ORIGINAL ARTICLE

Endovascular Management of Thoracic Central Venous Obstruction with Symptomatic Venous Hypertension in Hemodialysis Patients

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Abstract

Background: ***Vascular access is essential for a hemodialysis patient. The prevalence of end-stage renal disease (ESRD) patients is rising significantly on a global scale.***

Aim: ***To evaluate the feasibility and clinical success of endovascular management for symptomatic central venous obstruction in end-stage renal disease patients undergoing regular hemodialysis. The primary goal is to maintain hemodialysis access site patency and improve symptomatic outcomes.***

Methods: ***This was a prospective, randomized clinical study performed at the Vascular and Endovascular Surgery Departments in Al-Azhar University Hospital, Egypt, and Damanhour Medical National Institute, Egypt, on 60 patients with chronic kidney disease who underwent regular dialysis. The research study continued for two years, from February 2023 to March 2025.***

Results: ***(85%) of the studied group were primary improvement, (15%) were failed cases, (20%) were reintervention by stenting, and (5%) were complicated cases. At 3 months (100%) of the studied group were patent, at 6 months (94%) of the studied group were patent, (5%) were re-occluded, (5%) were need ligation, and at 12 months (88%) of the studied group were patent, 11.7%) were re-occluded, 7.8% were need ligation, and 3%) were need ligation.***

Conclusion: ***Preoperative ipsilateral subclavian vein hemodynamic catheters can cause venous stenosis and hypertension. Instead, internal jugular vein catheters are recommended. Diagnostic tools include venous duplex ultrasound and digital subtraction venography.***

Keywords: Endovascular Management; Thoracic Central Venous Obstruction; Venous Hypertension; Hemodialysis Patients

1. Introduction

Vascular access is essential for a hemodialysis participant. The prevalence of ESRD individuals is significantly rising globally, with the majority initiating treatment by hemodialysis (HD).[1] The most effective vascular access method is an arteriovenous fistula (AVF), which has a lower risk of complications than arteriovenous grafts and central venous catheters, which are linked to higher rates of death and illness.[2]

There are numerous variables that influence the type of fistula that is surgically implanted. Surgical planning is consistently initiated at the furthest feasible distance. A radial-cephalic fistula is the preferred distal AVF location. This can be achieved by performing an anastomosis between the radial artery and the cephalic vein at the wrist.[3]

Many complications are encountered in AVF creation. These complications include either systemic, such as high cardiac output, or heart failure. However, local complications may include early and late thrombosis, wound seroma, venous hypertension, steal phenomenon, ischemic changes, pseudoaneurysms, infection and abscess formation, huge dilatations of the output veins, aneurysmal dilatations of the veins sharing in arteriovenous anastomosis, and impending rupture of an infected aneurysm.[4]

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Central venous occlusive disease (CVOD) is characterized by occlusion or stenosis of at least 50 percent affecting the lumen of the internal jugular, subclavian, innominate veins, axillary, or superior vena cava. It is a substantial issue in people with HD, resulting in considerable morbidity (e.g., venous hypertension) that may progress to access dysfunction.[5]

The etiologies of central venous stenosis (CVS) in these individuals include venous trauma resulting from recurrent punctures and cannulations, as well as elevated shearing forces associated with blood turbulence, particularly in proximal AVF. Nonetheless, the aggregation of platelets and the formation of thrombi accompany the development of intimal hyperplasia and fibrosis at the location of the initial stenosis. [6,7]

The objective of this research was to provide a comprehensive account of our initial experience, feasibility, as well as clinical success in the endovascular management of symptomatic central venous obstruction among individuals with end-stage renal disease who are undergoing regular hemodialysis. This condition is characterized by significant ipsilateral limb swelling and edema in those on hemodialysis with venous access in the upper limb. The primary objective of our endovascular therapy is to maintain the patency of the hemodialysis access site and to provide symptomatic improvement.

2. Patients and methods

This was a prospective, randomized clinical trial performed at the Vascular and Endovascular Surgery Departments in Al-Azhar University Hospitals, Egypt; Damanhour Medical National Institute, Egypt, on 60 patients with chronic kidney disease who underwent regular dialysis. The research study continued for two years, from February 2023 to March 2025.

Inclusion criteria: All patients with autogenous and synthetic AVF on the ipsilateral side of the central venous obstruction; patients complicated with symptomatic venous hypertension of the ipsilateral upper limb; fistula failure, defined as inadequate hemodialysis flow, difficult cannulation access, or disappearance of a palpable thrill with the absence of a continuous machinery murmur by the stethoscope; patients with arteriovenous access dysfunction before complete failure; and patients with inadequate dialysis sessions (i.e. strong evidence of arteriovenous access obstruction).

Exclusion criteria: All patients with thrombosed AVF, patients with limb edema without central venous lesions, recurrent obstruction or venous stent occlusion, and arteriovenous fistulas in individuals beyond the age of 20 years old.

Methods

All patients were subjected to the following

Detailed history taking, clinical examination, laboratory investigation as needed, Duplex U/S, CTV/MRV, ECG, ECHO, and CT Pulmonary Angiogram (CTPA) in patients with acute on top of chronic venous occlusions.

Procedure details

Pre-procedure: All individuals underwent an ultrasound examination; the ultrasound exam was the first tool used to identify an obstruction. In addition, all patients underwent a CT venogram (CTV) to assess the IVC and brachiocephalic veins.

Equipments

Angiographic tools: Puncture introducer set: needle 21 G/ 7 cm, wire 0,018“/ 40 cm, sheath 4 F/ 10 cm, guidewire 0,035“(J-curved fixed core), Amplatz extra stiff guidewire 0,035“/80 cm, Brite tip sheath 10 F 0.035“/23 cm, ATLAS Gold PTA dilatation catheter 14 mm, 16 mm/60 cm, and Wallstent/BBARD Venovo/ZZilver Vena Venous/MMedtronic Abre self-expanding stents 14 mm, 16 mm/60 cm, 100 cm.

Medications

Contrast materials: The contrast media were Ultravist (lopromide), which is a non-ionic low-osmolar contrast material. Other drugs used: Xylocaine 0.5% was used for infiltration as a local anesthetic at the puncture site, saline 0.9%/heparin (500 ml saline + 5000 IU heparin) was used to flush the sheath, catheters, and balloons all through the procedure, and intravenous heparin to prevent thrombosis just after sheath insertion (5000 units).

Procedure

Procedures were conducted either under general anesthesia or with local anesthesia and conscious sedation. Patients were fully anticoagulated prior to, during (5,000–10,000 units of unfractionated heparin administered intraoperatively), and subsequent to the procedure. Subsequent to US-guided access via the axillary veins, common femoral veins, or internal jugular veins, venography was conducted. Initial venography reveals the location of the obstruction along with collateral vessels circumventing the occluded lesion. The wire was utilized to traverse the lesion first. Subsequently, pre-dilation was executed utilizing angioplasty balloons to match the diameter of the stent. Subsequently, stents were implanted from normal to normal. We utilized two distinct types of stent implantation: Wallstent (Boston Scientific, Marlborough, USA) and dedicated venous stents, namely Zilver Vena (Cook, Bjaeverskov, Denmark), Medtronic Abre (Minneapolis, MN, USA), and Venovo (Bard, Tempe, USA). Stents were available in diameters of

14 mm and 16 mm and lengths of 60 mm, 100 mm, and 140 mm, delivered using an 11-fr delivery system. The stent was subsequently re-inflated to the identical diameter. Stents stretched roughly 2 cm into the inferior vena cava with adequate flow.

Post procedure: A color Doppler ultrasound was conducted on the first postoperative day to verify stent patency. Post-procedure anticoagulation was determined by the clinical condition of each patient. In eleven non-malignant cases, individuals were administered therapeutic NOAC for at least three months; six individuals with compressive neoplasms were prescribed low molecular weight heparin (LMWH). Cases with appropriate indications were prescribed extended or lifelong anticoagulation. Cancer patients received routine oncology follow-up CTs, which were used to assess patency. Similarly, re-intervention was considered according to clinical symptoms and imaging findings.

Follow-up: Stent evaluations were performed by Duplex US at 1 month, 3 months, and 6-month intervals to assess patency, unless symptoms persist or worsen. CTV or MRV was conducted. Clinical follow-up to assess symptoms and treatment adherence.

Ethical consideration

Before starting the study, all patients provided informed consent after a comprehensive description of the procedure. Approval by the ethical committee of Al-Azhar University, Faculty of Medicine, was obtained before initiating this study.

Statistical Methods

Statistical analysis was conducted using IBM SPSS Statistics version 23 (IBM Corp., Armonk, NY). Intergroup variations in categorical variables were analyzed utilizing the Pearson chi-squared test or Fisher's exact test, alongside counts and percentages. The chi-squared test was employed to analyze ordinal data for trends, while the mean and SD of continuous numerical variables were documented, and intergroup differences were evaluated using the independent-samples t-test. P-values below 0.05 were considered statistically significant.

3. Results

The mean age was 52.53 ±6.60. (31.7%) of the studied group were males, (68.3%) females, 20% had hypertension, 30%) had DM (33%) had Hypertension, DM (16%) had heart diseases, and 20% were smokers. (Table 1)

Table 1. General characteristics of the examined Groups

GENERAL CHARACTERISTICS	STUDY GROUP (N = 60)	
	52.53 ±6.60 35-65	
	No.	%
SEX:		
MALE	19	31.7
FEMALE	41	68.3
COMORBIDITIES:		
HYPERTENSION	12	20
DM	18	30
HYPERTENSION & DM	20	33
HEART DISEASES	10	16
SMOKING:		
YES	10	20
NO	50	80

The mean duration of dialysis was 9.62±7.17 and duration of fistula was 3.63 ±2.74. (71.6%) were AVF, (41.6%) were Brachio-basilic fistula, (30%) were Brachio-cephalic fistula, 28.4% were AVG (71.6%) were subclavian, and 28.4% were jugular of the studied group. (Table 2)

Table 2. Clinical characteristics of the Studied Groups

GENERAL CHARACTERISTICS	STUDY GROUP (N = 60)	
DURATION OF DIALYSIS: MEAN ±SD RANGE	9.62±7.17 1-24	
DURATION OF FISTULA: MEAN ±SD RANGE	3.63 ±2.74 1-12	
TYPE OF DIALYSIS ACCESS:	no	%
*AVF	43	71.6
BRACHIO-BASILIC	25	41.6
FISTULA	18	30
BRACHIO-CEPHALIC		28.4
FISTULA	17	
* AVG		
HISTORY OF CVC:		
SUBCLAVIAN	43	71.6
JUGULAR	17	28.4

(80%) of the studied patients had axillary access, (20%) had axillary + femoral, (71.6%) had stonosis, (28.4%) had occlusion, (61.6%) were right, (38.4%) were left, (20%) were subclavian, and (80%) were innominate. (Table 3)

Table 3. characteristics lesions of the Studied Groups

LESION	NO.	%
SITE OF ACCESS:		
AXILLARY(AVF)	48	80
AXILLARY + FEMORAL	12	20
TYPE OF LESION:		
STENOSIS	43	71.6
OCCLUSION	17	28.4
SIDE OF LESION:		
RIGHT	37	61.6
LEFT	23	38.4
SITE OF LESION:		
SUBCLAVIAN	10	20
INNOMINATE	50	80

(85%) of the studied group were primary improvement, (15%) were failed cases, (20%) were reintervention by stenting, and (5%) were complicated cases. (Table 4)

Table 4. outcome of the Studied Group

OUTCOME	NO.	%
TECHNICAL SUCCESS	51	85
FAILED CASES	9	15
REINTERVENTION BY STENTING	12	20
COMPLICATED CASES	3	5

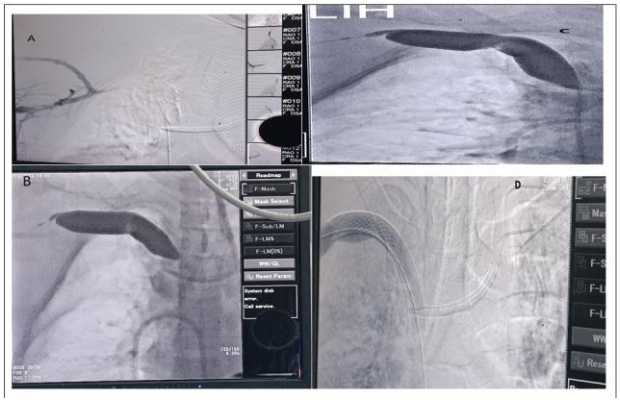
At 3 months (100%) of the studied group were patent; at 6 months (94%) of the studied group were patent; (5%) were reoccluded; (5%) were need ligation; and at 12 months (88%) of the studied group were patent; (11.7%) were reoccluded; (7.8%) were need ligation; and (3%) were need ligation. (Table 5)

Table 5. Follow-up of the Studied Group:

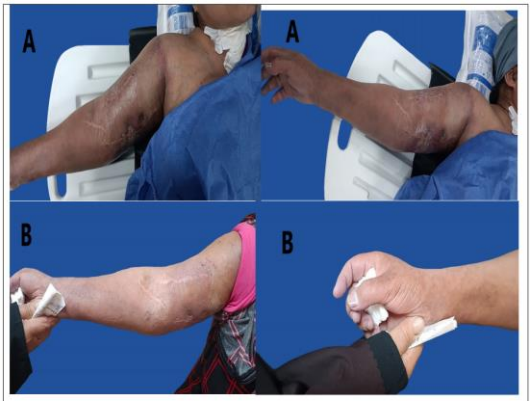
	SUCCEDED CASES (N=51)					
OUTCOME	3 months		6 months		12months	
	No.	%	No.	%	No.	%
PATENT	51	100	48	94	45	88
RE-OCCLUDED	_	_	3	5	6	11.7
NEED 2RY INTERVENTION	_	_	3	5	4	7.8
NEED LIGATION	_	_	_	_	2	3

CASE PRESENTATION

Case One



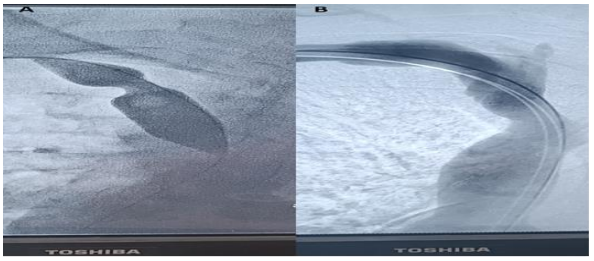
Example of PTA and stent in one of the cases included in this study. a, occluded lesion in right innominate vein. B, Waisting of the balloon; c, complete inflation of a 16x80mm venous balloon. D. Improvement of the flow after PTA and stenting.



Clinical improvement of right upper limb edema.a, preoperative arm and forearm edema. b. Six months postoperatively resolved upper limb edema.

Figure 1. Shows Case One

Case two



Example of PTA in one of the cases included in this study. A, waisting of the balloon. B, Slight improvement of the flow after PTA.

Clinical improvement of left upper limb edema. A. Preoperative arm and forearm edema. B. Six months postoperatively resolved upper limb edema.

Clinical improvement of left upper limb edema. A, preoperative hand edema. B, six months postoperatively resolved hand edema with visible superficial dorsal veins and skin corrugations.

Figure 2. Shows case two

4. Discussion

In the present study, there were sixty cases of ESRD suffering from venous hypertension. The sixty patients were 19 males (31.7%) and 41 females (68.3%). The age of those individuals varied from 35 to 65 years, with a mean age of 52.5 years. The main bulk was in the 5th and 6th decades of their lives, comprising mainly about 80% of the studied group. In the present study, it is apparent that venous hypertension is not linked to a particular sex or age group.

The effect of central venous catheters as a risk factor for venous hypertension has been evaluated by many authors, such as Kundu [8], who has reported that central venous stenosis is a prevalent issue among individuals undergoing hemodialysis in the United States. It is believed that 25% to 40% of patients with ESRD undergoing hemodialysis exhibit central venous stenosis, a proportion that has remained

relatively stable since the shift from subclavian to jugular access for hemodialysis catheters.

Coinciding with the previous studies, in this study, all of the sixty patients (100%) had a history of central venous cannulation on the same side of the limb complicated with venous hypertension. Forty-three patients (71.6%) had subclavian vein catheters; seventeen patients (22.4%) had internal jugular vein dialysis catheters.

Regarding arteriovenous fistula type in the present study, they were brachiocephalic fistula in eighteen patients (30%), brachiobasilic fistula in twenty-five patients (41.6%), and none of the patients had a radiocephalic fistula, which is consistent with the previous studies. The commonest duration of fistula usage before the onset of venous hypertension ranged between 6 and 14 months in twenty-four patients (80%) of the study group. In this study, patients who had had a functioning fistula for more than one year were twenty-two (73.3%).

Concerning the clinical manifestations of CVS, Prasad et al.,[9] reported that Central venous stenosis can show up in several ways. Unilateral edema, discomfort, soreness, or erythema of the upper or lower extremities is the most typical symptom that patients experience. Aneurysms and a dilated tortuous access are discovered during the physical examination. Depending on where the blockage is, severe central venous stenosis can lead to a variety of symptoms, including facial edema, dilated collateral chest veins, enlarged breasts on one side, and enlarged veins in the neck. Unilateral pleural effusions occur in very few individuals.

Venous hypertension leads to increased trans-capillary pressures, driving fluid into the interstitium. This edema can interfere with finger function and limit joint mobility. The overall tissue edema has been implicated in the increased incidence of carpal tunnel syndrome.[10]

Again coinciding with the previously mentioned studies, in the present study the clinical features of the studied patients were swelling in sixty patients (100%), pain and hyperesthesia in eighteen patients (30%), ulcers in four patients (6.7%), hyperpigmentation in two patients (3.3%), impaired finger function, weak hand grip, and decreased motor power in four patients (6.7%), cyanosis in ten patients (16%), and dilated chest and neck veins in comparison with the other side in fifty-four patients (90%).

Pain was increased by dropping the upper limb, with dialysis, in the evening, with movement, with palpation, and relieved by bandage, limb elevation above the heart, elastic sleeves, and in the morning.

In the present study, venous duplex ultrasound was a very useful, noninvasive, and good diagnostic study for the evaluation of venous hypertension after arteriovenous fistula. Duplex findings and CT venography in the studied patients revealed stenosis of the subclavian vein in ten patients (20%), innominate vein in fifty patients (80%), and no stenosis or occlusion of the internal jugular vein.

Duplex ultrasound was very useful, and the main investigation was the assessment of fistula flow improvement after the endovascular intervention, with a mean preoperative fistula flow rate of 593 ml/min and a postvenous fistula flow rate of 1964 ml/min.

The technical success rate of PTA for CVOD was 77 percent in one of the biggest trials conducted on the topic by Bakken et al.[11] which involved 47 participants. At 3 months, the primary patency rate was 58 percent, at 6 months it was 45 percent, and at 12 months it dropped to 29 percent. Three months later, the cumulative patency rate was 76 percent, six months later it was 62 percent, and twelve months later it was 53 percent.

In recent small cohort research, Massmann et al.[12] demonstrated encouraging results with substantially greater patency (12 months) compared to conventional balloon angioplasty (5 months) utilizing a drug-coated balloon. But at this time, there isn't a balloon available that's bigger than 7 mm. Trerotola et al.,[13] included 30 persons in their prospective trial; five subjects were deregistered due to untreatable lesions, poor flow measurement timing, or a lack of CVS. The symptoms in these subjects were ipsilateral to their access. The study only included 25 participants. Three hybrid access circuits, fifteen grafts, and seven fistulae were present. Prior treatment focused on peripheral stenosis if it was detected. Prior to and immediately following CVS treatment, intra-access flow was assessed using either a PTA or a stent. Only eleven patients had CVS, while fourteen had CVS and one or more peripheral lesions. All stenoses underwent PTA. With a mean increase of 111 ml/min, the flow rates increased from 1,424 ml/min before PTA to 1,535 ml/min thereafter. There was a 36% drop in flow in 9 patients. Within an average of 110 days following the first PTA, 24 patients (96%) had a reduction in CVS symptoms, while 14 patients (58%) experienced a recurrence. The average duration between interventions was 371 days.

In the present study, the choice of management was endovascular interventions as the primary line of treatment.

All of the patients (100%) have tried conservative measures before without significant improvement or relief of their symptoms.

In nine patients (15%), the guide wire failed completely to cross the stenotic or the occluded

lesion, indicating a higher failure rate than the previously mentioned study, while in fifty-one patients (85%), endovascular interventions were successful. Results were satisfactory.

Fifty-one patients (85%) in our study were treated by percutaneous transluminal angioplasty by ballooning of the stenosed segment, while only twelve patients (20%) needed primary stenting for tight recoiling venous stenosis.

Three cases (5%) needed re-intervention after six months from the intervention in the form of venous angioplasty and stent.

All cases had severe symptoms such as limb swelling, pain during rest, increasing during dialysis, impaired finger function, cyanosis, dilated veins at the shoulder, weak hand grip, decreased motor power, hyperesthesia, hyperpigmentation, and ulcer. All these symptoms and signs disappeared without scarifying the fistula, except for a change in skin color.

4. Conclusion

Endovascular treatment is an effective and safe method for the treatment of CVD in patients undergoing hemodialysis. It has a high technical success rate without significant morbidity or mortality. Despite improvements in the management of CVD in the HD patient population, there remains considerable variability in the long-term outcome of these treatment options. Moreover, current treatment modalities are challenged by recurrent stenoses and/or occlusions requiring multiple repeat interventions to maintain patency.

Disclosure

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Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

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