Original Article

The efficacy and safety of blunt impingement followed by a sharp recanalization technique in hemodialysis patients with refractory central vein occlusion: a single-center experience

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Background: Central vein occlusion (CVO) is a serious problem in hemodialysis patients. There is an unsatisfactory result for refractory CVO by sharp recanalization alone. This study evaluated the efficacy and safety of blunt impingement followed by sharp recanalization for the treatment of CVO in hemodialysis patients.

Methods: This study retrospectively examined hemodialysis patients with CVO who failed to recanalize using standard guidewire and catheter techniques in our department. In the first instance, all CVOs were recanalized using blunt impingement techniques, including a 6-Fr long sheath (Cook Incorporated, Bloomington, IN USA) and an 8-Fr sheath of Rosch-Uchida Transjugular Liver Access Set (RUPS-100; Cook Incorporated, Bloomington, IN, USA). If this was not successful, sharp recanalization devices were applied, including the stiff tip of a guidewire (Terumo, Tokyo, Japan), the RUPS-100, and the percutaneous transhepatic cholangial drainage (PTCD) needle (Cook Incorporated, USA). All patients were followed up at least 4 months postoperatively. The technical success rate, arteriovenous access patency rates, and operation-related complications were analyzed.

Results: The procedural success rate was 100.0% (30 of 30). Thirty patients with CVO underwent blunt impingement with a technique success rate of 70.0% (21 of 30), and 9 patients received sharp recanalization after failed blunt impingement, with a technique success rate of 100.0% (9 of 9). The primary patency rates at 6 and 12 months postoperatively were 86.7% and 53.3%, respectively. The primary assisted patency rates were 93.3% and 63.3%, and the secondary patency rates were 93.3% and 70.0% at 6 and 12 months, respectively. One major procedure-related complication was detected, namely, a small injury of the superior vena cava (SVC) wall in a patient receiving recanalization via the stiff end of a guidewire, but this did not require further treatment.

Conclusions: It is potentially effective and safe for interventionalists to use blunt impingement followed by sharp recanalization techniques to treat chronic CVO that is refractory to traversal using traditional catheter and guidewire techniques.

Keywords: Blunt impingement; sharp recanalization; refractory central venous occlusion; hemodialysis

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Introduction

Although hemodialysis is effective in sustaining the life of patients with renal failure, it is associated with potentially serious complications such as occlusion or stenosis of vascular access. Occlusions or stenoses in any part of the dialysis vascular access, particularly central vein occlusions (CVOs), disrupt hemodialysis access function and can result in hospitalization or death. The incidence of central vein diseases has been reported in the literature to be as high as 50% (1-3). The lesion may be due to initial damage to the vascular endothelium as a result of the placement of a central venous catheter (CVC), and this can lead to a local inflammatory response and finally, fibrosis (4). Long-term CVC use in patients on maintenance hemodialysis is the most common risk factor for central vein diseases (5). Additionally, the risks associated with subclavian catheter insertion are particularly high, with the incidence of subclavian vein (SV) stenosis being up to 50% (6).

Traditionally, endovascular intervention is the first-line treatment for CVO, as it is a minimally invasive approach with lower morbidity and mortality than surgical intervention. Endovascular techniques to treat CVO include percutaneous transluminal angioplasty (PTA), bare metal stent placement, and covered stent implantation or stent graft insertion (6). However, it has been reported that refractory CVO cannot be recanalized using traditional catheter and guidewire techniques (7,8). Therefore, sharp recanalization with more procedure-related complications, such as a Chiba needle, the stiff end of a hydrophilic wire, and transseptal needle, has been gradually applied to the treatment of challenging CVO (9-11). Currently, blunt impingement for refractory CVO is rarely reported.

The current study evaluated the efficacy and safety of blunt impingement followed by a sharp recanalization technique to treat patients with CVO. We present the following article in accordance with the STROBE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-3131/rc).

Methods

Study population

This retrospective observational study included hemodialysis patients who received recanalization of a chronic CVO between January 2019 and August 2021 at the West China Hospital of Sichuan University. The following inclusion criteria were applied: (I) patients with a CVO leading to dysfunction of vascular access; (II) patients who failed to recanalize using a catheter and guidewire technique; (III) patients who were males or nonpregnant females aged 18–90 years old; and (IV) patients who provided informed consent for surgery. Patients who had previously undergone open surgical treatment for CVO and patients who were unable to tolerate surgery due to underlying diseases or advanced age were excluded. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee on Biomedical Research at the West China Hospital of Sichuan University (No. 20211382). Individual consent for this retrospective analysis was waived.

Procedures

All procedures were performed by interventionalists under local anesthesia. Preoperative computed tomography chest angiography was performed for all patients, and intraoperative digital subtraction angiography (DSA) was performed to identify the CVO, including the brachiocephalic vein (BV), the SV, and the superior vena cava (SVC). The blunt impingement technique used a 4-Fr angiographic catheter (VER135°, Cordis, Corporation, Miami, FL, USA) with blunt impingement along the residual vascular tractus with support provided by a 6-Fr long sheath or an 8-Fr RUPS-100 sheath. First, a 0.035-inch hydrophilic guidewire (Terumo, Tokyo, Japan) and a 4-Fr angiographic catheter were successively introduced into the distal end of the CVO from a 6-Fr long sheath or an 8-Fr RUPS-100 sheath. A 4-Fr angiographic catheter was then used to impinge the distal end of the lesion repeatedly, with assistance from a 6-Fr long sheath or an 8-Fr RUPS-100 sheath when traditional guidewire and catheter techniques had failed (*Figures 1*,*2*). The key element of the procedure was to obtain sufficient support from a 6-Fr long sheath or an 8-Fr RUPS-100 sheath. Sharp recanalization using the stiff tip of a guidewire (*Figure 3*), a RUPS-100 (*Figure 4*), or a PTCD needle (*Figure 5*), was applied if the blunt impingement techniques failed.

Endpoints and statistical analysis

The primary endpoints included technique success and procedure-related complications, and the secondary outcomes were arteriovenous access patency rates at 6 and 12 months. Procedure success was defined as successful recanalization of the CVO, with angiography showing

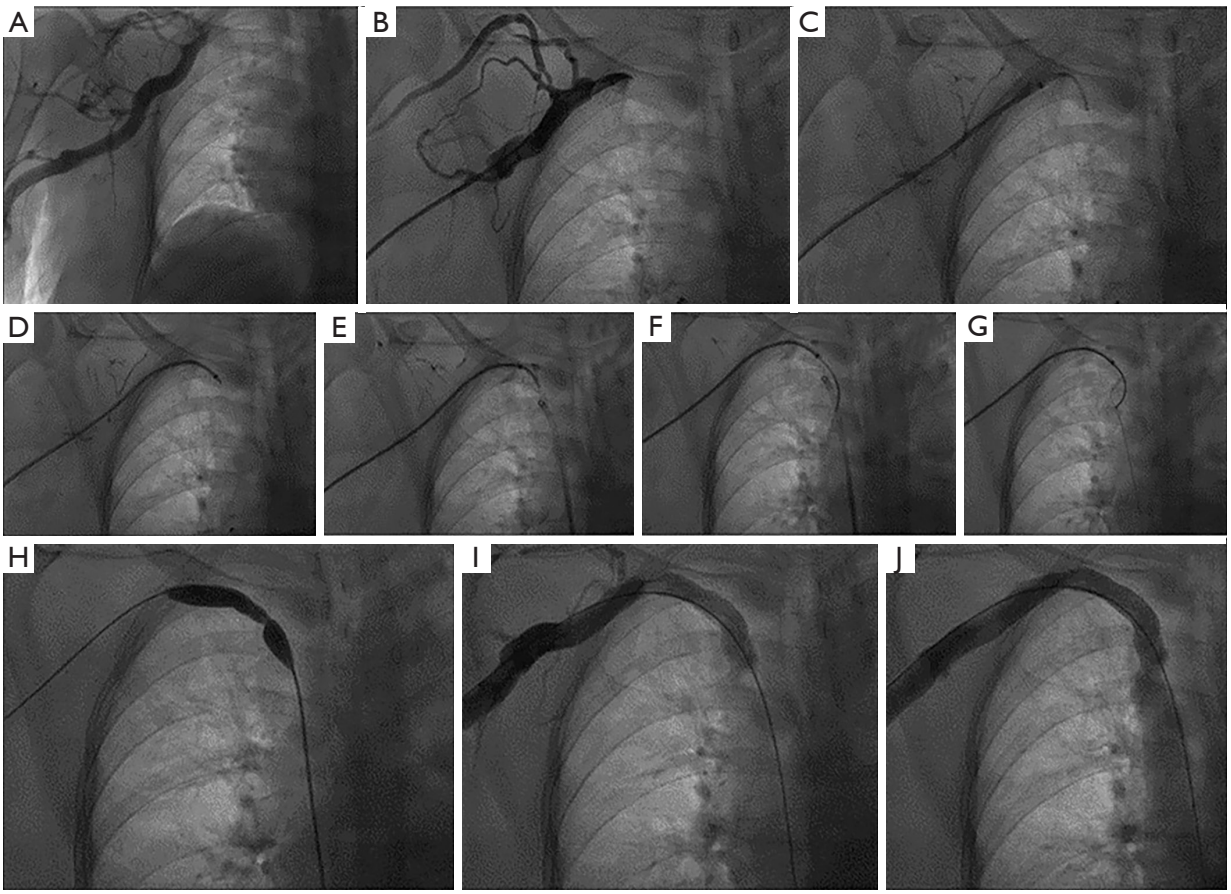

Figure 1 Procedure of the blunt impingement technique for recanalization of the occlusion of the RSV and the RBV. (A) Venography from the arteriovenous fistula of the right upper extremity showing the distal end of subclavian venous occlusion. (B) A 6-Fr introducer catheter was introduced into the lesion through the arteriovenous fistula. (C) A 4-Fr angiographic catheter was used to impinge the occluded segment of the RSV until it successfully crosses the lesion. (D) The 4-Fr angiographic catheter was used to repeatedly impinge the distal end of the RBV occlusion, with assistance and sufficient support from a 6-Fr long sheath, without success. (E) A 9-Fr long sheath was then introduced into the distal end of the SVC to act as a target for the 4-Fr angiographic catheter blunt impingement. (F) The distal end of the RBV occlusion was impinged again using a 4-Fr angiographic catheter and the SVC was reached successfully. (G) A guidewire from the femoral vein approach was snared from the SV. (H) A venogram showing the LSV was still narrow after balloon dilation. (I) An angiography indicted that the lesion was still narrow after the implantation of the 10-mm covered stent (W. L. Gore & Associates, USA). (J) A repeat venography revealed that complete restoration of patency was achieved after placement of the 10-mm bare stent (Cordis Corporation, USA). RSV, right subclavian vein; RBV, right brachiocephalic vein; SVC, superior vena cava; SV, subclavian vein; LSV, left subclavian vein.

apparent recovery of the lesion post-procedure and no serious complications. Patency rates were defined as described in Sidawy *et al.* (12). The patients were followed up every 3 months after surgery and assessed patency and complications. Descriptive statistics for patient characteristics are expressed as the mean ± standard deviation (SD) with normal distributions and as medians with skewed distributions. Categorical variables are expressed as percentages (n). The patency rates of primary and secondary were assessed using the Kaplan-Meier method. All statistical analyses were performed using the SPSS 26.0 software for Windows.

Results

Demographic data for the 30 cases included in this study are presented in *Table 1*. As shown, the average age of the study cohort was 62.0±11.2 years, and there were 19

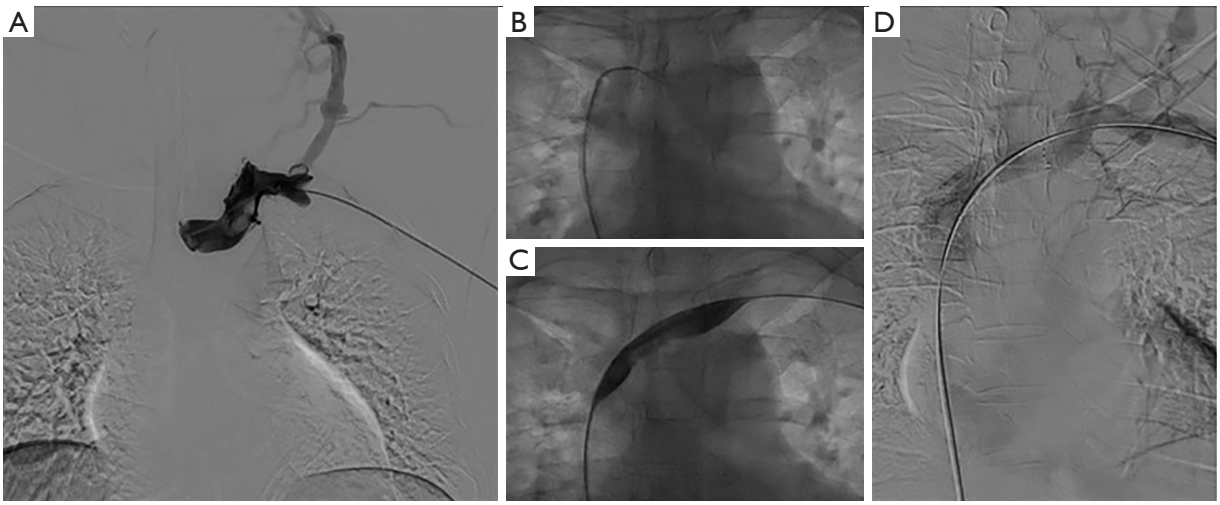

Figure 2 The procedure for the blunt impingement technique for the LBV occlusion. (A) An angiography showing complete occlusion of the LBV. (B) With the support of a 6-long sheath, a 4-Fr angiographic catheter was used to impinge the lesion. (C) Balloon angioplasty of the occlusive LBV. (D) Postangioplasty venography revealed complete restoration of patency of the LBV. LBV, left brachiocephalic vein.

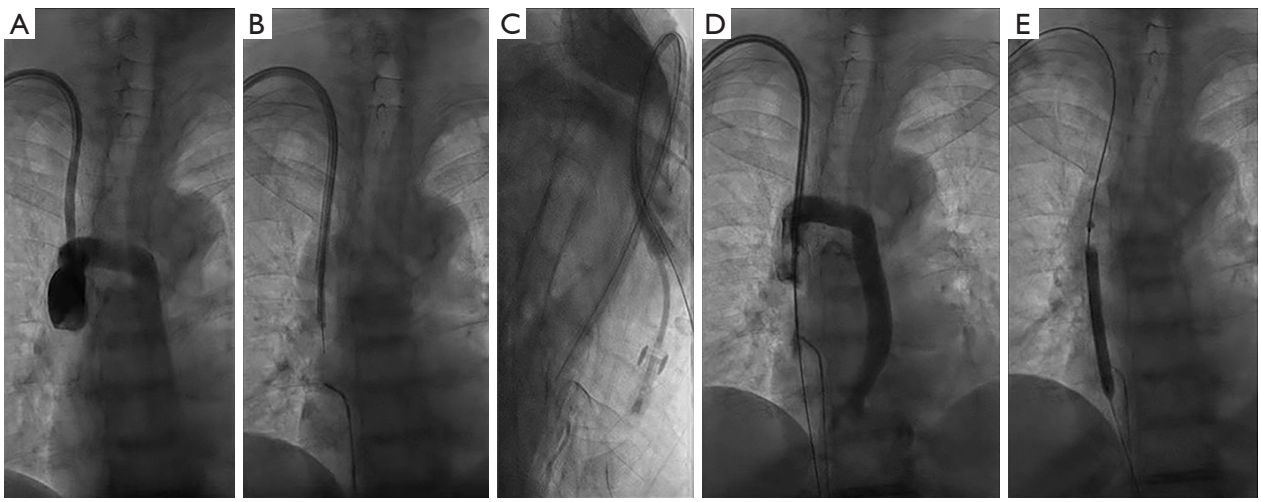

Figure 3 The stiff tip of the guidewire was used to recanalize the SVC occlusion. (A) A venogram showing the SVC occlusion. (B,C) The stiff tip of a hydrophilic guidewire crossed the SVC occlusion. (D) A second angiogram showing that a small amount of contrast was able to enter the right atrium through the residual slit in the occluded segment, and the hydrophilic guidewire passed the lesion successfully. (E) The lesion recovered well after balloon dilation. SVC, superior vena cava.

(63.3%) males. The average duration of hemodialysis was 78.2±52.4 months. The mean lesion length was 31.3±15.0 mm in the 30 patients, with occlusion of only the BV in 6 patients (20.0%), occlusion of the SV in 12 cases (40.0%), occlusion of the SVC in 4 patients (13.3%), occlusion in both the SV and BV in 6 patients (20.0%), and occlusion in both the BV and the SVC in 2 cases (6.7%) (*Table 2*).

The technique was performed successfully in all 30 patients (100.0%). The success rate of the blunt impingement technique was 70.0% (21/30), including a 6-Fr long sheath success rate of 69.2% (18/26) and a RUPS-100 sheath success rate of 75.0% (3/4) (*Table 3*). The remaining patients (n=9, 30.0%) underwent sharp recanalization after the blunt impingement techniques

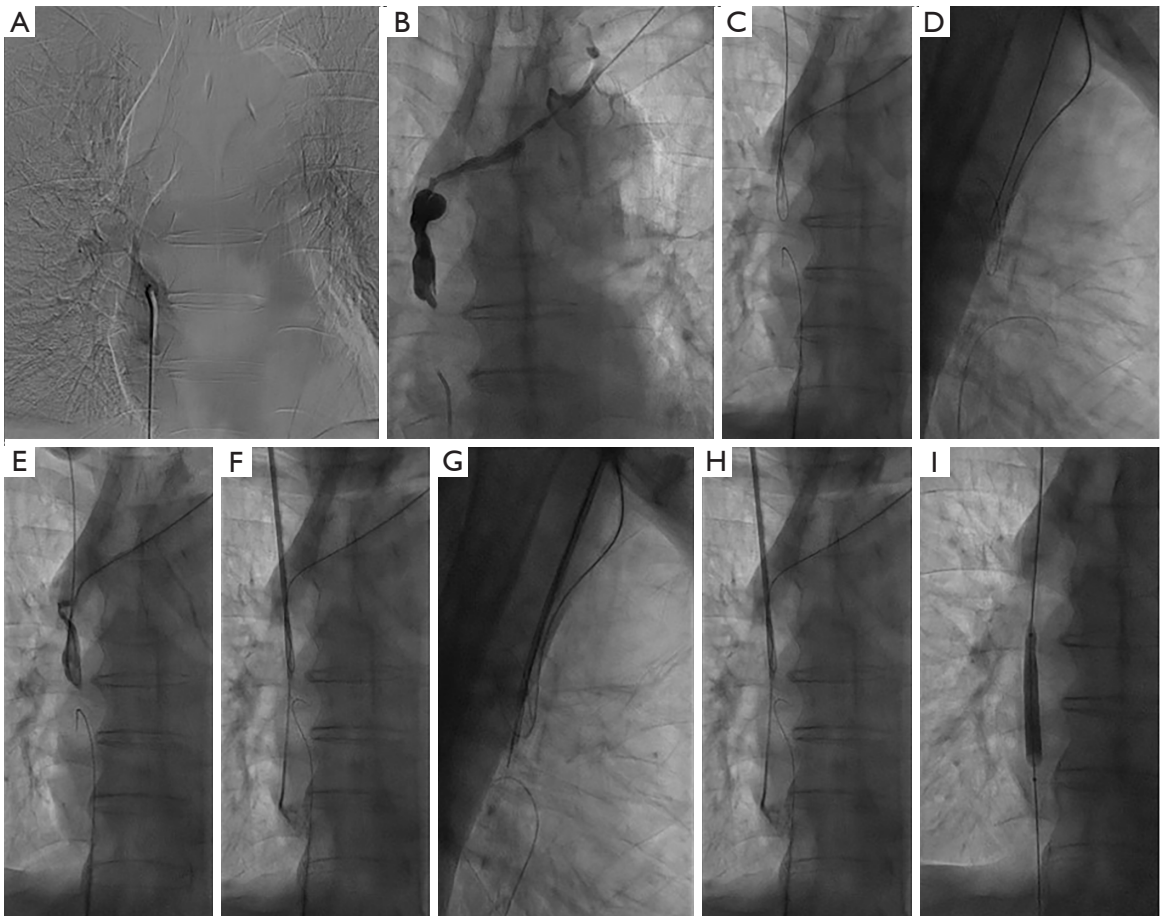

Figure 4 The RUPS-100 recanalized the SVC occlusion. (A,B) The venography revealed complete occlusion of the SVC. (C,D) The SVC was punctured using a PTCD needle from below the lateral head of the sternocleidomastoid muscle via the right neck. (E) The PTCD needle was placed at the distal end of the SVC. (F,G) A stiff guidewire was introduced into the RUPS-100 metal sheath from the right neck. (H) A venogram showing a 4-Fr catheter located in the right atrium after successful sharp recanalization. (I) A 6-mm balloon dilation. RUPS, Rosch-Uchida Transjugular Liver Access Set; SVC, superior vena cava; PTCD, percutaneous transhepatic cholangial drainage.

failed, and among them, 3 patients (10.0%) received treatment with the stiff end of a guidewire, 3 patients (10.0%) had a RUPS-100, and 3 patients (10.0%) had a PTCD needle, with a procedure success rate of 100.0% (9/9) (*Table 3*). PTA alone was performed in only 4 cases (13.3%), while balloon dilation and stenting were used in 26 cases (86.7%) (*Table 3*). One patient presented with a small injury to the wall of the SVC after recanalization with the stiff end of a guidewire, but this did not require further treatment (*Table 3*).

The median follow-up period was 12 (range, 4–26) months. The patency rates of primary, primary-assisted, and secondary treatment at 6 months were 86.7%, 93.3%, and 93.3%, respectively. The patency rates of primary, primary-assisted, and secondary treatment at 12 months were 53.3%, 63.3%, and 70.0%, respectively (*Figure 6*). One patient (3.3%) was lost to follow-up at 8 months. Three patients (10.0%) developed restenosis of lesions, and 3 patients (10.0%) developed complete CVO. The blood flow improved significantly in patients with lesion restenosis and occlusion after balloon dilation and stent placement. At the 5-month follow-up, 1 patient (3.3%) with left innominate vein occlusion underwent renal transplantation and recovered well after the operation. One patient (3.3%) with SVC occlusion died of cerebral hemorrhage at 7 months post-operation.

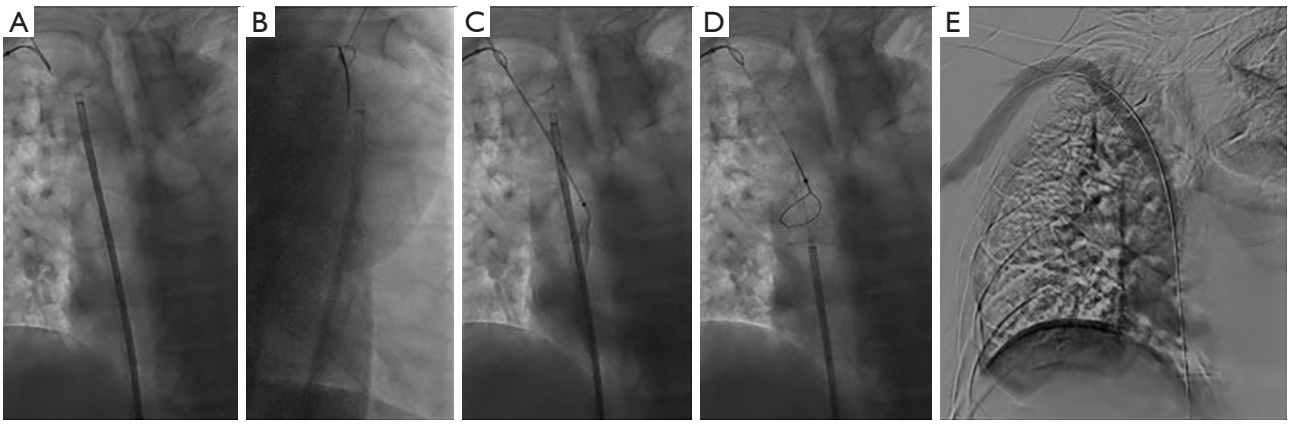

Figure 5 The procedure for PTCD needle puncture of the occlusion of the RBV. (A) and (B) A venogram showing the PTCD needle directly punctured the distal end of the RBV using a snare as a target. (C) The PTCD sheath was placed in the SVC. (D) The second snare grasped a guidewire from the right femoral vein access. (E) The lesion recovered well after balloon dilation and stenting. PTCD, percutaneous transhepatic cholangial drainage; RBV, right brachiocephalic vein; SVC, superior vena cava.

Table 1 The basic characteristics of the included patients

Variables	Number of patients
Sample size	30
Sex, n (%)	
Male	19 (63.3)
Female	11 (36.7)
Age (years), mean ± SD [range]	62.0±11.2 [37–83]
Dialysis duration (months), mean ± SD [range]	78.2±52.4 [3–238]
Primary diseases, n (%)	
Primary glomerulonephritis	14 (46.7)
Diabetic nephropathy	7 (23.3)
Hypertensive kidney disease	7 (23.3)
Polycystic kidney disease	1 (3.3)
Other	1 (3.3)

SD, standard deviation.

Table 2 Occlusion characteristics

Characteristics	Patients (n=30)
Lesion length (mm), mean ± SD [range]	31.3±15.0 [6–70]
Lesion location, n (%)	
RSV	8 (26.7)
LSV	4 (13.3)
RBV	3 (10.0)
LBV	3 (10.0)
SVC	4 (13.3)
RSV + RBV	2 (6.7)
LSV + LBV	4 (13.3)
RBV + SVC	1 (3.3)
LBV + SVC	1 (3.3)

SD, standard deviation; RSV, right subclavian vein; LSV, left subclavian vein; RBV, right brachiocephalic vein; LBV, left brachiocephalic vein; SVC, superior vena cava.

Discussion

In this retrospective observational study, the technical success rate for blunt impingement followed by sharp recanalization was significantly higher than that for sharp recanalization alone. The patency rates of primary, primary-assisted, and secondary treatment at 6 months were greater than 85.0%. No severe procedure-related complications were observed.

CVO is a severe complication in hemodialysis patients. These occluded lesions can lead to significant venous hypertension, which can lead to headaches, dizziness, coughing, and even cerebral edema and hemorrhage of the upper gastrointestinal tract (4,13). Currently, surgical and endovascular interventions are the main treatments for CVO. Although surgical treatment of central venous lesions has yielded good results, surgical procedures are more invasive than endovascular treatments and are usually not

Table 3 Clinical outcomes

Outcomes	Patients (%)	Technique success (%)	Complications
Balloon dilation	30 (100.0)	30/30 (100.0)	No
Balloon dilation and stenting	26 (86.7)	26/26 (100.0)	No
Blunt impingement			
Long sheath	26 (86.7)	18/26 (69.2)	No
RUPS-100 sheath	4 (13.3)	3/4 (75.0)	No
Sharp recanalization			
A stiff end of guidewire	3 (10.0)	3/3 (100.0)	One injury of SVC wall
RUPS-100	3 (10.0)	3/3 (100.0)	No
PCTD needle	3 (10.0)	3/3 (100.0)	No
Blunt impingement followed by sharp recanalization technique	30 (100.0)	30/30 (100.0)	One injury of SVC wall

PTCD, percutaneous transhepatic cholangial drainage; SVC, superior vena cava; RUPS, Rosch-Uchida Transjugular Liver Access Set.

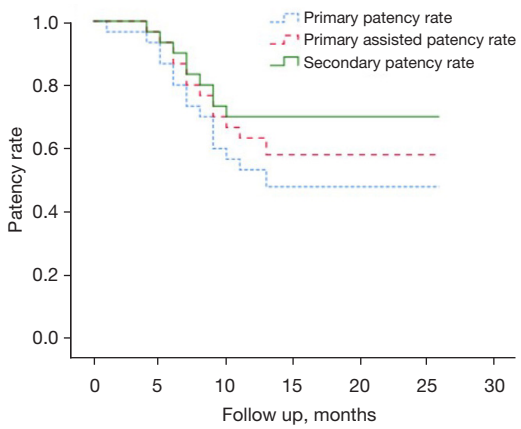

Figure 6 Kaplan-Meier curves of primary, primary assisted, and secondary patency rates post-operation.

the first choice for therapy (14,15). Endovascular treatment remains the mainstay of treatment in hemodialysis of patients with CVO, with good efficacy and safety (3,16-18). The key to endovascular treatment is guidewire passage through the occluded segment. However, in 42–49% of patients, there is a failure to cross lesions of the central vein using standard guidewire and catheter techniques (11,19).

This is the first report to discuss the efficacy and safety of blunt impingement followed by the sharp recanalization in hemodialysis patients with CVO. In this study, the technique success rate was significantly higher than that in previous studies, with fewer complications. Reindl-Schwaighofer *et al.* (20) reported on an inside-out access (IOA) device used to treat thoracic CVO with a technique success rate of 97% (38 of 39 cases). However, it cannot be used through the left femoral vein, and tight angles cannot be overcome, which seriously limits its application. Arabi *et al.* (21) reported an 85.7% success rate in gaining dialysis access in 7 patients with CVO by means of a septal puncture needle through the femoral vein or upper limb, although two complications of a right hemothorax and a hemopericardium occurred. A study by Goo *et al.* (22) reported the use of a Rösch-Uchida needle to recanalize CVO, with a success rate of 93.9% (31 of 33 procedures), although 1 patient presented with shoulder pain for up to 2 weeks. In 2019, Majdalany *et al.* (23) performed radiofrequency wire recanalization to traverse chronic occlusions after failing conventional techniques, with a technical success rate of 89% (17 of 19 cases), but one patient presented with severe injury to the inferior vena cava. Yang *et al.* (10) reported occlusive SVC lesions penetrated by the stiff end of a guidewire with the assistance of a guide wire through the femoral vein, which achieved a technique success rate of 87.5% (14/16). In 2020, we reported the use of a transseptal needle in 16 cases with BV occlusion, with a low success rate of 81.25% (13/16). The septal puncture needle was too stiff to pass through tight angles (24). In the current study, the blunt impingement technique was initially applied to all patients who failed the standard catheter guidewire technique. This technique, involving a 4-Fr catheter blunt impingement and support from a long sheath or a RUPS-100 sheath, greatly

reduced the incidence of procedure-related complications. In addition, one reason for the higher procedure success rates may be that blunt impingement shortened the lesion length, which provided better conditions for sharp recanalization. The patency rates in our study were not significantly higher than those in previous studies (10,25). The "mother-child" technique was previously used in 45 patients with total CVO, with primary patency rates at 6 and 12 months of 81.0% and 47.1%, respectively, and the assisted primary patency rates were 91.2% and 91.2%, respectively (25). In 2020, Yang *et al.* (10) reported on a stiff guidewire recanalized SVC occlusion with catheter patency rates at 6 and 12 months of 92.85% and 58.33%, respectively. Therefore, repeated interventions may be required to maintain patency of vascular access in this study. Furthermore, the lower 12-month patency rate was mainly due to 8 patients with less than 12 months of follow-up post-surgery, which substantially influenced the long-term patency rate. In conclusion, our technique may offer an alternative approach for patients with refractory central venous occlusion.

There were some limitations to this investigation, including the lack of a control group and the observational design of the study. In addition, although no severe complications were observed, the sample size of the study was small. Therefore, future research is warranted to further validate the efficacy and safety of this study and other recanalization methods.

In summary, it is potentially effective and safe for interventional nephrologists to use blunt impingement followed by a sharp recanalization technique for chronic CVO that is refractory to traversal using standard catheter and guidewire techniques. This strategy has a higher success rate and fewer complications than sharp recanalization alone.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-3131/rc

Data Sharing Statement: Available at https://atm.amegroups.com/article/view/10.21037/atm-22-3131/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-3131/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee on Biomedical Research at the West China Hospital of Sichuan University (No. 20211382). Individual consent for this retrospective analysis was waived.

References

1. Toomay S, Rectenwald J, Vazquez MA. How Can the Complications of Central Vein Catheters Be Reduced?: Central Venous Stenosis in Hemodialysis Patients. Semin Dial 2016;29:201-3.
2. Lumsden AB, MacDonald MJ, Isiklar H, et al. Central venous stenosis in the hemodialysis patient: incidence and efficacy of endovascular treatment. Cardiovasc Surg 1997;5:504-9.
3. Anaya-Ayala JE, Smolock CJ, Colvard BD, et al. Efficacy of covered stent placement for central venous occlusive disease in hemodialysis patients. J Vasc Surg 2011;54:754-9.
4. Lok CE, Huber TS, Lee T, et al. KDOQI Clinical Practice Guideline for Vascular Access: 2019 Update. Am J Kidney Dis 2020;75:S1-S164.
5. Kundu S. Review of central venous disease in hemodialysis patients. J Vasc Interv Radiol 2010;21:963-8.
6. Agarwal AK. Central vein stenosis. Am J Kidney Dis 2013;61:1001-15.
7. Liao Z, Zhou L, Zheng X, et al. A case report of sharp recanalization in a hemodialysis patient with severe occlusion of both superior and inferior vena cave. Ann

Palliat Med 2021;10:3495-9.
8. Yoong GSW, Koh FHX, Wee BBK, et al. How to do it: value-driven sharp recanalization of central vein occlusion. ANZ J Surg 2020;90:362-3.
9. Chen B, Lin R, Dai H, et al. Sharp recanalization for treatment of central venous occlusive disease in hemodialysis patients. J Vasc Surg Venous Lymphat Disord 2022;10:306-12.
10. Yang L, Yang L, Zhao Y, et al. The feasibility and safety of sharp recanalization for superior vena cava occlusion in hemodialysis patients: A retrospective cohort study. Hemodial Int 2020;24:52-60.
11. Uceda PV, Feldtman RW, Peralta J, et al. Endovascular treatment of type 3 and 4 thoracic central vein obstruction in hemodialysis patients. J Vasc Surg Venous Lymphat Disord 2021;9:643-51.e3.
12. Sidawy AN, Gray R, Besarab A, et al. Recommended standards for reports dealing with arteriovenous hemodialysis accesses. J Vasc Surg 2002;35:603-10.
13. Young JL, McLennan G. Thoracic Central Vein Occlusion in the Dialysis Patient: An Interventional Perspective. Adv Chronic Kidney Dis 2020;27:236-42.
14. Sfyroeras GS, Antonopoulos CN, Mantas G, et al. A Review of Open and Endovascular Treatment of Superior Vena Cava Syndrome of Benign Aetiology. Eur J Vasc Endovasc Surg 2017;53:238-54.
15. Uceda PV, Feldtman RW, Ahn SS. Long-term results and patient survival after first rib resection and endovascular treatment in hemodialysis patients with subclavian vein stenosis at the thoracic outlet. J Vasc Surg Venous Lymphat Disord 2022;10:118-24.
16. Kim YC, Won JY, Choi SY, et al. Percutaneous treatment of central venous stenosis in hemodialysis patients: long-term outcomes. Cardiovasc Intervent Radiol 2009;32:271-8.
17. Eguchi D, Honma K. Results of Stenting for Central Venous Occlusions and Stenoses in the Hemodialysis Patients. Ann Vasc Dis 2020;13:235-9.
18. Surowiec SM, Fegley AJ, Tanski WJ, et al. Endovascular management of central venous stenoses in the hemodialysis patient: results of percutaneous therapy. Vasc Endovascular Surg 2004;38:349-54.
19. Hongsakul K, Leelarujijaroen P, Boonsrirat U. Outcome of Central Vein Occlusion Recanalization in Hemodialysis Patients and Predictors for Success: A Retrospective Study. J Belg Soc Radiol 2020;104:20.
20. Reindl-Schwaighofer R, Matoussevitch V, Winnicki W, et al. A Novel Inside-out Access Approach for Hemodialysis Catheter Placement in Patients With Thoracic Central Venous Occlusion. Am J Kidney Dis 2020;75:480-7.
21. Arabi M, Ahmed I, Mat'hami A, et al. Sharp Central Venous Recanalization in Hemodialysis Patients: A Single-Institution Experience. Cardiovasc Intervent Radiol 2016;39:927-34.
22. Goo DE, Kim YJ, Choi DL, et al. Use of a rosch-uchida needle for recanalization of refractory dialysis-related central vein occlusion. AJR Am J Roentgenol 2010;194:1352-6.
23. Majdalany BS, Monfore N, Khaja MS, et al. Radiofrequency Wire Recanalization of Chronically Occluded Venous Stents: A Retrospective, Single-Center Experience in 15 Patients. Cardiovasc Intervent Radiol 2019;42:130-6.
24. Yin X, Shen X, Zhou Z, et al. Efficacy and safety of recanalization with transseptal needle for chronic total occlusion of the brachiocephalic vein in hemodialysis patients. Ann Transl Med 2020;8:1141.
25. Wan Z, Lai Q, Zhou Y, et al. Efficacy and safety of a mother-child technique for recanalization of chronic central venous occlusive disease in hemodialysis patients. J Vasc Surg Venous Lymphat Disord 2020;8:558-64.

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