Outcome of percutaneuos transluminal angioplasty with and without stenting of central venous stenosis in hemodialysis patients

Original Article

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ABSTRACT

Background: Patients receiving hemodialysis frequently have access dysfunction and morbidity as a result of central venous occlusion and stenosis. The ongoing advancement of technology, has rendered percutaneous transluminal angioplasty (PTA) with or without stenting, a safer and more reliable procedure than alternatives involving surgery.

Objectives: Evaluation of the efficacy and safety of the endovascular treatment of central venous stenosis (CVS) in hemodialysis patients.

Patients and Methods: 56 patients with end-stage renal disease who were receiving regular hemodialysis and had CVS at Cairo University Hospitals' Vascular Surgery Department were included in this prospective research. All patients were treated with PTA, either with or without stenting, between April 2020 and March 2023. Patients were told about the operation, its risks, advantages, and alternative interventions, and their informed consent was acquired. Planned follow-ups were at 1,3,6, 9, and 12 months. The major goal of this study was to assess the primary and assisted patency rates.

Results: The study was conducted on 56 patients with end-stage renal disease, comprising 31 males and 25 females. The mean age was 51.89±14.11 years. Total 48 (85.7%) patients were treated initially with balloon angioplasty only, and only eight venous stents were initially deployed. Technical success was achieved in 100% of patients. One-year primary patency rate was 83.9, 55.6, 32.1, and 21.4% at 3, 6, 9 months, and 1 year, respectively, in all patients. Assisted patency rates were 87.5, 71.4, 57.1, and 42.9% at 3, 6, 9 months, and 1 year, respectively, in all patients.

Conclusion: Endovascular treatment of CVS is a safe and effective technique in hemodialysis patients, with acceptable primary and assisted patency rates. However, in some cases, multiple PTA is needed. Venous stenting should only be utilized in cases with PTA-resistant lesions or frequent stenosis and occlusions.

Key Words: Central venous stenosis, end-stage renal disease, hemodialysis, percutaneous transluminal angioplasty.

Received: 29 August 2024, **Accepted:** 22 September 2024, **Published:** 1 January 2025

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ISSN: 1110-1121, January 2025, Vol. 44, No. 1: 342-348, © The Egyptian Journal of Surgery

INTRODUCTION

A well-functioning vascular access (VA) is the key to ensure sufficient hemodialysis and to improve the prognosis of hemodialysis patients[1].

In the past decades, significant scientific advances in understanding mechanisms of arteriovenous fistula (AVF) maturation and failure have contributed to an increase in the amount of research into techniques for the creation and strategies for AVF dysfunction prevention and treatment, to improve patient care and outcomes[2].

Since VA is considered the Achille's heel of end-stage renal disease (ESRD), then central venous stenosis and occlusion (CVSO) remain one of the most common VA related complications, with an occurrence rate of up to 40% in prevalent hemodialysis patients. Stenosis of central veins may interfere with the creation and development of an AV access[3].

PATIENTS AND METHODS:

A total of 56 ESRD patients participated in this prospective trial, which was carried out at Kasr Al Ainy Hospital between April 2020 and May 2023. 56 ESRD patients with AVF who were receiving regular hemodialysis and had CVS were included in the study.

Patients were told about the operation, its risks, advantages, and alternative interventions, and their informed consent was acquired.

Methodology

Clinical assessment: Age, sex, etiology of renal failure, existence of cardiovascular co-morbidities, previous access sites, kind of access utilized for hemodialysis currently in use, location, and length of the failed or failing access were all included in the history. Congestive heart failure

DOI: 10.21608/EJSUR.2024.316685.1181

was assessed in each patient since it may have a negative impact on the hemodynamics of the AVF.

The upper limb was checked for edema, scars from prior surgeries, and dilated veins on the shoulder and chest wall, which might be signs of central venous disease. Pulses were palpated at all levels. Both upper limb blood pressure readings were taken, and any differences were analyzed. The quality and spread of thrill over the AVF, the existence of aneurysmal dilatation, the condition of the skin covering it, and the existence of external compression caused by a hematoma were all assessed.

Preprocedural investigations

We performed duplex scans on every case. The feeding artery up to the level of the subclavian artery and the draining vein down to the innominate vein were visualized during the duplex scan procedure. The peak systolic velocity ratio that is, the peak systolic velocity at and before the location of any constricted areas was another concept provided by Duplex. Major stenosis is considered if the peak systolic velocity ratio is three times or higher. Significant stenosis was also defined as a PSV of more than 375 cm/s or a grayscale (B-mode) narrowing of 50% or more of the diameter.

Selection criteria for this study

Inclusion criteria: ESRD patients with CVS diagnosed clinically and by duplex on central veins.

Exclusion criteria

(a) Complete central venous occlusion.

(b) Central venous thrombosis.

(c) Patients having AVF aneurysmal dilatation with impending rupture (skin changes).

(d) Patient with a previous history of steal.

All cases were done in the angio-suite. The field was sterilized, and the patients were monitored clinically and by pulse oximetry. The procedure was performed under local anesthesia at the puncture site (2% lidocaine hydrochloride).

Accessing

A sheath of the proper size (often 6 F) was inserted into the fistula's venous limb using a guide wire; however, a sheath with a larger diameter (7–10 Fr) was utilized if the insertion of a stent was expected. Angioplasty was conducted utilizing femoral access if the lesion in the central veins could not be crossed with a wire using the arteriovenous access. In certain instances, long sheaths were used. The sheath was tested for free blood flow. In total, a flush was performed using 5000 IU of heparin injection to avoid intravascular thrombosis. If the endovascular access was antegrade or next to the fistula site, a diagnostic fistulogram was performed by injecting the dye directly through the sheath. (with the flow), injection of the dye was directly through the sheath. Otherwise, a vertebral guiding catheter was used as a diagnostic catheter. The angiographic findings were evaluated for each patient to assess the problem and to put a plan for proper management.

Passing the guide wire

Next, a guide wire was advanced to the level of the central veins by passing it through the sheath. Typically, a 6- or 5 F selective Bern catheter was placed in the sheath over a 260 cm, 0.035 angled hydrophilic guide wire (Terumo, Radifocus Terumo Guidewire, Germany) under angiographic guidance. After that, the wire and catheter were moved and progressed under imaging guidance, with the wire being advanced into the vein and over the lesion while the catheter was supporting it, until it was secured in the central vein. The catheter was advanced passing the lesion, and then the wire was removed and the central vein was imaged for any stenosis or occlusion. The wire was then advanced through the catheter till it reached the heart. There was no difficulty in crossing the lesions except in the following circumstances:

(a) Tight lesion.

(b) Multiple tight lesions.

(c) Preceding aneurysmal dilatation.

For the tight lesion, a Terumo stiff wire was used to give pushability. For the multiple tight lesions difficulties, the first lesion was dilated first with a small balloon. We used the combined venous access approach to cross difficult tight lesions.

Balloon dilatation

After being chosen, the angioplasty balloon was prepared by using a syringe filled with diluted contrast to put the inflation port under negative pressure. The air in the balloon-inflation tube is replaced by the contrast solution when the suction is released. Subsequent balloon inflation was carried out using contrast instead of air, which reduced the chance of air embolization in the event that the balloon burst and allowed radiographic observation of the inflation.

The angioplasty balloon catheter was moved to the most proximal lesion after traversing the lesions and going over the guide wire. If there were any more lesions, they were treated by moving peripherally. Using radiopaque external markers or fluoroscopic reference to anatomic structures, the balloon was precisely positioned over the target lesion during the diagnostic angiography. Precise placement

was further aided by 'road-mapping' fluoroscopy, which included superimposing a contrast-enhanced vascular image on top of a live fluoroscopic image. The balloon's location is efficiently monitored and guided by contrast infusion using an appropriately positioned, large guiding catheter or sheath.

A 14 mm balloon was mainly utilized, which was advanced to the lesion site and then inflated under high pressure to widen the stricture. To aid in the dilation of the stenotic location, pressure was applied with a relatively short balloon. Overlapping dilations were done to cover the whole lesion if the chosen balloon length was less than the lesion and a longer balloon could not be employed. Fluoroscopic monitoring of balloon inflation was performed and as the balloon pressure increased any waist in the balloon profile vanished as the lesion widened. Increasing the pressure, extending the time for inflation, switching the location of the balloon, and utilizing bigger balloons helped to solve the challenges of dilatation.

After dilating the lesion the balloon was deflated and withdrawn with the guide wire left in place and the catheter was advanced over the wire till the central vein, the wire was removed and, fistulogram was done till the central veins to ensure the patency and to exclude any residual stenosis or free-floating or flow limiting thrombi. In cases of residual stenosis, dilatation was repeated using high pressure inflation. Venous stenting was required in the following circumstances:

(a) Residual stenosis greater than 30% after two times balloon dilatation.

(b) Immediate recoil after angioplasty.

A 14 mm stent was mainly used and advanced till the site of the lesion and then deployed and extended more peripherally than centrally to achieve more stability and prevent central displacement or slippage.

RESULTS:

This study was conducted on 56 ESRD patients on regular hemodialysis. In all, 31 (55.4%) patients were males, and 25 (44.6%) were females. The mean age was 51.89±14.11 years. Thirteen (23.3%) patients were diabetic, 24 (42.9%) were hypertensive, 21 (37.5%) had ischemic heart disease, and 18 (32.1%) were smokers.

The causes of ESRD in the study patients were hypertension in 12 (21.4%) of patients, diabetes in five (8.9%) of patients, combined diabetes and hypertension in eight (14.3%) of patients, glomerulonephritis in two (3.6%) of patients, systemic lupus in three (5.4%) of patients, obstructive uropathy in six (10.7%) of patients, preeclampsia and eclampsia in three (5.4%) of patients, drug-induced in three (5.4%) of patients, atrophic kidney in two (3.6%) of patients and in 12 (21.4%) of patients the causes of renal failure were unknown (Fig. 1).

Presentation

Seventeen (30.4%) patients had weak thrill, all the patients had upper limb edema. Twenty-four (42.9%) patients had arm pain, 35 (62.5%) patients had dilated veins on the chest due to venous hypertension. The dialysis was interrupted (repeated suction) in 16 (28.6%) patients, while 31 (55.4%) patients had prolonged bleeding from the puncture site (Table 1).

Single access from the venous limb of the fistula was done in 44 patients while 12 patients had combined transfemoral and transfistula accesses to cross the tight lesions through a retrograde approach. Standard 0.035 (Terumo.) guidewire was used to cross the lesion in 43 (76.8%) patients, while in 13 (23.2%) patients stiff 0.035 wire was used. Balloon dilatation only was done in 48 (85.7%) patients. Residual stenosis 30% occurred in seven (12.5%) patients after completion angiography. Combined venoplasty and stenting (Fig. 2) was done in eight (14.3%) patients.

The initial interventional success rate was 100%. Primary patency rate is defined as the time interval from initial intervention to 1st reintervention (venoplasty or stenting), conservative management, permcath insertion or ligation) was: 83.9, 55.6, 32.1, and 21.4% at 3, 6, 9 months, and 1 year, respectively. Assisted patency rate is defined as the time interval from initial intervention to recurrence of stenosis or occlusion requiring stent or balloon venoplasty was: 87.5, 71.4, 57.1, and 42.9% at 3, 6, 9 months, and 1 year, respectively (Table 2).

Survival analysis of last access

Status of event failure of access

Figure 3

Status of event functioning access

Figure 4

Correlations between patency and result in follow-up:

Tables 3 and 4

There was a statistically significant positive correlation between hypertension presence and restenosis; *P=.018*, r=0.315.

The results showed that there was an inverse relationship between the stent diameter and the overall prognosis, as between the 2 cases with 18 mm stents; 1 AVF had ruptured after 6 months *P=0.102*, r=0.619 and the other was occluded after 9 months. *P=0.016*, r=0.803.

Table 1: Shows presentation

Presentation	*N* (%)
State of last access:	
Failing	17 (30.4)
Functioning	39 (69.6)
Edema	56 (100.0)
Pain	24 (42.9)
Dilated veins	35 (62.5)
Interrupted flow on dialysis	16 (28.6)
Continuous flow on dialysis	40 (71.4)
Hemostasis of puncture site	
Normal	25 (44.6)
Prolonged	31 (55.4)

Table 2: Primary and assisted primary patency rates

Duration	3 months	6 months	9 months	1 year
Primary patency rate, *n* (%)	83.9	55.6	32.1.6	21.4
Assisted patency rate, *n* (%)	87.5	71.4	57.1	42.9

Table 3: Correlation between patency and demography and comorbidities

Correlations					
	Result	3 months	6 months	9 months	1 year
Spearman correlation					
Age					
Correlation Coefficient	0.169	0.074	–0.057	0.074	–0.008
Significance (2-tailed)	0.214	0.588	0.682	0.591	0.956
N	56	56	55	55	51
Sex					
Correlation Coefficient	0.014	0.233	–0.095	–0.021	0.097
Significance (2-tailed)	0.921	0.085	0.492	0.876	0.496
N	56	56	55	55	51
DM					
Correlation Coefficient	–0.048	0.080	–0.029	–0.013	0.052
Significance (2-tailed)	0.726	0.556	0.835	0.923	0.717
N	56	56	55	55	51
HTN					
Correlation Coefficient	0.109	0.315	–0.065	0.128	0.167
Significance (2-tailed)	0.423	0.018	0.636	0.351	0.242
N	56	56	55	55	51
IHD					
Correlation Coefficient	0.293	0.172	0.120	0.124	0.016
Significance (2-tailed)	0.029	0.205	0.382	0.369	0.909
N	56	56	55	55	51
Smoking					
Correlation Coefficient	0.145	–0.083	–0.007	0.233	0.002
Significance (2-tailed)	0.288	0.545	0.960	0.086	0.991
N	56	56	55	55	51

Table 4: Correlation between result and stenting

Correlations					
	Result	3 months	6 months	9 months	1 year
Site of stent					
Correlation Coefficient	0.162	0.145	0.100	0.061	–0.208
Significance (2-tailed)	0.232	0.288	0.468	0.658	0.143
N	56	56	55	55	51
Access					
Correlation Coefficient	0.197	–0.094	0.132	0.070	0.069
Significance (2-tailed)	0.145	0.491	0.336	0.613	0.631
N	56	56	55	55	51
Wire					
Correlation Coefficient	0.048	0.097	0.213	–0.063	0.011
Significance (2-tailed)	0.726	0.478	0.118	0.646	0.937
N	56	56	55	55	51
Stent diameter					
Correlation Coefficient	–	0.286	0.619	0.803	–
Significance (2-tailed)	–	0.493	0.102	0.016	–
N	8	8	8	8	6
Balloon diameter					
Correlation Coefficient	–0.026	0.017	0.090	0.258	0.179
Significance (2-tailed)	0.848	0.903	0.515	0.057	0.209
N	56	56	55	55	51

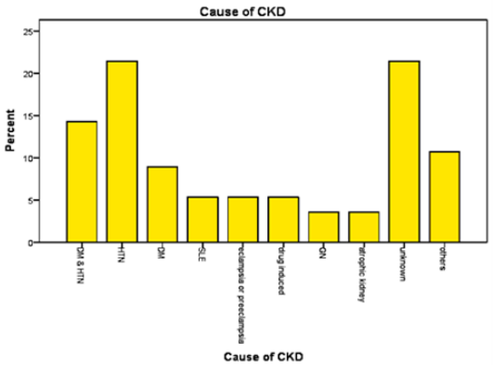

Fig. 1: Causes of chronic kidney disease.

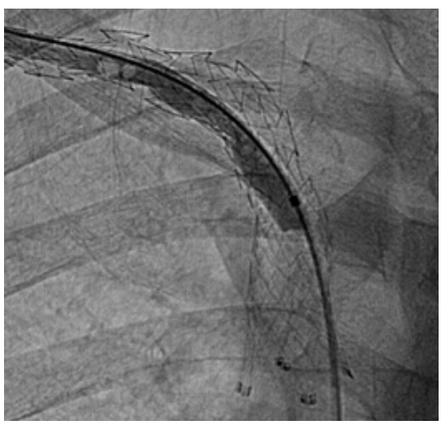

Fig. 2: Central venous stent.

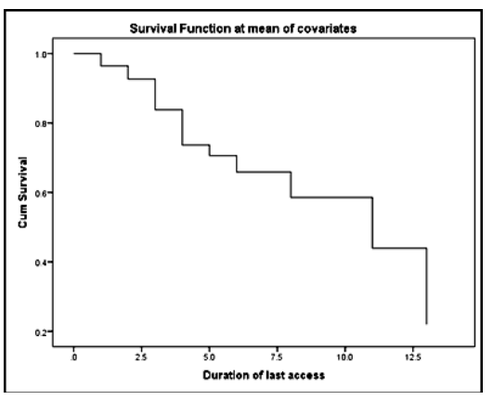

Fig. 3: Status of event failure of access.

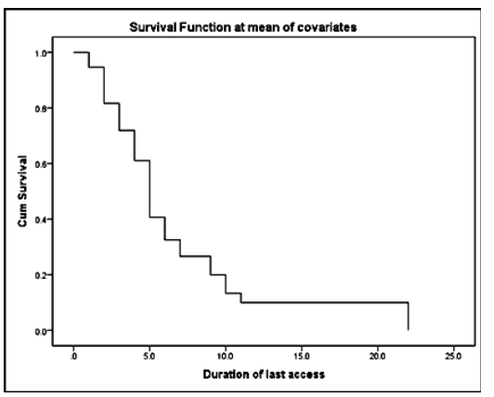

Fig. 4: Status of event functioning access.

DISCUSSION

CVS is encountered frequently among hemodialysis patients. Prior ipsilateral central venous catheterization and cardiac rhythm device insertions are common risk factors[4]. The following factors may lead to intimal hyperplasia and venous stenosis: shear stress from turbulent blood flow after the creation of AVF, mechanical trauma from venipuncture, and angioplasties[5]. Endovascular techniques have gained popularity for the initial treatment because of their less invasiveness, no surgical wound, shorter hospital stay, and the fact that the fistula can be used immediately for dialysis[6,7].

All patients in the present study had a history of a temporary central venous line insertion in the ipsilateral side. This denotes the intimate relationship between temporary dialysis catheters and the occurrence of CVS, especially with subclavian vein catheters rather than other types, as reported by recent studies Dhamija and Asif[8] and Echefu *et al*.[9].

Lesions were most commonly located in the innominate vein in 41.1% of patients, followed by the subclavian vein in 32.1%, and the combined innominate and subclavian veins in 26.8% of patients. This was similar to those found by Yadav and his colleagues, who stated that most lesions were located in the innominate vein[10].

In the present study, 30.4% of patients had weak thrill, all the patients had upper limb edema. 42.9% of patients had arm pain, 62.5% of patients had dilated veins on the chest due to venous hypertension. 28.6% of patients had inadequate dialysis. This was similar to those found by Hongsakul and his coworkers, who reported in their study that the most common presenting symptom was edema of the ipsilateral upper extremity and face[11].

In the present study, technical success was achieved in 100% of patients. This was similar to the results obtained by Quaretti and his coworkers who reported 100% technical success rate[12]. Saleh and his colleagues reported an 85% technical success rate[13]. The 100% success rate in the present study is explained by the fact that all lesions were stenotic and there was no complete venous occlusion. Huang and his group had analyzed the aspects of technical success or failure and found two major factors: lesion crossing and recanalization. Crossing is the key for success. Recanalization is influenced by occlusion length, extent, and location[14].

One-year primary patency rate was 83.9, 55.6 32.1, and 21.4% at 3, 6, 9 months, and 1 year, respectively. Saleh and his colleagues reported 87,, 67.4, and 51.7% primary patency rates in their study[13]. Better results were achieved by Quaretti and his coworkers, who stated that 3, 6, and 12-month primary patency rates were 90, 79, and 58%, respectively. Several reasons may explain the low number of recurrences: clinically guided as opposed to venographic follow-up, the high proportion of long-term CVCs (37 patients) without the AV-related shear stress risk of restenosis and technical details such as intentional size and length overstenting to completely cover lesion edges. Antiplatelet therapy may have been a significant factor for low rates of stent edge restenosis[12].

In the present study, 30 patients developed a recurrence of stenosis or occlusion (53.5%), Attempts of recanalization were performed to restore the fistula function. Balloon dilatation was successful in 15 (26.8%) patients, deployment of a stent in 11 (19.6%) patients, and in four (7.14%) patients, there was a failure to cross the lesion. Assisted patency rates were 87.5, 71.4, 57.1, and 42.9% at 3, 6, 9 months, and 1 year, respectively. Better results were achieved by Quaretti and his coworkers, who stated that assisted patency rates were 95, 89, and 78% at 3, 6 and 12 months respectively in the percutaneous transluminal angioplasty (PTA) group[12]. Wu and his group, confirmed in their systemic review that the assisted primary patency rates at 24-month follow-up of CVS were improved following balloon angioplasty than those achieved with venous stenting[15]. In the present study there was no significant improvement in patency following balloon angioplasty alone compared to venous stenting.

CONCLUSION

PTA with or without stenting for CVS is an effective interventional procedure for patients on regular dialysis. However, in some cases, multiple PTA is needed owing to rapid recurrences and restenosis. Venous stenting should only be utilized in cases with PTA-resistant lesions or frequent concurrent stenosis and occlusions.

CONFLICT OF INTEREST

There are no conflicts of interest.

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