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Research Article

Emergent Hemodialysis Access: Balloon Venoplasty and Tunneled Catheter Placement in Patients with Exhausted Venous Access – Evaluation of Safety and Patency Determinants

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Background/Objectives: Central venous occlusion (CVO) presents a significant challenge in providing emergency hemodialysis to patients with end-stage renal disease (ESRD). This study evaluated the feasibility, safety, and effectiveness of percutaneous transluminal balloon venoplasty to restore central venous patency and enable tunneled hemodialysis catheter placement in patients with complete CVO. This study specifically focused on patients with complete occlusion of all central venous pathways, a rare and underreported scenario in the literature.

Methods: This retrospective, single-center observational study included 50 dialysis patients with confirmed occlusion of all central veins between November 2015 and September 2024. Balloon venoplasty was performed to recanalize the occluded veins, followed by the placement of a catheter. Patients were monitored for catheter patency and complications, and predictors of catheter dysfunction were analyzed.

Results: A 100% technical success rate was achieved. The mean primary patency duration was 4 months (range: 1–37 months). Catheter dysfunction occurred in 11 patients (22%), primarily due to infection or occlusion. Multivariable analysis identified catheter distal tip location as the sole predictor of dysfunction (OR: 0.146, 95% CI: 0.026–0.816, p = 0.028). Catheters with tips in the right atrium demonstrated better patency than those in the inferior vena cava. Minor complications included hematomas (11.3%) and arrhythmias (16.1%).

Conclusions: Balloon venoplasty is a safe and effective technique for managing patients with exhausted central venous access, providing emergency hemodialysis, and acting as a bridge to definitive solutions such as AV fistulas, peritoneal dialysis, or renal transplantation. To optimize patency and reduce the risk of dysfunction, catheter tips are recommended to be placed in the right atrium. Further research is needed to refine this approach and extend access longevity.

Keywords: Central venous occlusion, Balloon venoplasty, Tunneled dialysis catheter, Emergency hemodialysis, Vascular access, Central vein recanalization

1. INTRODUCTION

Long-term dialysis catheter use can cause vascular injury, endoluminal occlusion due to thrombus formation, extrinsic compression from musculoskeletal (e.g., costoclavicular or sternal) or vascular (e.g., aortic ectasia) sources, or hemodynamic abnormalities that promote neointimal hyperplasia. Several factors may cause bilateral occlusion of central veins, necessitating catheter placement in the femoral vein.[1,2] Emergency hemodialysis becomes a significant challenge when all viable access routes are blocked, requiring innovative approaches to restore central venous patency.

Percutaneous transluminal balloon venoplasty (PTBV) recanalizes occluded central venous (OCV) pathways to enable tunneled dialysis catheter (TDC) placement through PTBV.[2-4] With this technique, patients can initiate hemodialysis promptly and transition to more definitive treatment options, such as renal transplantation, preparation for peritoneal dialysis, or the creation of arteriovenous fistulas (AVF).

In addition to PTVB, sharp recanalization has been demonstrated to restore central venous patency, allowing TDC to be placed in challenging situations.[5,6] TDC placement can also be achieved

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via alternative methods, including femoral vein access and mediastinal tunneling. However, each has specific limitations and risks.[7, 8]

This study aimed to evaluate the feasibility, safety, and effectiveness of PTBV in restoring central venous patency in patients with complete OCV pathways who require emergency hemodialysis. The research also looked into the duration of hemodialysis possible after recanalization of the pathway using this method and the functional duration of this intervention before transitioning to more permanent solutions.

2. MATERIALS AND METHODS

2.1. Patients

This study was designed as a retrospective, single-center observational study. A total of 54 patients with an urgent need for hemodialysis and who underwent central venous occlusion treatment followed by tunneled hemodialysis catheter placement were identified from hospital records between November 2015 and September 2024. Among these, 50 patients met the specific inclusion criteria and were included in the study. Four patients were excluded as they did not meet the required criteria.

This study was approved by the Başkent University Medical and Health Sciences Research Committee (Project No. KA 25/17) and conducted in accordance with the ethical principles outlined in the Declaration of Helsinki**.** Written informed consent was obtained from all patients prior to the procedure.

The included patients were those with complete occlusion of all central veins, including the right and left brachiocephalic veins (BCVs) or superior vena cava (SVC), and the right and left iliac veins or inferior vena cava (IVC), resulting in no remaining vascular access for hemodialysis.

2.2. Inclusion criteria

Patients were included in the study if they met the following criteria:

1. Angiographic imaging confirmed the Complete occlusion of all four central venous systems (right and left BCVs or SVC, and right and left iliac veins or IVC).
2. Acute need for hemodialysis at the time of presentation.
3. Placement of a tunneled hemodialysis catheter following central venous intervention.
4. Availability of complete clinical and procedural records.

Patients who did not meet these criteria were excluded from the study.

The patients were selected based on clinical examination and duplex ultrasound (DUS) findings of both the upper and lower limbs. The occlusion of all central veins was confirmed by angiography.

2.3. Technical aspects

Written informed consent was obtained before the procedure, and potential drawbacks were explained to the patients in simple language. Patients were transferred to the angiography suite (*GE Innova™ 3100 angio system*, *GE HealthCare*, USA) and positioned supine on the angiography table. Interventional radiologists performed all procedures with at least 10 years of experience in central venous interventions. Local anesthesia was administered for all angioplasty procedures, supplemented with sedation and analgesia as needed. Throughout the procedure, patients were continuously monitored for blood pressure, oxygen saturation, and ECG changes.

Venograms were initially performed via the right subclavian or right internal jugular vein, followed by the left subclavian or left internal jugular vein, respectively. If direct access to these veins was not feasible under USG guidance, their occlusion was confirmed, and tunneling catheter placement was deemed unfeasible due to the inability to visualize the veins in both upper extremities.

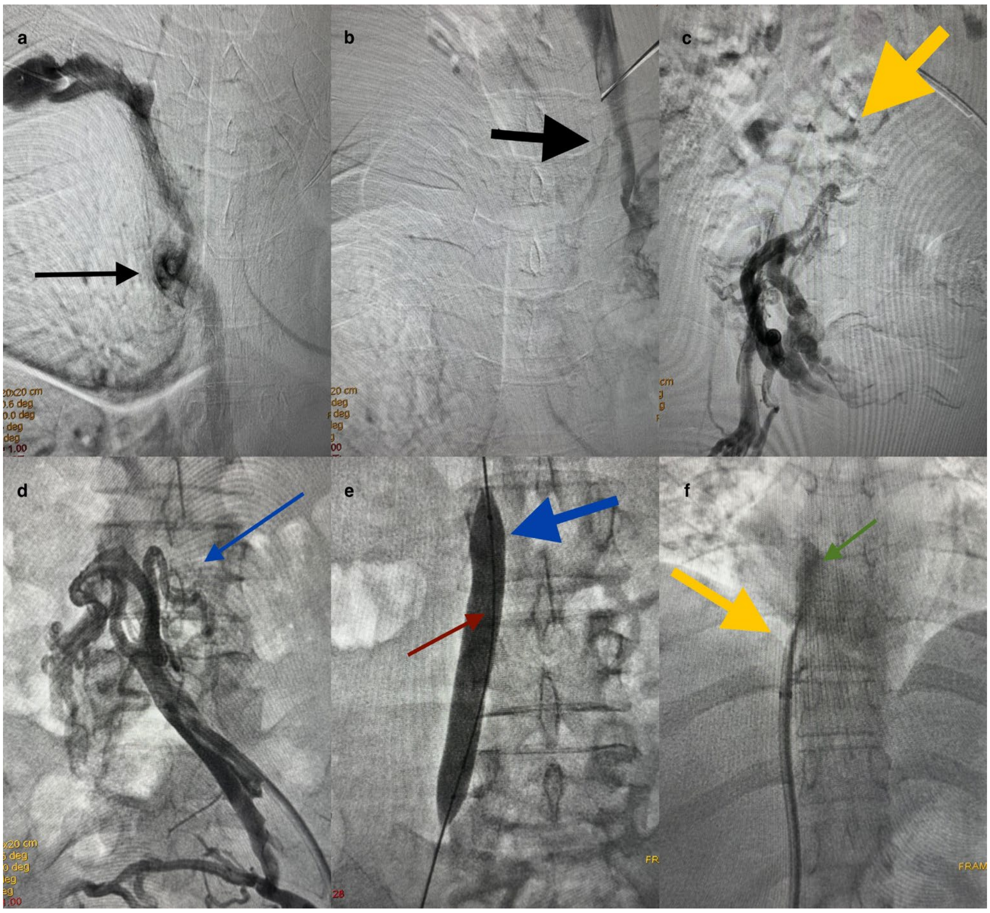
Upon confirming occlusion of the upper extremity central veins (right and left brachiocephalic veins or superior vena cava [SVC]), the right and left femoral veins were cannulated to assess the lower extremity central veins. The occlusion of the right and left iliac veins or inferior vena cava (IVC) was confirmed. The location and length of the occlusion, as well as the presence of collaterals, were identified during the procedure.

All vascular punctures were performed under USG guidance to ensure accuracy and minimize complications.

Figure 1 illustrates the imaging findings and interventional steps involved in treating a complete central venous occlusion with balloon venoplasty.

Figure 1.

Imaging and interventional steps in the treatment of complete central venous occlusion with balloon venoplasty



Caption:
(a) Fluoroscopic venography via the right subclavian vein demonstrates an occluded superior vena cava. The arrow identifies the azygos vein, which functions as a collateral pathway.
(b) Venography from the left internal jugular vein reveals occlusion of the left subclavian vein, with the arrow indicating the presence of collateral veins.
(c) Imaging via the right common femoral vein illustrates occlusion of the right common iliac vein and the inferior vena cava, with the arrow pointing to dense pelvic collateral vessels.
(d) Venograms acquired from a dysfunctional temporary dialysis catheter demonstrate proximal occlusion of the left common iliac vein as well as the inferior vena cava. The arrow highlights the presence of collateral venous pathways.
(e) The balloon venoplasty procedure is depicted, with the thick blue arrow marking the balloon and the thin red arrow designating the stiff guidewire.
(f) Post-venoplasty venography confirms proper placement of a tunneled catheter. The thick yellow arrow indicates the catheter tip positioned at the atriocaval junction, while the thin green arrow shows the flow of contrast material into the atrium.

2.4. Access technique

The decision on which vein to recanalize was based on the patient's clinical condition, urgent dialysis requirement, anatomical features, and imaging findings. The operator's experience and technical preference significantly affected this process.

Under ultrasonography (USG) guidance, the most appropriate entry site was determined to enable access to the OCV and facilitate the placement of a tunneled catheter. Access was achieved using the

Micropuncture Set (Merit MAK™ Mini Access Kit, Merit® Medical Systems, South Jordan, Utah, USA), followed by the introduction of a 6F or 8F vascular sheath (Cordis® Introducer Sheath, Cordis Corporation, Miami Lakes, Florida, USA) at the selected site. After visualizing the occluded segments, a 0.035-inch hydrophilic guidewire (*Radiofocus® Guide Wire-Angled*, *Terumo Corporation*, Hanoi City, Vietnam) and a vertebral catheter were used to navigate through the central vein occlusion. When needed, a 0.035-inch hydrophilic rigid guidewire (*Radiofocus® Guide Wire, Straight-Stiff Type or Angled Type*, *Terumo Corporation*, Tokyo, Japan) was employed for further support.

If the occlusion could not be crossed despite various guidewire and catheter manipulations, a 0.018-inch angled guidewire (*Radiofocus™ Glidewire Advantage™, *Terumo Corporation*, Fujinomiya City, Japan) was utilized. For cases where this approach was unsuccessful, sharp recanalization was performed using the hard posterior part of the guidewire to overcome the occlusion.[9]

A balloon catheter (Sterling™ PTA Balloon Dilatation Catheter, Boston Scientific, Marlborough, MA, USA, monorail, 0.018-inch system) or Mustang™ PTA Balloon Catheter (Boston Scientific, Marlborough, MA, USA, over-the-wire, 0.035-inch system) was advanced over the guidewire and centered on the occluded segment. The choice of balloon was based on operator preference and the type of guidewire that successfully crossed the occlusion. In cases recanalized with a 0.035-inch guidewire, the Mustang™ balloon was used, whereas in cases requiring 0.018-inch wires, the Sterling™ balloon was preferred. No additional balloon types were required in this series. Inflation was conducted for 60–90 seconds and repeated as necessary to ensure adequate dilatation.

Following the reopening of the central vein, the guidewire was replaced with a stiff guidewire (*Amplatz Super Stiff™ Guidewire*, *Boston Scientific*, Marlborough, Massachusetts, USA), further dilatations were performed, and a peel-away sheath was inserted. The hemodialysis catheter was then tunneled to the infraclavicular region to optimize patient mobility.

The same catheter placement technique was applied for upper extremity interventions (right and left subclavian veins and left and right internal jugular veins). For femoral vein interventions, the cuffed catheter was tunneled into the anterolateral region of the thigh to ensure optimal positioning and patient comfort.

2.5. Follow-up and reinterventions

Each patient was monitored for complications related to endovascular access site problems and catheter patency during the first three months following the procedure. During hemodialysis sessions, nursing staff assessed the catheter exit site and pathway for signs of infection, dialysis adequacy, pressure and suctioning, facial or arm edema, clot aspiration, and blood flow. When problems were identified, the patient was instructed to consult our unit.

Catheter kinks or misalignment of the tip were evaluated using chest X-rays. If a mechanical malfunction was identified, the catheter was repositioned or replaced. If no mechanical problem was detected, a thrombolytic solution was infused into both lumens and clot removal was attempted overnight. If these methods failed, DUS followed by CT venography was performed to exclude central vein thrombosis.

If the central vein was re-occluded, the catheter was left in place, and the occluded vein was accessed with a guidewire. When necessary, the sharp posterior end of the guidewire was used to cross the occlusion site. After the new catheter was successfully placed, the old catheter was removed. If resistance was encountered during catheter passage, a 10F vascular sheath was placed, and vein dilatation was performed using a balloon of appropriate diameter. The new catheter was then advanced over the wire.

If the occluded vein was narrow or could not be fully dilated, a longer catheter was used, and its tip was directed towards the right atrium to mitigate the risk of failure if the catheter remained in the stenotic vein.

2.6. Definitions of primary patency/technical success and identification of complications

Primary patency was defined as maintaining catheter functionality from placement until treatment completion, with no failure or need for replacement. Technical success meant restoring patency in the OCV and successfully placing the TDC. Complications were classified as major or minor according to the CIRSE guidelines [10]. Major complications included prolonged hospital stays, required additional or surgical treatment, or led to permanent damage or death. Minor complications were transient and clinically insignificant, and were managed conservatively. These criteria were recorded and evaluated for all events that occurred during or after the procedure.

2.7. Statistical analysis

Data was analyzed using SPSS software version 21.0 (SPSS Inc., Chicago, Illinois). The Kolmogorov-Smirnov test was applied to assess the normality of continuous variables. Descriptive statistics of the normally distributed data were expressed as mean ± standard deviation, while non-normally distributed data were presented as median (interquartile range). Categorical variables were defined using frequencies and percentages. Non-normally distributed data of the continuous variables between groups were compared using the Mann-Whitney U test, and Fisher's exact Chi-squared test was applied to compare categorical variables. The Independent Samples t-test was utilized for continuous variables with a normal distribution. A p-value <0.05 was defined as statistically significant. Correlation analyses of the normally distributed variables were performed using the Pearson correlation coefficient, and Spearman's rank correlation coefficient was used for the non-normally distributed variables. Multivariable logistic regression analysis was used to determine the independent predictors of catheter dysfunction after the PTBV.

3. RESULT

A total of 50 patients were included in the analysis. The mean age was 60.8 ± 18.3 years, with 70% of the participants being female, and the mean maintenance dialysis duration before the procedure was 53.6 ± 35.8 months (Table 1). A 100% technical success rate was achieved in recanalizing OCV and placing a TDC for emergency dialysis. The mean primary patency was 4 months (1–37 months). Fifty patients were divided into two groups based on catheter dysfunction: those with dysfunction (n = 11) and those without (n = 39). Baseline characteristics, laboratory values, angiographic data, primary patency duration, and total hemodialysis duration are shown in Table 2. No significant differences were observed between the groups except for total cholesterol levels (164.7 ± 35.2 vs. 143.1 ± 29.1, p = 0.043). While technical data, such as complication rates, stent implantation, and venous access sites, were similar between groups, catheter dysfunction was associated with the distal tip position. Dysfunction occurred more frequently when the catheter tip was placed in the inferior vena cava (7 [63.6%] vs. 8 [20.5%], p = 0.010).

Multivariable logistic regression, including age, heart failure, balloon diameter, and catheter tip position, showed that only the tip location was associated with dysfunction (OR: 0.146, 95% CI: 0.026–0.816, p = 0.028) (Table 3 and Figure 2). No major complications were observed. Minor complications included small hematomas (11.3%), transient arrhythmias (16.1%), and minor vein perforations (2.4%). As shown in Figure 3 and Table 1, the most common reasons for catheter removal were mortality (36%), transition to peritoneal dialysis (22%), and occlusion (16%), while infection accounted for 6% of the removals. Additionally, 42% of patients eventually transitioned to more permanent solutions.

Table 1.

Indications for hemodialysis catheter removal

n (%)	
Mortality	18 (36)
Renal transplantation	4 (8)
Peritoneal dialysis	11 (22)
Occlusion	8 (16)
Catheter infection	3 (6)
Fistula creation	6 (12)

Table 2.

Patient characteristics according to catheter dysfunction status

	Catheter dysfunction present (n = 11)	Catheter dysfunction absent (n = 39)	Total (n = 50)	p value
Age	60.6±13.8	60.9±19.5	60.8±18.3	0.967
Gender (Female), n (%)	10 (90.9)	25 (64.1)	35 (70)	0.139
Smoking, n (%)	4 (36.4)	12 (30.8)	16 (32)	0.728
Diabetes mellitus, n (%)	6 (54.5)	22 (56.4)	28 (56)	0.589
Hypertension, n (%)	7 (63.6)	27 (69.2)	34 (68)	0.728
Dyslipidemia, n (%)	1 (9.1)	1 (2.6)	2 (4)	0.395
Heart failure, n (%)	5 (45.5	13 (33.3)	18 (36)	0.494
Fasting blood glucose, mg/dL	116 (74-208)	101 (62-370)	104.5 (62-370)	0.461
ALT, units/liter	12 (8-30)	14 (6-57)	13.5 (6-57)	0.532
AST, units/liter	17.5±8.1	22±9.8	21±9.6	0.175
Total cholesterol, mg/dl	164.7±35.2	143.1±29.1	147.8±31.5	0.043
LDL-C, mg/dl	109.1±30.3	99.1±21.9	101.3±24	0.230
HDL-C, mg/dl	34±8.7	38.4±6.9	37.4±7.5	0.074
Triglyceride, mg/dl	140 (85-216)	125 (85-404)	126 (85-404)	0.379
Hemoglobin, g/dl	10.1±1.5	10.5±1.3	10.4±1.3	0.394
Albumin, g/dl	3.6±0.5	3.5±0.5	3.6±0.5	0.744
Balloon diameter, mm	11.4±2.8	12.6±2.1	12.4±2.3	0.127
Stent implantation, n (%)	1 (9.1)	2 (5.1)	3 (6)	0.534
Complications, n (%)	1 (9.1)	6 (15.4)	7 (14)	0.513
Catheter distal tip location (IVC), n (%)	7 (63.6)	8 (20.5)	15 (30)	0.010
Venous access sites, n (%)				
Right internal jugular vein	2 (18.2)	11 (28.2)	13 (26)	0.188
Left internal jugular vein	0 (0)	10 (25.6)	10 (20)	
Right subclavian vein	0 (0)	2 (5.1)	2 (4)	
Left subclavian vein	1 (9.1)	3 (7.7)	4 (8)	
Right femoral vein	6 (54.5)	8 (20.5)	14 (28)	
Left femoral vein	2 (18.2)	5 (12.8)	7 (14)	
Total hemodialysis duration, months	64±42.2	50.7±33.8	53.6±35.8	0.282
Primer patency duration, months	4 (1-14)	4 (1-37)	4 (1-37)	0.637

ALT: Alanine transaminase, AST: Aspartate transaminase, LDL-C: Low-density lipoprotein cholesterol, HDL-C: High-density lipoprotein cholesterol, IVC: Inferior vena cava.

Table 3.

Univariate and multivariable regression analysis for the catheter dysfunction after the percutaneous transluminal angioplasty

Univariate	p value	OR	95% CI		Multivariate	p value	OR	95% CI	
			Lower	Upper				Lower	Upper
Age	0.966	1.001	0.965	1.038	Age	-	-	-	-
Heart failure	0.462	1.667	0.427	6.499	Heart failure	-	-	-	-
Balloon diameter	0.133	1.238	0.937	1.634	Balloon diameter	-	-	-	-
Catheter distal tip location	0.010	0.147	0.034	0.631	Catheter distal tip location	0.028	0.146	0.026	0.816

OR: Odds ratio

Figure 2.

Regression analysis

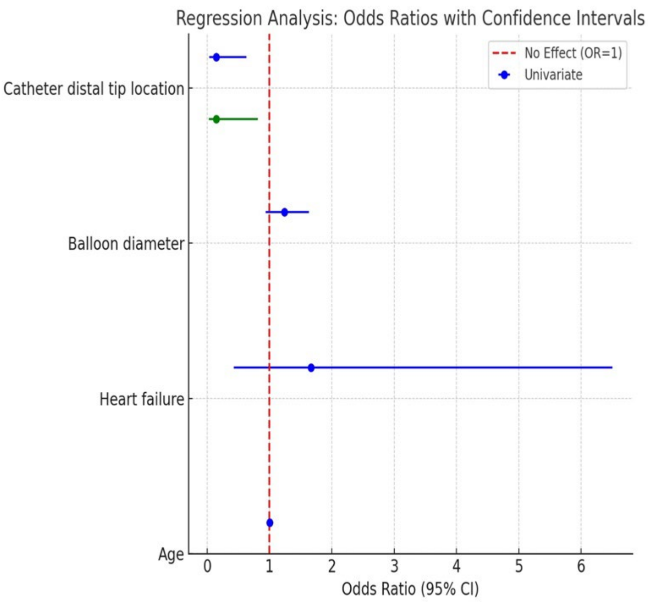
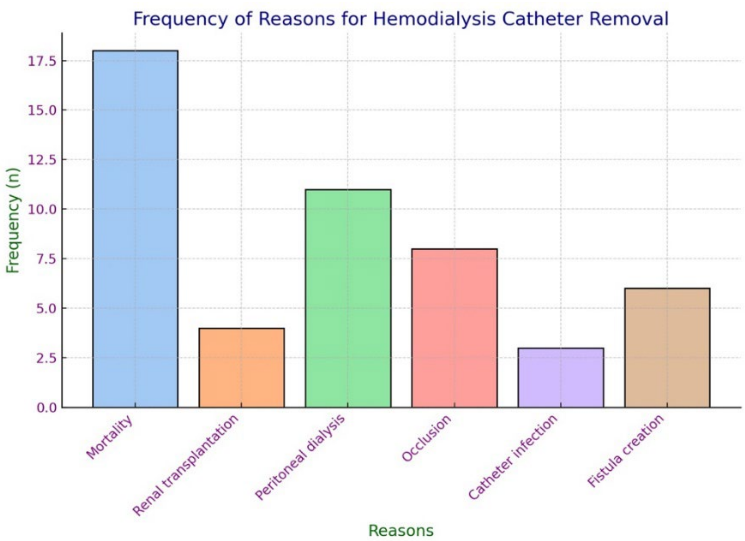


Figure 3.

Frequency of reasons for catheter removal



4. DISCUSSION

Complete central venous occlusion creates a significant access challenge in emergency hemodialysis. This condition requires rapid and effective vascular access, as it can lead to life-threatening complications. Our study evaluated patients with complete OCV pathways in both the upper and lower extremities, thereby addressing a scenario not comprehensively investigated in the literature.

Existing literature has shown that innovative methods, such as PTBV, can effectively restore central venous patency and facilitate the placement of a TDC. However, most studies have primarily focused on upper limb venous occlusions and have not adequately addressed the application of these techniques in more complex cases where all central venous pathways are entirely blocked. Additionally, there is limited knowledge about the factors contributing to catheter dysfunction and strategies to enhance long-term catheter patency. Addressing these knowledge gaps is crucial for improving care standards for high-risk patient populations.

In our series, the balloon venoplasty method proved effective in high-risk patients requiring hemodialysis access, achieving 100% technical success with no major complications. During follow-up, four patients underwent kidney transplantation, 11 transitioned to peritoneal dialysis, and six arteriovenous fistulas were created.

Although open surgical bypass procedures are available to treat central venous occlusions, endovascular therapy has emerged as the primary method for restoring central venous patency, with reported success rates ranging from 80% to 100% [11-13]. Our study reached a 100% technical success rate in line with these findings. The effectiveness of venoplasty in restoring patency in OCD is well-documented, particularly in thoracic central vein occlusions.[14,15] This intervention provides a crucial window of opportunity to allow preparation for and transition to more permanent access methods such as AVF creation or peritoneal dialysis.

However, data on patients requiring hemodialysis where all central venous pathways are completely occluded remain limited. Falk et al.[5] demonstrated a 93% technical success rate in placing TDC across stenotic or OCV, emphasizing the feasibility and safety of endovascular recanalization in preserving central venous access for future use.[5] However, their study primarily focused on upper extremity venous occlusions and did not address the more complex scenarios where all central venous pathways are entirely occluded. Similarly, Frampton et al. [16] explored the use of femoral artery access as an emergency method for hemodialysis in patients with no other viable access options. In contrast to our approach, their study involved surgical interventions when endovascular techniques failed, resulting in higher complication rates.[16]

The study by Lotfy et al.[17] included patients with central venous stenosis or partial occlusion, some of whom had alternative vascular access routes, such as the subclavian or jugular veins. In contrast, our study focused exclusively on patients who had exhausted all central venous access options and had no alternative vascular access. In this patient group, a 100% technical success rate was achieved. Lotfy et al.[17] reported a 79% technical success rate in patients with complete central venous occlusion. The higher success rate in our study (100%) may be attributed to factors such as the advanced techniques employed, operator experience, patient selection, and study design.

Furthermore, when comparing primary patency durations, we observed that catheters with the tip placed in the right atrium maintained functionality for a more extended period and had a significantly lower dysfunction rate than those placed in the inferior vena cava. Our multivariate analysis demonstrated that right atrial catheter tip placement had a direct positive impact on patency duration. In contrast, catheters placed in the inferior vena cava had a significantly higher risk of dysfunction (OR: 0.146, 95% CI: 0.026–0.816, $p = 0.028$). Although Lotfy et al. [17] did not provide a detailed analysis of primary patency duration, they reported a decline to 70% at one year and 5% at four years.[17] In contrast, our study demonstrated that catheters placed in the right atrium had significantly longer patency durations. These findings underscore the crucial role of catheter tip location in maintaining long-term catheter functionality.

In our study, complications associated with PTBV were generally minor. The recorded issues included access site hematoma (11.3%), accidental arterial puncture (3.2%), arrhythmias (16.1%), and small vein perforations in three cases of central vein occlusion (2.4%). None of these events required prolonged hospitalization or additional surgical intervention. However, more severe complications have been reported in the literature during central venous recanalization procedures, including extraluminal perforations of large veins, which can result in massive bleeding into the pleural or pericardial space or even pneumothorax[14]. Despite the low complication rate observed in our study, potential risks such as re-occlusion, infection, and catheter dysfunction remain concerns.[15,18] To mitigate these risks, adjunctive treatments, including anticoagulants and antibiotic lock solutions, are recommended to prolong the patency of the recanalized track and improve patient outcomes.

According to the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines, native arteriovenous fistulas (AVFs) remain the preferred long-term vascular access for hemodialysis.[19] Endovascular treatment is well established in the management of thrombosed or dysfunctional AVFs, with percutaneous transluminal angioplasty (PTA) demonstrating high technical success (≈89%) and acceptable short- to mid-term patency (≈60–79% at 6–12 months).[19] Larger series have confirmed these findings, reporting primary patency rates exceeding 90% and mean patency durations approaching two years when repeat interventions were performed.[20] Our study addresses the most advanced stage of vascular access failure, in which all central venous pathways were completely occluded and no option for AVF salvage or creation was immediately feasible. In this setting, balloon venoplasty allowed 100% technical success in recanalizing occluded veins and placing tunneled dialysis catheters, thereby ensuring urgent dialysis and providing a bridge to definitive access options (AVF creation, peritoneal dialysis, or transplantation). Thus, while AVF salvage procedures aim to preserve native access and reduce catheter dependence, our findings demonstrate that the same principle—timely endovascular intervention—can be extended to the central venous system when conventional access is entirely exhausted.

This study has several limitations. First, it was a retrospective, single-center study with a relatively small sample size, which may limit the generalizability of the findings. Second, the follow-up duration varied among patients, potentially affecting the assessment of patency outcomes. Third, the study did not include a comparison group treated with alternative interventional or surgical approaches. Finally, although the procedures were performed by experienced operators, operator-dependent variability in technical approaches may have influenced outcomes.

5. CONCLUSION

This study demonstrates that PTBV of a total OCV, combined with PTBV and placement of a TDC, is a safe and effective method for dialysis patients with a depleted vascular bed. This approach provides not only emergency hemodialysis access but also serves as a critical bridge, facilitating the transition to more permanent vascular access methods. Our findings demonstrated that the distal tip location of the catheter is a determining factor in long-term patency, revealing that catheters placed in the right atrium have a lower risk of dysfunction than those placed in the inferior vena cava. In this critical scenario, which has not been extensively addressed in the literature, the success of endovascular treatment approaches offers an important treatment option for this patient group. Our study demonstrates that individualized endovascular strategies can increase treatment success and improve current standards for patients with exhausted central venous access.

Article Information Form

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Authors' Contribution

Conceptualization, M.M. and I.K.; methodology, M.M. and I.K.; software, I.K.; validation, M.M. and I.K.; formal analysis, M.M.; investigation, I.K.; resources, M.M. and I.K.; data curation, M.M. and I.K.; writing—original draft preparation, M.M. and I.K.; writing—review and editing, M.M. and I.K.; visualization, I.K.; supervision, M.M.; project administration, M.M. and I.K.; All authors have read and agreed to the published version of the manuscript.

The Declaration of Conflict of Interest/ Common Interest

No conflict of interest or common interest has been declared by authors.

The Declaration of Ethics Committee Approval

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Baskent University Faculty of Medicine (protocol code KA25/17, approved on January 29, 2025).

Artificial Intelligence Statement

No artificial intelligence tools were used while writing this article.

Copyright Statement

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