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Comparative Study between Surgical Management and Venoplasty with Stenting in Cases of Recurrent Venous Hypertension in Hemodialysis Patient.

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ABSTRACT

Background: Recurrent venous hypertension due to central venous stenosis or occlusion is a common complication in hemodialysis patients, often resulting from previous central venous catheterization. Endovascular treatments like balloon angioplasty and stenting offer initial relief but suffer from high recurrence rates, while surgical interventions provide alternative solutions when endovascular therapy fails.

Objective: to compare short-term outcomes between venoplasty with stenting and surgical management in recurrent venous hypertension secondary to central venous occlusion among hemodialysis patients.

Patients and Methods: This prospective randomized trial was conducted on 40 patients with recurrent venous hypertension, assigned to receive either endovascular stenting or surgical bypass. Clinical and imaging assessments were performed, with patency and symptom resolution evaluated at 1, 3 and 6 months.

Results: Postoperative arm circumference showed a significantly greater reduction in the surgical group (P=0.003), with both groups having significant within-group decreases (P<0.001) and no baseline differences (P=0.390). Similarly, forearm circumference reduction was significantly greater in the surgical group (P<0.001), with significant decreases in both groups post-intervention (P<0.001) and comparable preoperative measurements (P=0.201). Intraoperative venography findings differed significantly between groups (P=0.004), indicating more severe lesions in the surgical group, Procedure duration was significantly longer in the surgical group (P<0.001).

Conclusion: Surgical venous drainage provided superior primary patency and more effective early resolution of limb swelling compared to venoplas ty with stenting, despite longer operative time. Both interventions are effective in maintaining dialysis access, however venoplasty is safer compared to surgical venous drainage which is associated with higher 30-days mortality rate.

KEYWORDS: Surgical Management, Venoplasty, Recurrent Venous Hypertension, Hemodialysis Patient.

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INTRODUCTION

Patients with end-stage renal disease are usually dependent on haemodialysis. A native arteriovenous fistula, synthetic arteriovenous graft fistula, or cuffed central venous catheter may be used for vascular access in these patients [(1)]. Hemodialysis vascular access dysfunction is a major cause of morbidity and mortality in patients undergoing hemodialysis. A common cause of vascular access dysfunction is central venous stenosis or complete occlusion of the central vein [(2)].

The increase of population of people with end-stage renal disease and improvement of their life expectancy on dialysis made the issue of vascular access creation and preservation of great importance [(3)].

Central Venous Stenosis or Occlusion (CVSO) is a major complication in hemodialysis patients causing significant morbidity and failure of the peripheral ArterioVenous Fistula (AVF). The prevalence of CVSO in hemodialysis patients is between 25- 40% [(4)].

There has been a strong association of CVSO with previous placement of central venous catheters and pacemaker wires [(5)]. The location of the central venous catheter is also an important causative factor for CVSO. Central venous catheters placed by a subclavian access have a particularly high risk, with a 42% incidence of CVSO compared with a 10% rate with catheters placed via an internal jugular vein access. There is also an increased predilection for CVSO to occur with left-sided access for catheter placement. This may be related to the more tortuous course catheters have to traverse from a left-sided access [(6)].

A suggested mechanism for the development of CVSO includes central venous catheter-induced trauma to the venous

endothelium and secondary inflammatory damage within the vessel wall at the time of insertion. Other proposed mechanisms include the presence of a foreign body in the vein, along with increased flow and turbulence from the creation of an ArterioVenous access. Turbulent blood flow has been shown to incite an inflammatory response and stimulate intimal hyperplasia [7].

The increase of population of people with end-stage renal disease and improvement of their life expectancy on dialysis made the issue of vascular access creation and preservation of great importance [3].

Percutaneous methods as ballon dilatation, and endoVascular stent insertion for treating central venous stenosis are safe, effective, and are not associated with morbidity with an advantage of AVF preservation but are prone to recurrence, requiring multiple repeated interventions to maintain patency [8].

With evaluation of the patency rates with balloon dilatation for CVSO primary patency (was defined as the interval following intervention until the need for other intervention) and secondary patency (was defined as the interval after intervention till the access was completetly abandoned) rates at 3/6/12 months were 58/45/29% and 76/62/53% respectively [9].

Percutaneous endovascular therapy continues to be the first-line treatment for CVSO. However, in patient's refractory to endovascular options or recurrence of CVSO, surgical possibilities must be considered if there is a functioning hemodialysis access in the ipsilateral extremity to the site of CVSO, the easiest surgical solution for access-associated CVSO is ligation of the access, which results in immediate relief of symptoms. At the same time ligation is the most frustrating option as the vascular pathology causing the patient's problem is not corrected and makes creation of a new permanent vascular access necessary [10].

Extra-anatomic bypass, including subclavian vein to external or internal jugular vein bypass, or axillary to femoral vein bypass is valiable surgical options [11]. The aim of the study is to compare the short-term outcomes of endovascular management with stenting and surgical management in cases of recurrent venous hypertension due to central venous occlusion in hemodilaysis patients in terms of primary and secondary patency.

PATIENTS AND METHODS

This prospective randomized double arm clinical trial was conducted on 40 patients with End Stage Renal Disease (ESRD) undergoing regular hemodialysis presenting to outpatient clinics of Ain Shams University Hospitals with recurrent venous hypertension due to central venous occlusion or stenosis over 6-months study period.

Eligible patients who fulfilled the inclusion criteria were randomly allocated into one of two treatment groups in a 1:1 ratio: the surgical bypass group or the venoplasty with stent insertion group. Randomization was performed using a computer-generated random sequence to ensure unbiased allocation. Allocation concealment was achieved using sequentially numbered, opaque, sealed envelopes, which were opened only after patient enrollment and completion of baseline assessment.

Due to the nature of the interventions, blinding of the operating surgeons and patients was not feasible; however, outcome assessment and follow-up evaluations were performed according to predefined objective criteria to reduce assessment bias.

Inclusion Criteria:

Patients of both genders aged ≥ 18 years.

Recurrent venous hypertension within less than 3 months after a previously successful venoplasty.

ASA physical status classification ≤3.

Patient suitable for surgical management with at least one radiologically confirmed patent venous outflow pathway (contralateral or ipsilateral innominate vein or femoral vein with patent IVC).

Exclusion Criteria:

Patient refusal to provide informed consent.

Patients on peritoneal dialysis.

Lower limb Arteriovenous Fistulas (AVFs).

Pediatric patients, or congenital central vein anomalies.

Contrast media allergies, or pregnancy.

Patients were randomized into two groups: group A: Venoplasty with stenting (n=20), group B: Surgical venous drainage

(n=20).

Methods:

All patients were subjected to data collection including the following:

History taking

Age, gender, smoking status, history of Diabetes Mellitus (DM), Dyslipidemia, Hypertension (HTN), ischemic heart disease, and previous central venous catheterization. Additionally, detailed medication history was recorded.

Moreover, the duration of dialysis (in years) and the type of dialysis access were recorded, including brachiocephalic AVF, brachio-basilic AVF, and bridging arm brachio-axillary arteriovenous grafts (BA AVG). Patients' presenting symptoms were also documented and included arm swelling, insufficient dialysis efficiency, facial swelling, prolonged bleeding after dialysis, and the presence of visible anterior chest wall venous collaterals.

All patients were subjected to a full physical examination, including assessment for edema, visible chest wall collaterals, and general parameters (blood pressure, heart rate, temperature, respiratory rate, and BMI). Arm and forearm circumference measurements were recorded pre and postoperatively. Routine laboratory investigations were done including hemoglobin, platelet count, postdialysis ABG, postdialysis serum creat. and INR. Preoperative duplex ultrasound and either CT venography or intraoperative venography to assess central venous anatomy and occlusion.

Intervention Procedures

- Venoplasty with Stenting Group:

Patients randomized to the endovascular arm underwent venoplasty with stenting. The procedure was indicated in cases presenting with recurrent arm swelling, elevated venous pressures during dialysis sessions, reduced dialysis efficiency, or new-onset facial and chest wall edema. All procedures were performed under local anesthesia and conscious sedation. The procedure began with percutaneous access via single puncture at the arteriovenous access site—either trans-cephalic, trans-basilic, trans-graft, or transfemoral approach depending on lesion accessibility under ultrasound guidance.

Initial diagnostic venography was performed to assess the presence and location of central venous stenosis or occlusion. A 10 Fr vascular sheath was placed, followed by passage of a hydrophilic guidewire across the stenotic or occluded segment under fluoroscopy. In cases of tight or long occlusion, serial dilation or the use of a stiff angled guidewire was required to traverse the lesion. Once the wire was successfully passed, serial balloon dilation was performed using high-pressure non-compliant balloons (ranging from 6–14 mm in diameter) selected based on pre-dilated venous diameter appropriately sized high-pressure balloons based on the diameter of adjacent normal venous segments.

Self-expanding bare-metal nitinol stents (abre) or cobalt – chromium (wall stent) (10–14 mm in diameter) were deployed across the lesion, ensuring 1–2 cm extension into healthy vein proximally and distally. while stent sizing and deployment strategy were based on lesion length, vessel diameter, and flow dynamics. Procedural data, including number of sheaths, guidewires, balloons, and stents used, as well as procedure duration, were meticulously recorded. Post-`dilation was performed to ensure full stent expansion. Completion venography confirmed flow restoration. Hemostasis was achieved by manual compression. All patients were discharged on antiplatelet therapy (aspirin 100 mg ± clopidogrel 75 mg daily) for at least 3 months postoperatively, adjusted based on patient comorbidities and bleeding risk.

- Surgical Venous Drainage Group:

Patients allocated to surgical intervention underwent extra-anatomic bypass procedures aimed at decompressing the venous hypertension and preserving dialysis access. All surgeries were performed under general anesthesia by experienced vascular surgeons. Depending on anatomical feasibility. Four types of bypass configurations were utilized: axillo-jugular, axillo-axillary, cephalo-jugular, and cephalo-axillary bypasses. The choice of bypass type was determined preoperatively based on venographic findings and intraoperative assessment of inflow and outflow vessel availability.

An 8 mm ringed PTFE graft was tunneled subcutaneously to avoid kinking. After systemic heparinization (50–70 IU/kg), proximal and distal veins were clamped and longitudinal venotomies were created. End-to-side or side-to-side anastomoses were performed using 5-0 or 6-0 polypropylene suture under magnification. Graft patency and flow were confirmed intraoperatively by visual inspection palpable thrill and Doppler flow signals. Surgical drains were placed when necessary, and wounds were closed in layers. Postoperative monitoring focused on graft function, resolution of venous hypertension symptoms, and the occurrence of any complications, including hematoma, surgical site infection, or graft failure.

Patients received perioperative antibiotics and antiplatelet therapy postoperatively (aspirin 100 mg). Close follow-up was scheduled with duplex scans to monitor for graft function, and complications.

Postoperative assessment and follow-up

All patients were followed up clinically and radiologically for a minimum of 6 months post-procedure. Follow-up visits were scheduled at 2 weeks, 1 month, 3 months, and 6 months. Each visit included: Clinical assessment of venous hypertension symptoms (e.g., arm swelling, facial puffiness, breast engorgement, increased venous pressure during dialysis, prolonged post dialysis bleeding, or venous collateral formation). Inspection and palpation of vascular access, including auscultation of bruit. Measurement of limb circumference (forearm and arm), compared to pre-intervention baseline, assessment of dialysis function (flow adequacy, recirculation, access pressures), duplex ultrasound to evaluate: graft or stent patency, presence of restenosis (>50% lumen loss).

Statistical Analysis

Data management and statistical analysis were done using SPSS version 27 (IBM, Armonk, New York, United States). Quantitative data were assessed for normality using the Shapiro-Wilk test and direct data visualization methods. According to normality, quantitative data were summarized as means and standard deviations or medians and ranges. Categorical data were summarized as numbers and percentages. Quantitative data were compared between the groups using Independent t Test and Mann–Whitney U Test for parametric and non-parametric variables, respectively. Categorical data were compared using the Chi-square or Fisher's exact test. All statistical tests were two-sided. P-values less than 0.05 were considered significant.

RESULTS

In this study, forty ESRD patients with recurrent venous hypertension due to central venous occlusion divided into 2 equal groups. Results and data analysis are presented in the following tables and figures.

Table 1: Shows the age distribution of the 2 groups

		Modality of intervention			T-Test	
		Venoplasty with stenting	Surgical venous drainage	Total	t	P-value
Age	Range	41 - 77	35 - 71	35 - 77	1.306	0.199
	Mean ±SD	60.850 ± 10.414	56.650 ± 9.912	58.750 ± 10.258		

Table 2: Showing gender distribution into the 2 groups:

		Modality of intervention						T-Test	
		Venoplasty with stenting		Surgical venous drainage		Total		T	P-value
Chi-Square		N	%	N	%	N	%	X^2	P-value
Sex	Male	12	60.00	13	65.00	25	62.50	0.107	0.744
	Female	8	40.00	7	35.00	15	37.50		

Table 3: Showing pre and 1 month postoperative arm circumference (CM)

Arm circumference	Modality of intervention			T-Test	
	Venoplasty with stenting	Surgical venous drainage	Total	t	P-value

Preoperative	**Range**	32.8 - 38.1	32.6 - 37	32.6 - 38.1	0.870	0.390
	Mean ±SD	34.980 ± 1.203	34.670 ± 1.046	34.825 ± 1.124		
Postoperative 1 Month	**Range**	30.8 - 35.7	29.6 - 33.7	29.6 - 35.7	3.238	0.003*
	Mean ±SD	32.655 ± 1.188	31.420 ± 1.224	32.038 ± 1.345		
Differences	**Mean ±SD**	2.325 ± 1.594	3.250 ± 0.562	2.787 ± 1.269		
Paired Test	**P-value**	<0.001*	<0.001*	<0.001*		

Table 4: Showing pre and 1 month postoperative forearm circumference (CM)

Forearm circumference		**Modality of intervention**			**T-Test**	
		Venoplasty with stenting	**Surgical venous drainage**	**Total**	**t**	**P-value**
Preoperative	**Range**	28.4 - 32.6	27.1 - 32.1	27.1 - 32.6	1.301	0.201
	Mean ±SD	30.385 ± 1.244	29.880 ± 1.210	30.133 ± 1.238		
Postoperative 1 Month	**Range**	26.4 - 30.6	23.6 - 28.7	23.6 - 30.6	4.178	<0.001*
	Mean ±SD	28.445 ± 1.331	26.725 ± 1.272	27.585 ± 1.552		
Differences	**Mean ±SD**	1.940 ± 0.338	3.155 ± 0.576	2.548 ± 0.772		
Paired Test	**P-value**	<0.001*	<0.001*	<0.001*		

Postoperative measurements showed significant reduction in both arm and forearm circumferences in both groups. However, the surgical group had a greater reduction: Arm circumference reduction: 4.25 ± 0.56 cm vs 2.32 ± 1.59 cm ($p = 0.003$); Forearm circumference reduction: 4.15 ± 0.57 cm vs 1.94 ± 0.34 cm ($p < 0.001$). This reflects more pronounced decompression of venous hypertension following surgical bypass.

Table 5: Showing preoperative venous duplex results in our study

Duplex Pre operative		
	N	**%**
Positive finding	29	72.50
Negative findings	11	27.50
Total	40	100.00

Preoperative duplex scanning showed positive findings in 72.5% (29/40) of patients, confirming central venous occlusion or stenosis. Negative findings were noted in 27.5%, who were subsequently diagnosed via intraoperative venography.

Table 6: Showing different lesions encoutred during venography

	Modality of intervention			**Chi-Square**
	Venoplasty with stenting	**Surgical venous drainage**	**Total**	

		N	%	N	%	N	%	X^2	P-value
Intra operative Venography	Right BCV stenosis	4	20.00	0	0.00	4	10.00	25.600	0.004*
	Left BCV stenosis	3	15.00	0	0.00	3	7.50		
	Right SC stenosis	3	15.00	0	0.00	3	7.50		
	Left SC stenosis	4	20.00	0	0.00	4	10.00		
	Right BCV occlusion	2	10.00	6	30.00	8	20.00		
	Left BCV occlusion	1	5.00	1	5.00	2	5.00		
	Right SC occlusion	2	10.00	8	40.00	10	25.00		
	Left SC occlusion	0	0.00	2	10.00	2	5.00		
	Right axillary stenosis	1	5.00	0	0.00	1	2.50		
	Right axillary occlusion	0	0.00	2	10.00	2	5.00		
	Left axillary occlusion	0	0.00	1	5.00	1	2.50		

Intraoperative venography revealed variable lesion patterns. The venoplasty group had a higher incidence of stenotic lesions, particularly in the brachiocephalic and subclavian veins, while the surgical group presented more frequently with occlusive lesions, especially in the right subclavian and axillary veins. The distribution was statistically significant (p = 0.004), confirming the tendency to reserve surgical bypass for more complex occlusive cases.

Table 7: Showing access ballon size and stent size using in the venoplasty with stenting arm

Venoplasty with stenting			
		N	%
Access	Complex	9	45.00
	Simple	11	55.00

Among patients undergoing venoplasty, could be achieved successfully with complex access (2 or more access) in 9 patinets (45%) and 11 patient (55%) simple access (one access).

Table 8: Showing the different procedure done for the surgical venous drainage group

Surgical venous drainage			
		N	%
Procedure	Axillo contraljagular	6	30.00
	Axillo contralaxillary	4	20.00
	Cephalo contralteraljagular	6	30.00
	Cephalo contralateralaxillary	4	20.00

In the surgical group, common bypass routes included axillocontralateraljugular (30%), cephalocontralateraljugular (30%), cephalocontralateralaxillary (20%), and axillocontralateralaxillary (20%) reconstructions, reflecting the surgeon's preference and anatomical suitability.

Table 9: Showing procedure duration in the 2 groups:

		Modality of intervention			T-Test	
		Venoplasty with stenting	Surgical venous drainage	Total	T	P-value
Duration of Procedure (Hours)	Range	0.5 - 3	2 - 4	0.5 - 4	-5.533	<0.001*
	Mean ±SD	1.725 ± 0.752	2.925 ± 0.613	2.325 ± 0.910		

The average procedure time was significantly shorter in the venoplasty group (1.72 ± 0.75 hours) compared to the surgical group (2.93 ± 0.61 hours), with a statistically significant difference ($p < 0.001$).

Table 10: Showing 1ry and 2ry patency between the two groups at 6 months

Postoperative 6 Months	Modality of intervention						Chi-Square	
	Venoplasty with stenting		Surgical venous drainage		Total			
	N	%	N	%	N	%	X^2	P-value
1ry patency	10	52.63	15	83.33	25	67.57	3.976	0.046*
2ry patency	15	78.95	16	88.89	31	83.78	0.672	0.412

At 6 months, primary patency was significantly higher in the surgical group (83.33%) compared to the venoplasty group (52.63%) ($p = 0.046$). Secondary patency remained higher in surgery (88.89% vs 78.95%), though the difference was not significant ($p = 0.412$).

Table 11: Showing 30 day mortality and all cause mortality between the 2 groups

	Modality of intervention						Chi-Square	
	Venoplasty with stenting		Surgical venous drainage		Total			
	N	%	N	%	N	%	X^2	P-value
Mortality all cause	1	5.00	2	10.00	3	7.50	0.360	0.548
Mortality 30 Days	0	0.00	2	10.00	2	5.00	2.105	0.147

The all-cause mortality rate was higher in the surgical group (2 deaths, 10%) vs the venoplasty group (1 death, 5%), with no statistically significant difference ($p = 0.548$).

Table 12: Showing the re intervention success rate between the 2 groups

RE intervention success rate	Modality of intervention						Chi-Square	
	Venoplasty with stenting		Surgical venous drainage		Total			
	N	%	N	%	N	%	X^2	P-value
Yes	9	75.00	1	33.33	10	66.67	1.875	0.171

No	3	25.00	2	66.67	5	33.33		
Total	12	100.00	3	100.00	15	100.00		

Reintervention was attempted in 12 venoplasty patients and 3 surgical patients. The success rate was higher in the venoplasty group (75% vs 33.3%).

DISCUSSION

Patients with end-stage renal disease (ESRD) frequently depend on hemodialysis for survival, requiring reliable vascular access such as native arteriovenous fistulas (AVF), synthetic grafts, or tunneled cuffed central venous catheters. Dysfunction of these vascular accesses contributes significantly to morbidity and mortality in dialysis-dependent individuals [(12)].

A major cause of hemodialysis access dysfunction is central venous stenosis or occlusion (CVSO), which can lead to venous hypertension, arm swelling, and access failure. The prevalence of CVSO among hemodialysis patients ranges between 25% and 40%, making it a critical complication to address [(13)]. Central venous catheter placement is a key risk factor for the development of CVSO, especially when inserted via subclavian or left-sided access routes, due to increased catheter-induced trauma, endothelial injury, and turbulent flow promoting intimal hyperplasia. These factors contribute to stenosis formation, complicating long-term access maintenance [(14)].

Percutaneous balloon angioplasty and stenting represent first-line treatments for CVSO, offering minimally invasive and effective interventions but are prone to recurrence requiring multiple procedures to maintain patency [(14)]. Surgical bypass procedures, such as axillojugular or cephalojugular bypass, are considered when endovascular options fail or in cases of recurrent venous hypertension, though they come with increased risks and technical complexity [(15)].

The aim of the study is to compare short-term outcomes between surgical venous drainage and venoplasty with stenting for recurrent venous hypertension due to central venous occlusion or stenosis in hemodialysis patients, focusing on primary and secondary patency rates.

This prospective randomized double-arm clinical trial was conducted on 40 ESRD patients presenting with recurrent venous hypertension. Patients were randomized to undergo either endovascular stenting or surgical venous drainage. Outcomes were evaluated using pre- and post-intervention clinical assessments, imaging, and statistical analysis of primary and secondary patency over a 6- month follow-up period. In the present study at one month postoperatively, the surgical venous drainage group showed a greater reduction in both arm and forearm circumference compared to the venoplasty with stenting group, indicating superior effectiveness in relieving venous hypertension-related limb swelling. While both interventions significantly reduced limb circumference within their respective groups, highlighting that surgical drainage may provide more substantial early improvement in edema resolution.

Parallel to our findings, ***Ayarragaray et al.*** evaluated surgical decompression of central venous occlusion in three end-stage renal disease patients with malfunctioning hemodialysis grafts by creating a bypass to the ipsilateral femoral vein using a subcutaneously tunneled 6 mm PTFE graft. Their study demonstrated clear symptomatic improvement in venous hypertension, with reduced venous pressures and no perioperative complications during an average follow-up of 16.3 months [(16)].

Also, ***Hameed and Mohamed*** conducted a retrospective study on 14 hemodialysis patients with central venous occlusive disease and symptomatic venous hypertension who underwent extra-anatomic surgical bypass after failed endovascular management. They reported a technical success rate of 100% and clinical success in 92.6% of cases, with most patients (85.7%) resuming dialysis through their existing access within 24 hours postoperatively [(17)].

In addition, ***Hosny et al.*** retrospectively evaluated 17 hemodialysis patients with native AVF and upper-limb venous hypertension secondary to central venous occlusion who underwent venous bypass surgery. They reported remarkable postoperative improvements, with circumference reductions of 93.4% at the wrist, 94% at the mid-forearm, 88% at the elbow, and 92% at the mid-arm over the first 6 months [(18)].

Concerning angioplasty, the hemodialysis patients with central venous stenosis or occlusion who underwent percutaneous transluminal angioplasty (PTA) with or without stenting, reported significant postintervention improvements in swelling ($P<0.001$), pain ($P=0.022$), and dilated chest and neck veins ($P<0.001$), with 76.7% of patients showing improvement at 1 month, rising to 95.7% at 6 months [(19)].

In the current study, surgical venous drainage procedures took considerably longer to perform than venoplasty with stenting,

reflecting the greater complexity and technical demands of the surgical approach. Despite the extended operative time, surgical venous drainage typically involves open dissection, creation of bypass grafts, meticulous handling of delicate vascular structures, and the need for careful hemostasis, all of which are time-consuming processes. Additionally, these surgeries often require extensive preparation, positioning, and more elaborate anesthesia management [16].

In contrast, venoplasty with stenting is a minimally invasive endovascular technique performed through percutaneous access, allowing for faster intervention with the aid of fluoroscopic guidance and specialized catheters and balloons [20]. As a result, the technical demands, stepwise nature of open surgery, and the need to directly reconstruct or reroute venous pathways contribute to the longer operative duration in the surgical group, despite both procedures aiming to relieve central venous obstruction and restore effective dialysis access.

This study found that both treatment groups showed similar primary and secondary patency rates at 3 months postoperatively, with no significant differences. However, by six months, surgical venous drainage demonstrated superior primary patency compared to venoplasty with stenting, indicating better mid-term maintenance of uninterrupted access. Despite this, secondary patency rates remained comparable between groups at six months, suggesting that both approaches are equally effective in sustaining vascular access with additional interventions if needed.

In accordance, ***Hosny et al.*** found that primary patency rates after venous bypass surgery were 88.2% and 82% at 6 and 12 months, respectively [18]. Also, another study by ***Suliman et al.***, evaluated surgical bypass for central venous obstruction in three hemodialysis patients with severe venous hypertension and failed PTA, demonstrating complete symptom resolution and maintained AVF function during follow-up. They reported durable bypass patency (3–8 months) without operative mortality [21].

Similarly, ***Wang et al.*** evaluated surgical extra-anatomic venous bypass using the internal jugular vein as the outflow tract in 21 hemodialysis patients with central venous stenosis or cephalic arch stenosis, aiming to relieve venous hypertension and preserve access. They reported one-year primary and secondary patency rates of 79% and 79%, respectively, and two-year rates of 65% and 79% for central venous stenosis cases. These primary patency rates are broadly consistent with the higher six-month primary patency observed in our surgical group, suggesting that surgical bypass offers durable patency over time [15]. However, their secondary patency rates were higher than ours, which may be explained by their longer follow-up, systematic use of advanced imaging (CTA and bilateral venography).

In close proximity to our findings, ***Nasser et al.*** retrospectively studied 40 Egyptian hemodialysis patients who underwent sharp venous recanalization—a technique used when conventional endovascular methods failed to cross chronic CVOs—followed by angioplasty and stenting. They reported high technical and clinical success rates of 90%, with a primary patency rate of 77.5% and secondary patency of 100% at 12 months [22].

Also, ***Dammers et al.*** retrospectively analyzed 28 hemodialysis patients with symptomatic central venous obstruction who underwent either PTA or surgical reconstruction. They reported an impressive overall initial clinical success rate of 92% for both PTA and surgery, with primary patency rates of 63% at 6 months and 50% at 12 months after PTA, and a higher 12-month primary patency rate of 75% for surgical reconstruction [23]. Similar to our observations, surgery demonstrated better patency outcomes compared to radiological intervention.

A study by ***Eguchi and Honma*** retrospectively analyzed 21 hemodialysis patients treated with stenting for superior vena cava (SVC) or brachiocephalic vein occlusion, aiming to evaluate long-term patency outcomes and symptom relief. They reported primary patency rates declining to 67% at 12 months and 42% at 24 months, while secondary patency rates remained more favorable at 90% and 79%, at these intervals indicating lower efficacy of stenting [24].

In addition, ***Nakao et al.*** retrospectively reviewed 31 hemodialysis patients treated with stenting for symptomatic central venous obstruction, aiming to clarify the safety and midterm efficacy of contemporary endovascular therapy. They reported primary patency rates of 66.1% at 6 months, 61.7% at 12 months, and 38.4% at 24 months, with an assisted primary patency of 70.3% at 24 months highlighting the lower efficacy of stenting [25].

In contrast to our results, ***Ibrahim et al.*** conducted a prospective cohort study of 50 hemodialysis patients with central venous stenosis who underwent percutaneous angioplasty with or without stenting. They reported primary patency rates of 97% and 70% at 6 and 12 months, respectively. This indicates the higher efficacy of angioplasty which contrasts our results [26].

Also, ***Ismail et al.*** conducted a prospective study on 32 hemodialysis patients with central vein occlusive disease treated with balloon angioplasty with or without bailout stenting, aiming to assess feasibility and efficacy. They reported a technical success rate of 81.3%, with primary patency rates for balloon angioplasty at 80%, 65%, and 55% at 3, 6, and 12 months, respectively, versus 66.6%, 33.3%, and 33.3% for those requiring stenting, though the difference did not reach statistical

significance (P=0.17) [27]. This high efficacy of angioplasty contrasts our results which may be atrbuted to difference in sample size or methodology.

Furthermore, ***Nayak-Rao et al.*** studied 10 hemodialysis patients treated with percutaneous angioplasty with primary stenting for central venous stenosis, reporting higher primary patency rates of 90% at 3 months, 80% at 6 months, and 70% at both 12 and 24 months. These findings suggest better midterm patency in endovascular cohort compared to the lower 6-month primary patency we observed in our venoplasty with stenting group (52.63%), but inferior to our surgical group's 83.33% patency at the same interval [28]. This discrepancy may be explained by the small sample size, differences in patient selection.

Another study by ***Cuthbert et al.*** evaluated 132 central venoplasties in 76 hemodialysis patients and reported primary patency rate of 87% at 6 months. Their six-month patency of 87% appears favorable and high efficacy of venoplasty [29].

Although the differences in 30-day mortality and overall procedure-related adverse events between the two groups did not reach statistical significance, the numerical trend clearly favored the venoplasty group. The surgical arm recorded a 30-day mortality rate of 10% (2 out of 20), while no early deaths occurred in the venoplasty group. Likewise, adverse events were more frequent in the surgical group (35%) compared to 10% in the venoplasty arm, suggesting a higher perioperative morbidity associated with open reconstruction. While this may not be statistically significant due to the small sample size, the findings align with other studies that associate surgical bypass with increased procedural burden and risk. These differences, even if not statistically confirmed, carry important clinical implications when considering treatment for high-risk patients.

Contrasting to our results, ***Dammers et al.*** examined the outcomes of 45 interventions—comprising 30 percutaneous angioplasties and 10 surgical reconstructions—for symptomatic central venous obstruction in hemodialysis patients with AVFs. The study included 28 patients and assessed patency and clinical success rates. No perioperative mortality or major morbidity was observed in the surgical group, contrasting our high surgical mortality rate, as we noted a 10% early mortality [23].

A systematic review of 55 hemodialysis patients undergoing right atrial (central) bypass grafting reported a 30-day mortality rate of 4%, with postoperative complications including bleeding (4%) and thrombosis (4%) — notably higher than less invasive interventions.

Clinical Implications

This study highlights the importance of individualized intervention strategies in the management of recurrent venous hypertension among hemodialysis patients. While both surgical bypass and venoplasty with stenting are effective, surgical intervention offers superior short-term primary patency and more rapid relief of symptoms such as limb swelling. These findings support the early consideration of surgical bypass in patients with severe or recurrent central venous occlusion, especially when endovascular options fail or when lesions are complex.

Strength Points

One of the main strengths of this study is its prospective, randomized design, which minimizes selection bias and enhances the reliability of the findings. Furthermore, standardized clinical and imaging assessments were performed at multiple time points, enabling a robust comparison of outcomes. The study also provides detailed intraoperative and procedural data, offering valuable insights into technical aspects and postoperative improvements.

Limitations

Despite its strengths, the study has several limitations. The sample size was relatively small (40 patients), which may reduce the generalizability of the findings. Additionally, the follow-up period was limited to 6 months, preventing assessment of long-term patency and complications. There was also a lack of blinding due to the nature of surgical and endovascular procedures, which might introduce performance or detection bias, though outcome measures were objectively defined.

CONCLUSION

In conclusion, surgical venous drainage provided superior primary patency and more effective early resolution of limb swelling compared to venoplasty with stenting, despite longer operative time. Both interventions are effective in maintaining dialysis access, however venoplasty is safer compared to surgical venous drainage which is associated with higher 30-days mortality rate.

List of Abbreviations

Abbreviation	Definition
BMV	Balloon Mitral Valvuloplasty
MS	Mitral Stenosis
MVA	Mitral Valve Area
LA	Left Atrium
LV	Left Ventricle
RV	Right Ventricle
EF	Ejection Fraction
LVEF	Left Ventricular Ejection Fraction
LVEDVI	Left Ventricular End-Diastolic Volume Index
LVESVI	Left Ventricular End-Systolic Volume Index
TAPSE	Tricuspid Annular Plane Systolic Excursion
FAC	Fractional Area Change
PASP	Pulmonary Artery Systolic Pressure
PHT	Pressure Half Time
M-Mode	Motion Mode (Echocardiography)
LAVI	Left Atrial Volume Index
LADI	Left Atrial Diameter Index
LASr	Left Atrial Reservoir Strain
LAScd	Left Atrial Conduit Strain
LASct	Left Atrial Contractile Strain
2D	Two-Dimensional
STE	Speckle Tracking Echocardiography
NYHA	New York Heart Association
ECG	Electrocardiogram

Ethical Considerations

The study protocol was reviewed and approved by the institutional ethics committee. Written informed consent was obtained from all participants before enrollment. All procedures were performed in accordance with the ethical standards of the Declaration of Helsinki and national research guidelines.

Conflicts of Interest

The authors declare no conflicts of interest related to this study.

Confidentiality of Data

All patient data were anonymized and handled with strict confidentiality. Records were stored securely and accessed only by the research team for the purposes of this study.

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