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CASE REPORT

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Utility of covered stents as a bypass for the treatment of central venous occlusion: a case report

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Abstract

Background Central venous occlusion (CVO) is difficult to treat with percutaneous transluminal angioplasty because the guidewire cannot pass through the occluded segments. In this study, we devised a new method for establishing an extra-anatomic bypass between the right subclavian vein and the superior vena cava via a covered stent to treat whole-segment occlusion of the right brachiocephalic vein (BCV) with calcification.

Case presentation We present the case of a 58-year-old female patient who complained of right arm swelling present for 1.5 years. Twelve years prior, the patient began hemodialysis because chronic glomerulonephritis had progressed to end-stage renal disease. During the first 3 years, a right internal jugular vein (IJV)-tunneled cuffed catheter was used as the dialysis access, and the catheter was replaced once. A left arteriovenous fistula (AVF) was subsequently established. Owing to occlusion of the left AVF, a new fistula was established on the right upper extremity 1.5 years prior to this visit. Angiography of the right upper extremity revealed complete occlusion of the right BCV and IJV with calcification. Because of the failure to pass the guidewire across the lesion, we established an extra-anatomic bypass between the right subclavian vein and the superior vena cava with a covered stent. Angiography confirmed the patency of whole vascular access system. After 3 months of follow-up, the patient's AVF function and the bypass patency were satisfactory.

Conclusions As a new alternative for the treatment of long, angled CVO with or without calcification, a covered stent can be used to establish an extravascular bypass between central veins.

Keywords Central venous occlusion, Covered stent, Extravascular bypass, Interventional therapy, Hemodialysis

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Background

Vascular access patency is crucial for hemodialysis (HD) patients. Central venous disease (CVD), including central venous stenosis (CVS) and central venous occlusion (CVO), is one of the most important factors affecting vascular access patency. The most common mechanism of CVD is turbulent flow, mechanical trauma and inflammation caused by current and prior central venous catheters, resulting in intimal hyperplasia [1]. A history of central venous access placement is the most important risk factor for CVD. In addition, peripherally inserted central catheters and central venous port catheters are becoming increasingly important risk factors for CVD. An increased duration of catheter indwelling and a larger catheter caliber might aggravate the lesion. The access site for central venous catheter placement is also important in patients with CVD. Central venous catheters placed by subclavian access pose a particularly high risk, with a 42% incidence of CVD compared with a 10% incidence with catheters placed via internal jugular vein (IJV) access [2]. The incidence of CVD is as high as 50% [3].

Percutaneous transluminal angioplasty (PTA) with or without stenting is the first-line treatment for CVD [3]. Guidewire passage through the occluded segment is the key to this surgical procedure [4]. However, it is difficult to pass guidewires through some old, stiff, or calcified lesions. Despite its risks, sharp recanalization or extra-anatomic bypass techniques are used as rescue measures for treating CVOs that are difficult to recanalize [4, 5]. Reportedly, covered stents can be implanted to establish extra-anatomic bypass between peripheral veins or between peripheral veins and central veins during endovascular angioplasty so that blood in the vascular access can be successfully returned to the right atrium [6, 7]. Bypass establishment between two anatomically unrelated central veins has rarely been reported. Here, we report a case of an angled, long-segment, calcified CVO that was treated with a covered-stent graft bypass between the subclavian vein (SCV) and the superior vena cava (SVC).

Case presentation

A 58-year-old female HD patient was hospitalized due to swelling of the right upper limb over the past 1.5 years. She received dialysis 12 years prior because of end-stage renal disease caused by chronic glomerulonephritis, and for the first 3 years, a tunneled catheter in the right IJV was used for vascular access. The catheter was replaced once because of dysfunction. A left arteriovenous fistula (AVF) was subsequently established for HD. During this period, because of left AVF dysfunction, percutaneous stenting of the left SCV and SVC was performed. One and a half years prior to the current visit, a right AVF was established to replace the left dysfunctional AVF. Edema in the right upper limb occurred immediately after the operation and was significantly aggravated at 6 months prior to surgery. Currently, the patient presented with swelling of her right upper limb accompanied by numbness of her right hand, no limb dysfunction, respiratory distress, and no neurologic manifestations; and the right upper-extremity arteriovenous fistula function was still sufficient for dialysis. Physical examination revealed superficial varicose veins in the patient's right chest and neck and edema in her right upper limb, but the circumference of the right upper limb was not measured (Fig. 1A).

We first attempted to confirm the occlusive sites and to manage them via conventional methods. A 7 F and a 6 F sheath were inserted into the right fistula cephalic vein and right femoral vein, respectively. Contrast imaging verified complete occlusion of the right brachiocephalic vein (Fig. 1B) and the right external iliac vein. Recanalization with a 2.6 m superslippery guidewire assisted by a 5 F angiographic catheter failed in these two occluded veins. Next, we inserted the guidewire through the left femoral vein. The contrast agent was injected through the 6 F sheath into the left femoral vein, which revealed occlusion of the left external iliac vein. Fortunately, we were able to recanalize the left external iliac vein, place the guidewire into the distal end of the SVC via the inferior vena cava (IVC) and right atrium, and then retain an angiographic catheter. Angiography revealed that the left BCV and IJV were patent, but the right BCV and left SCV were occluded. Next, we successfully punctured the right IJV and inserted a 6 F vascular sheath. An occlusion was found on the proximal end of the right IJV (Fig. 1C). Angiography revealed open collateral circulation (Fig. 1D). The patient was thus diagnosed with a type 2B central venous obstruction [8].

Depending on the patient's history and the results of the angiography, the treatment options for this condition include the following:

A. A more aggressive but risky surgical approach to repair the AVF blood return pathway.
B Establishment of new vascular accesses.

·Left internal jugular vein tunneled cuffed catheter (TCC): Patients with a history of superior vena cava and left subclavian vein stent implantation are at high risk of catheter failure and central vein reocclusion.

·Left femoral vein TCC: The primary patency rate of femoral vein TCC is lower, and the risk of catheter failure is greater [9]. If the left iliac vessel is occluded, the patient will lose the opportunity for puncture of the superior vena cava, because we can't deliver the puncture indicator to the inferior vena cava.

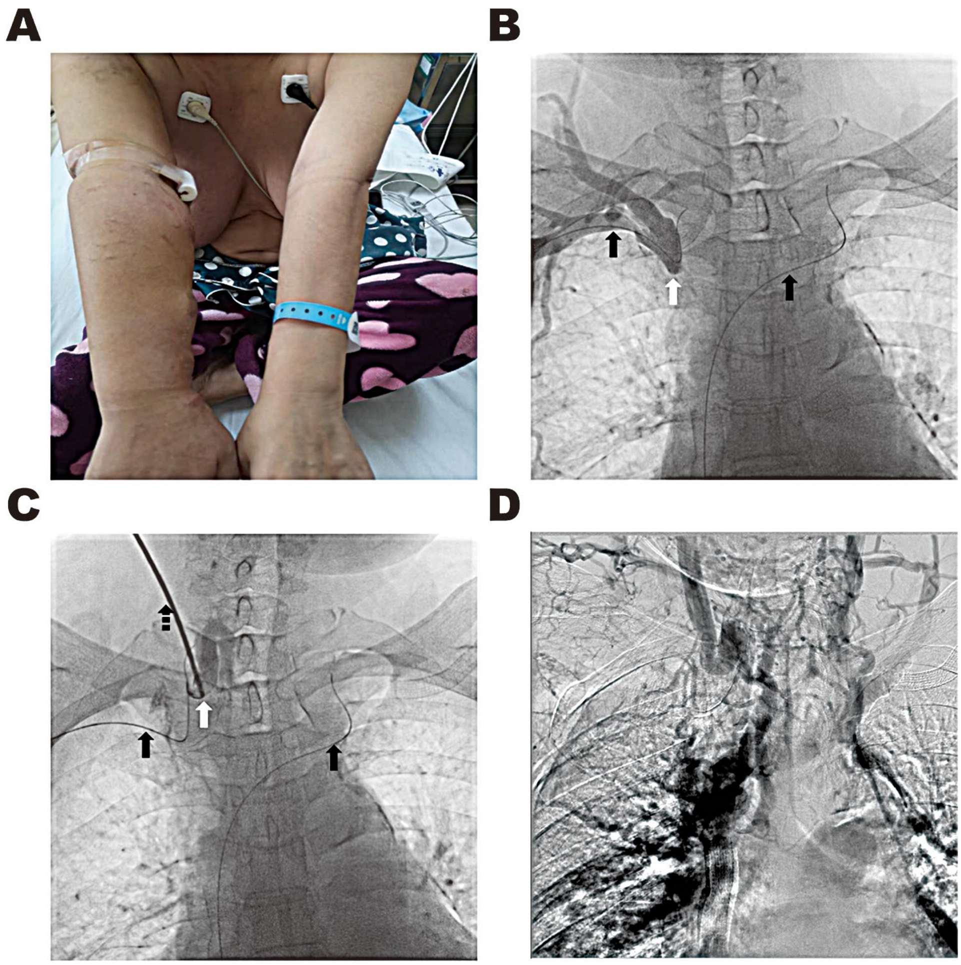

Fig. 1 Symptoms of the patient and angiography of the central venous vessels prior to surgery. **A** Marked swelling of the right upper extremity compared with the left extremity prior to surgery. **B** Angiography revealed right brachiocephalic vein occlusion with collateral formation. **C** A 6 F sheath was inserted into the right internal jugular vein. There was an occlusion on the proximal end of the vessel. **D** Angiography revealed open collateral circulation. The solid white arrow indicates the lesion; the solid black arrow indicates the guidewire. The dashed black arrow indicates the sheath

·Left lower extremity AVF: a remedy for failed repair of the thoracic central vein.

C. Other types of renal replacement therapy.

·Peritoneal dialysis: The present patient refused peritoneal dialysis.

·Urgent kidney transplant: According to the basic principles of human organ allocation and sharing in China, patients with exhausted vascular resources for hemodialysis do not have priority for transplantation.

To preserve the patient's valuable vascular resources and the opportunity to establish new AVFs in the future, we chose the risky and difficult repair operation for vascular bypass construction [10, 11]. More importantly, we had the ability to perform this surgery.

Because of the failure to pass the guidewire across the lesion, we began to perform an extravascular bypass as planned. Through the right sternocleidomastoid triangle, a needle was inserted into the proximal end of the right SCV, and a 6 F sheath was inserted. Under the guidance of digital subtraction angiography (DSA) in the longitudinal and horizontal directions, the SVC was punctured with a percutaneous transhepatic cholangial drainage (PTCD) needle through the sheath in the right SCV (Fig. 2A, B), and then the 6 F sheath was advanced to the SVC (Fig. 2C). This was the key step of the whole surgery. A 1.5 m hydrophilic guidewire was inserted into the IVC along the sheath and pulled out of the body through the sheath in the left femoral vein using an endovascular snare (Fig. 2D). A stretch guidewire was established between the right neck and the left femoral vein. Then, a 2.6 m stiff guidewire was passed through the left femoral vein to enter the right SCV through the 6 F sheath in the right neck. The guidewire was extracted with a snare through the vascular sheath in the right upper limb (Fig. 2E). Next, a stretch guidewire was inserted between the left femoral vein and the outflow vein of the AVF in the right upper limb. The left femoral sheath was replaced with an 11 F sheath. A 6 mm×100 mm balloon

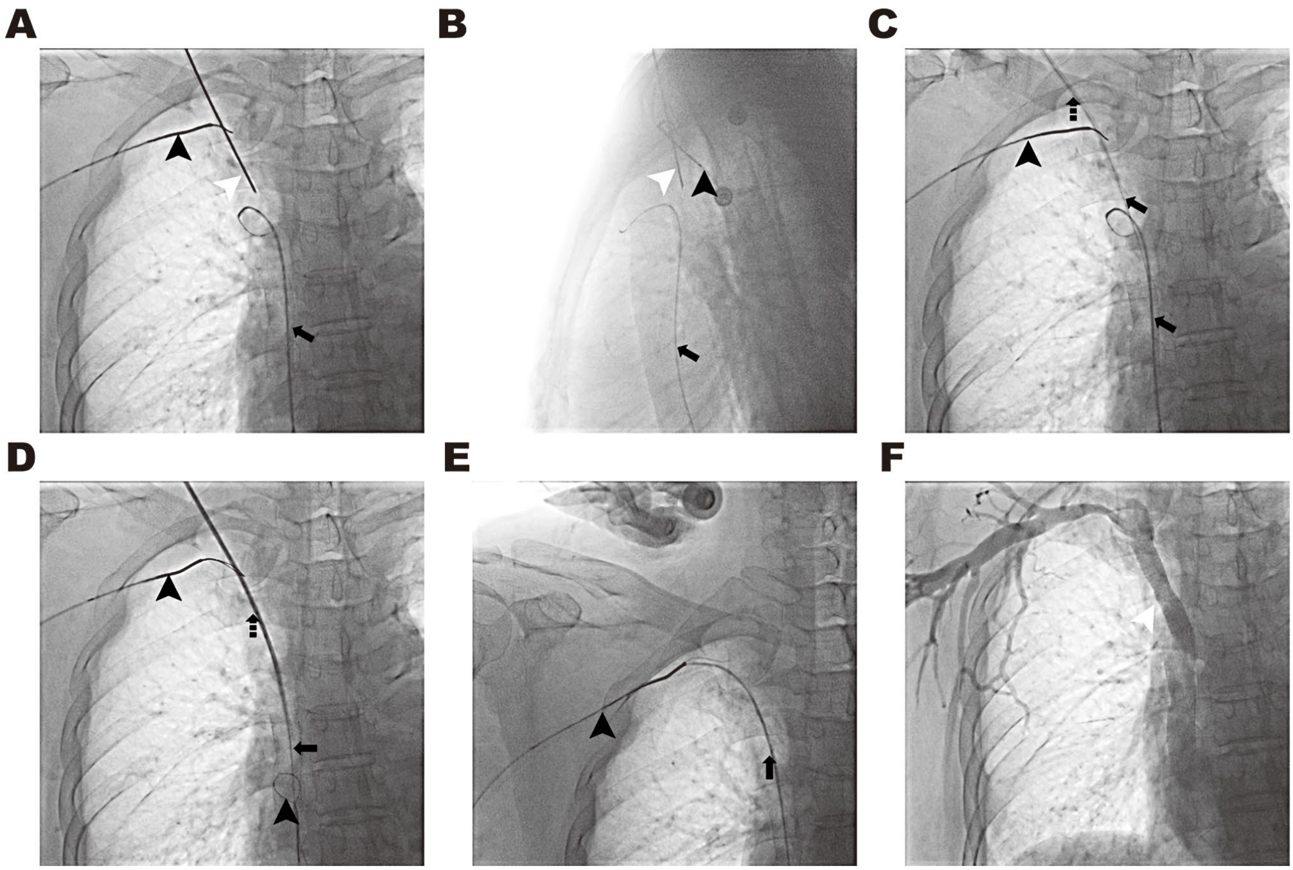

Fig. 2 Creation of a bypass between the right SCV and the SVC with a covered stent. **A** The superior vena cava was punctured with the PTCD needle under DSA guidance in the longitudinal direction. **B** In the horizontal direction, the needle was carefully inserted into the superior vena cava. **C** The 6 F sheath in the subclavian vein was advanced to the superior vena cava after successful percutaneous puncture at the distal end of the superior vena cava. **D** A 1.5 m hydrophilic guidewire inserted through the sheath in the neck was pulled out of the body via an endovascular snare. A stretch guidewire was established between the right neck and the left femoral vein. **E** A 2.6 m guidewire was extracted with a snare through the sheath in the right upper limb to establish the stretch guidewire between the left femoral vein and the outflow vein of the AVF. **F** Contrast image showing the patency of the right SCV, covered stent and SVC. The bottom white arrowhead indicates the needle; the solid black arrow indicates the guidewire. The dashed black arrow indicates the sheath. The bottom black arrowhead indicates the endovascular snare

and an 8 mm×60 mm balloon were passed through the left femoral vein and over the guidewire to dilate the right SCV and SVC. A 10 mm×50 mm covered stent was placed along the guidewire to bridge the right SCV and SVC, and a 10 mm×60 mm balloon was used for dilation. Thus, an extravascular bypass was successfully established between the right SCV and the SVC. Postoperative DSA verified the patency of the fistula vein, right SCV, bypass pathway and SVC (Fig. 2F).

At 180 days of follow-up, the patient's right-hand numbness had disappeared, and her right forearm edema had significantly decreased (Fig. 3). During dialysis, the blood flow was maintained at 280 ml/min, and the dialysis process was smooth. Unfortunately, the patient refused to return to the hospital for further angiography, so we did not know the condition of the central veins, nor could we accurately measure the forearm circumference to quantify the reduction in swelling.

Discussion and conclusions

CVD is common and clinically important in hemodialysis patients. The treatment of CVD should be individualized according to the technical conditions of the institution and the clinical characteristics of the patient. It is important not only to relieve the symptoms caused by CVD but also to resolve the AVF or arteriovenous graft (AVG) in the ipsilateral limb. The present patient had whole segmental occlusion of the right BCV with calcification at the proximal segment of the occlusive lesion. The occluded vessels had adverse anatomic angles, which involved the proximal end of the right SCV and the distal end of the SVC. We successfully established an extravascular bypass between the right SCV and the SVC via an inside-outside-inside technique with a covered stent, which restored the blood flow of the AVF at the right forearm.

Factors such as complete occlusion, calcification, collateral circulation or a poor anatomical angle of the

Fig. 3 Reduction of the right upper extremity swelling 180 days after the intervention

central venous lesion make it difficult to pass the guidewire, and consequently, endovascular treatment cannot be implemented [4, 11]. Therefore, more aggressive treatment strategies, including sharp recanalization and graft bypass, are needed [10].

Sharp recanalization is safe and feasible for the treatment of CVD in cases where recanalization cannot be performed by conventional techniques. Chen et al. used the sharp recanalization technique in 25 patients with CVO, with an overall success rate of 92.6% and no deaths [4]. However, 18% of patients may not respond to sharp recanalization. In the present patient, the occluded lesion was long, calcified and angulated, and it was difficult to achieve recanalization via traditional sharp puncture. To resolve long-segment angled occlusion, Xiong et al. used a "two-step" strategy with the assistance of high-pressure venography to puncture the distal end of the SVC and the proximal end of the right SCV and successfully placed the stretched guidewire across the occlusion. For occlusions in the thoracic cavity, there are several limitations to the sharp recanalization technique. First, the thoracic central vein is surrounded by the heart, aortic arch, carotid artery and other important vessels, the possibility of severe complications is much greater. Second, the negative pressure in the thoracic cavity makes bleeding from venous perforation difficult to control. Third, the safety of sharp recanalization is reduced because of the curved vessel pathway, which limits its application in thoracic CVO [4].

Recently, extra-anatomic vascular bypass techniques for the treatment of CVD have been extensively reported. Surgery and hybrid surgery, which combines surgical and endovascular intervention techniques, are highly reliable because they can be performed under direct vision. The hemodialysis reliable outflow (HeRO) graft consists of an artificial blood vessel and an endovenous catheter that can pass through venous stenosis or occlusion to establish an extra-anatomic bypass between the peripheral vessels and the central vessels. Pipeline technology is another method for establishing an extra-anatomic bypass method that can be used percutaneously to create a long stent bypass outside the thrombotic vascular access site to connect two anatomically unrelated veins and thereby drain the blood from the vascular access to the SVC. Although with these endovascular bypass technologies, surgeons avoid causing major intraoperative trauma [7, 12], many vascular resources are wasted because of the long bypass pathway. However, in cases of long peripheral venous occlusion, the long-stent bypass procedure has advantages. Multiple bypasses can even be established to solve the problems of simultaneous limb return and dialysis access [13].

Covered stents were developed from materials similar to AVGs. In HD patients, covered stents are mainly used for pseudoaneurysms closure and for vascular dissection in cases of an old vascular access, or to inhibit intimal hyperplasia to compensate for the deficiency of bare metal stents. Chen et al. first reported the use of covered stents to establish a vascular bypass between the cephalic and basilic veins (both of which are peripheral vessels) and thereby reestablish a return access for the AVG [6]. In this case, we used a covered stent to perform bypass between two central vessels, which is more difficult and riskier than connecting peripheral vessels.

The keys to successful central venous bypass establishment using a covered stent are puncturing the right SCV and the SVC simultaneously on the basis of percutaneous SVC puncture and then building a guidewire connection between the proximal and distal ends of the occluded site. Percutaneous SVC puncture is an advanced but high-risk technique that effectively solves the problem associated with occlusion of the distal end of the vascular access of the SVC [14]. Simultaneous puncture of the right SCV and the SVC on this basis is more difficult, thus requiring experienced interventionalists to operate carefully under angiography and observe multiple angles to ensure the accuracy of the puncture.

We first reported the use of an endovascular technique to establish a bypass between two central veins to restore the return blood flow of an AVF of the ipsilateral limb. Angiography revealed no contrast agent leakage at the end-to-side anastomosis between the covered stent and the vessels. Three months after the operation, the patient's AVF function, the adequacy of dialysis, and anemia improved. Our experience provides a new approach for treating long, angled central venous occlusive lesions with or without calcification that are difficult to treat via the conventional PTA technique. Our procedure effectively preserves the valuable vascular resources that are exclusively available to dialysis patients and avoids the high risk of sharp puncture recanalization as well as the risk of trauma related to the surgical operation. However, its safety and long-term efficacy still need to be further observed and evaluated. Conclusively, our method is safe and effective at establishing an extra-anatomic bypass between two central veins using covered stents for the treatment of long, angled CVO with or without calcification. Our experience provides a novel way to manage complicated CVD.

Abbreviations

AVF	Arteriovenous fistula
BCV	Brachiocephalic vein
HD	Hemodialysis
CVD	Central venous disease
CVS	Central venous stenosis
CVO	Central venous occlusion
PTA	Percutaneous transluminal angioplasty
SCV	Subclavian vein
SVC	Superior vena cava
IJV	Internal jugular vein
IVC	Inferior vena cava
DSA	Digital subtraction angiography
PTCD	Percutaneous transhepatic cholangial drainage
AVG	Arteriovenous graft

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Author contributions
X.L. and Z.X. diagnosed and treated the patient. Y.H. supervised this case report. Z.X. wrote the main manuscript text and prepared Figs. 1, 2 and 3. X.L. approved the final version. All authors read and approved the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Approval for publication was obtained from the Ethics Committee of Heilongjiang Provincial Hospital, China.

Consent for publication
We obtained written informed consent from the patient, as well as her legally authorized representative, for the publication of this case report.

Competing interests
The authors declare no competing interests.

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