Results:

The demographic and clinical characteristics of patients are reported in **Table(1)** and the characteristics of AVF and lesions are reported on **Table(2)**.

Table (1): Patients demographic and clinical characteristics.

Number of patients	22
Age (yr) mean (± SD)	61.6 ± (9.8)
Gender (male/female)	(13/9)
Prevalence of DM No. (%)	11 (50 %)
Prevalence of Hypertension No. (%)	13 (59.1 %)
Symptomatic coronary artery disease No. (%)	11 (50 %)
Symptomatic cerebro-vascular disease No. (%)	5 (22.7 %)
Symptomatic peripheral vascular disease No. (%)	3 (13.6 %)

Table (2): Characteristics of AVF and lesions.

Number of treated AVF	22
Type of AVF	
∗ Radio-cephalic	11
∗ Brachio-cephalic	8
∗ Brachio-basilic	3
Age of AVF (months) range(mean)(±SD)	2.5 - 24.5 (14.4)(±6.4)
Side of AVF (left/right)	(15/7)
Number of stenoses / AVF	
∗ One	13
∗ Two	7
∗ Three	2
Degree of stenosis :	
∗ Moderate (50 - 75 %)	12
∗ Severe (76 - 99 %)	10
Length of stenosis :	
∗ < 3 cm	18
∗ > 3 cm	4
Location of stenosis	
∗ Arterial	1
∗ Proximal venous (initial 5 cm after anastomosis)	10
∗ Distal venous (after 5 cm from anastomosis)	11

The initial success of PTA of the attempted cases was 26 of 29 patients (89.6%). Recorded complications of the technically successful cases (26 patients) were only 2 cases (7.7%): one case with puncture site haematoma which was managed conservatively and second case with minute vein rupture and significant leakage which was managed by stent placement.

Successful PTA was associated with significant improvement in AVF haemodynamic status. Immediately after PTA, Qb returned to the prescribed level in all AVF (300 to 350ml/min) increasing by a mean of 76 (±26) ml/min which was statistically significant (p<0.001). Also, Qa increased significantly by a mean of 407(± 92) ml/min (P<0.001) compared to pre-intervention levels. PTA was associated with improvement of adequacy of dialysis demonstrated by a significant increase in URR by a mean of 24.6(±6.1)% (p<0.001) compared to pre-intervention levels. The effects of PTA on Qb, Qa and URR are shown in **Table(3)**.

Table (3): The effects of PTA on Qb, Qa and URR .

	Before PTA	After PTA	Change	P. Value
Qb mean (±SD) ml/min	264 (±33)	341 (±13)	76 (±26)	<0.001
Qa mean (± SD) ml/min	379 (±96)	791 (±107)	407 (±92)	<0.001
URR mean (± SD) %	54.7 (±5.3)	79.4 (±3.7)	24.6 (±6.1)	<0.001

The primary patency rates of AVF (from time of PTA to time of dysfunction or failure) were 95.4% (21 of 22 patients), 68.2% (15 of 22 patients), 45.4% (10 of 22 patients) , and 22.7% (5 of 22 patients) at 1,3,6 & 12 months, respectively.

The secondary patency rates of AVF (from time of PTA to time of permanent failure whatever the number or type of interventions) were not assessed in our study because of exclusion of surgically treated cases from the study. The only significant factor was found to affect primary patency rate, from both patient and lesion characteristics was the degree of stenosis. Primary patency rate at 6 months was 66.7% (8 of 12 patients) in moderate stenosis (50-75% of luminal diameter) versus 20% (2 of 10 patients) in severe stenosis (76-99% of luminal diameter), respectively (P=0.029).

Discussion:

Long term patency for all haemodialysis access remains a significant clinical problem. The most common morbidity related to AVF or grafts for haemodialysis is stenosis or thrombosis accounting for more than 80% of complications.[11] PTA is regarded as an established modality for stenosis in vascular access for haemodialysis although the vast majority of trials reporting its efficacy are uncontrolled.[12] Moreover, the best time for PTA has yet to be clearly defined, while there is evidence to support elective intervention on a malfunctioning access, correction of stenosis in absence of significant haemodynamic, functional or clinical impairment of the access is not warranted because there are no prospective studies to demonstrate its effectiveness.[1] In our study all enrolled patients had significant AVF dysfunction proved by decrease in Qb, Qa and URR.

Our findings support the usefulness of PTA for stenotic AVF with significant access dysfunction by significant improvement of AVF haemodynamics and adequacy of dialysis. The improvement of AVF haemodynamics was demonstrated by restoring Qb to the prescribed levels with a significant increase by a mean of 76 (±26) and producing a significant increase of Qa by a mean of 407(±92) compared to the pre-intervention levels, a finding reported by others.[13,14] In addition, post-intervention Qa levels were always higher than 400ml/min, a level above which is essential for adequate haemodialysis[2] and consequently these levels were higher than 300ml/min, a threshold below which a risk of incipient thrombosis is reported very high.[5] Moreover PTA increased Qa level by a mean of 407(±92)ml/min, a level which is higher than recommended by others that a successful PTA procedure should lead to an increase in Qa of at least 250ml/min.[7,15] The improvement of adequacy of dialysis was demonstrated by the significant improvement in URR from before to after PTA by a mean of 24.6 (±6.1)%, a finding reported by others.[16,17] Moreover, post PTA, URR was always higher than 65% for all patients, a threshold above which dialysis is considered to be adequate.[1,9]

The initial technical success rate of PTA depending on presence of less than 30% stenosis of luminal diameter[1,10] was 89.6% in our study which fall within the reported ranges of initial success rates between 82 to 94%.[6,7,15,18] Primary patency rates in our study were 95.4%, 68.2%, 45.4% and 22.7% at 1, 3, 6 & 12 months, respectively. Although comparing patency rates is difficult because of differences in patient selection, access types and definition of efficiency of the PTA procedure, other studies reported primary patency rates at 6 months after PTA range from 43 to 77%.[7,13,18,19] Again our finding of primary patency rate at 6 months of 45.4% falls within this range. Only one controlled surveillance study evaluated PTA results in AVF stenoses[15] and reported 6 months primary patency rate of more than 95% which seems to be significantly higher than our results. However, this study was performed for stenotic but proper functioning AVF as a prophylactic procedure. Results of PTA after vascular access thrombosis are generally worse with reported 6 months patency rate of only 19%.[20] This finding together with our finding that patency rates of less severe stenoses are superior to those of more severe stenoses in response to PTA, emphasizing the importance of effective surveillance of haemodialysis access stenosis and pre-emptive PTA.

In our study, we do not use a stent as routine adjunct to PTA for stenotic lesions in AVF. We used an adjunct stent only in two cases: one case with elastic recoil of the lesion with persistence of more than 30% stenosis and second case with minute vein rupture and significant leakage. In a prospective randomized controlled trial, 87 patients with significant stenotic lesions in AVF were randomized in treatment with PTA or PTA and stent replacement, the 6 months primary patency rate was 31% in PTA group and 27% in the PTA and stent group.[21] Moreover, Hoffer et al[22] concluded in their prospective randomized trial, that despite of a significant increase in cost, there was no advantage to stent placement compared with conventional PTA. Over all, additive placement of self-expanding stents should be considered only in a selected group of patients with central elastic lesions not responsive to PTA or recurrence within three months after successful PTA and patients with vein rupture after PTA.[1]

Complications in our study were encountered in two patients (7.7%) of the technically successful cases: one case of puncture site haematoma which was managed conservatively and another case with minute vein rupture and significant leakage which was managed by placement of self expanding stent. The majority of trials reporting optimistic results with a clinically significant morbidity rate of less than 5%, considering PTA a safe procedure for haemodialysis access stenosis.[7, 10, 15, 17, 23] We are aware that our study has some limitations, mainly it is uncontrolled. Moreover, no long term follow-up with relatively fewer number of cases. Larger controlled studies with longer follow-up are needed.

Conclusion:

PTA is an effective and safe procedure in the treatment of dysfunctional stenotic haemodialysis native AVF. When successful, it improves AVF haemodynamics, adequacy of dialysis and primary patency rates in short and intermediate terms. Our findings also suggest the importance of haemodialysis access surveillance programs for early detection of AVF stenosis causing access dysfunction and pre-emptive PTA which improves access survival. Future larger controlled studies with longer follow-up are recommended.

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