Cardiovasc Intervent Radiol (2020) 43:1942–1945
https://doi.org/10.1007/s00270-020-02615-1

CASE REPORT

Percutaneous Extra-Anatomic Double-Barrel Bypass for Salvage of Hemodialysis Access and Treatment of Venous Occlusive Disease

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Received: 16 April 2020 / Accepted: 2 August 2020 / Published online: 17 August 2020

Abstract A woman with an upper extremity brachioaxillary arteriovenous dialysis graft presented with a 9-month history of profound ipsilateral arm swelling and numbness secondary to chronic axillosubclavian vein occlusion. Previous endovascular and open venous recanalization attempts were unsuccessful. A totally percutaneous extra-anatomic venous bi-bypass was created to salvage the dialysis access circuit and reconstruct the deep venous system. Using overlapping Viabahn stent-grafts, two parallel bypasses were created from the arteriovenous graft and brachial vein, respectively, to the brachiocephalic vein. The hemodialysis graft regained function. Upper extremity symptoms resolved within 48 h. This is the first reported percutaneous double-barrel technique of extra-anatomic venous bypass creation for simultaneous management of a failed dialysis access and chronic venous occlusive disease.

Keywords Percutaneous extra-anatomic venous bypass · Costoclavicular bypass · Chronic venous occlusive disease · Thoracic outlet syndrome · Dialysis access · End-stage renal disease · Interventional radiology

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Abbreviation
AV Arteriovenous

Introduction

Central venous occlusive disease is an adverse outcome in patients with upper extremity hemodialysis access. Occlusions, based on anatomic location, may be treated with recanalization and stent or stent-graft placement with 1-year primary and secondary patencies of 60% and 98%, respectively [1]. When endovascular treatments are unsuccessful, open surgical approaches may be beneficial. Surgical options for upper extremity central venous occlusions include claviculectomy, inflow banding to reduce flows and pressures while preserving hemodialysis access, and complex bypass graft reconstruction [2, 3]. Previous reports of surgical graft reconstruction have demonstrated 1-year primary and primary-assisted patencies of 40% and 85%, respectively [4, 5]. Given that hemodialysis patients are typically older with multiple comorbidities; however, open surgical approaches are not without risk [6]. Access ligation may improve symptoms, but at the cost of the hemodialysis access abandonment and any possibility for future access creation.

Alternative endovascular options have been successful in prior reports including blunt and sharp needle recanalizations [7]. When inline recanalization is not feasible, particularly in the costoclavicular region, endovascular extra-anatomic venous bypass creation has been successful

[8–11]. These reports; however, are limited to single lumen bypass creation in the dialysis access outflow.

This report describes a totally percutaneous double-barrel venous bypass creation to simultaneously restore outflow for a failed hemodialysis arteriovenous (AV) graft and to reestablish adequate native upper extremity venous drainage (Fig. 1).

Case Report

Presentation

Family consent was obtained for publication of this report. A 74-year-old woman with multiple comorbidities and a right upper extremity brachioaxillary AV graft presented with profound right upper extremity swelling and numbness secondary to chronic right axillosubclavian vein occlusion (Fig. 2A). The 6-mm polytetrafluoroethylene AV graft was created 269 days prior to this endovascular intervention and was never used for hemodialysis. The patient developed mild right upper extremity swelling after graft construction secondary to the new right axillosubclavian vein thrombosis. An initial endovascular intervention on postoperative day 18 included a sharp recanalization attempt which was unsuccessful. Repeat endovascular and open interventions occurred on postoperative day 154 and again were unsuccessful (Fig. 2B). Hemodialysis access was limited to a left internal jugular vein tunneled central venous catheter while the right arm swelling and numbness worsened. A multidisciplinary decision was made to create a totally percutaneous extra-anatomic venous bi-bypass to restore the AV graft outflow and reconstruct the deep venous system.

Venous Bi-Bypass Creation

Percutaneous extra-anatomic double-barrel venous bypass creation is shown in Fig. 1. The patient was maintained under general endotracheal anesthesia. Cefazolin was administered. Right upper extremity venography, performed from the right AV graft and right brachial vein, demonstrated chronic right axillosubclavian venous occlusion (Fig. 2C). Antegrade and retrograde accesses were obtained using ultrasound-guidance into both the peripheral and central right AV graft and right brachial vein with placement of 5-French sheaths. From the antegrade accesses, wires from the retrograde accesses were snared, and subsequently 7-French antegrade, through-and-through, Peel-Away Introducer Sheaths (Cook Medical; Bloomington, IN) were placed in the AV graft and brachial vein (Fig. 2D). An anterior chest venous collateral with drainage into the right brachiocephalic vein and superior vena cava was then cannulated, and an 8-French Peel-Away Introducer Sheath (Cook Medical) was placed into the right neck (Fig. 2D). The 7-French through-and-through sheaths were then tunneled subcutaneously toward the neck sheath (Fig. 2E). Two subcutaneous steel reinforced wires were then placed, extending from the antegrade arm accesses to the superior vena cava. Over each wire, three overlapping 11 mm × 10 cm Viabahn stent-grafts (W. L. Gore and Associates; Flagstaff, Arizona) were placed to create two parallel extra-anatomic venous bypasses from the graft and brachial vein, respectively, to the brachiocephalic vein (Fig. 2F). The stents were post-dilated using an 8-mm high-pressure balloon (Boston Scientific; Marlborough, MA) (Fig. 2G). Completion venography demonstrated brisk inline flow throughout the venous bi-bypass (Fig. 2H). Skin closure was performed with the

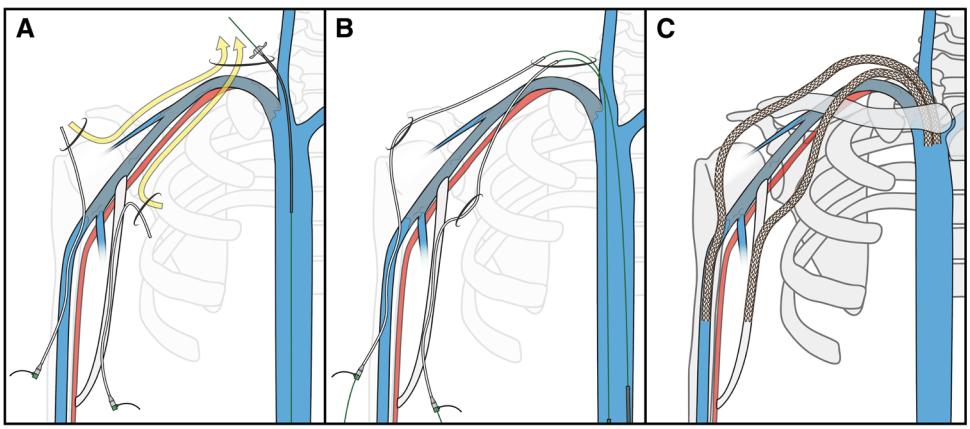

Fig.1. *Percutaneous Extra-Anatomic Double-Barrel Venous Bypass Creation*. **A** A right neck central venous access and dual through-and-through accesses along both the arteriovenous graft and brachial vein were obtained. **B** The arm sheaths were then tunneled subcutaneously toward the neck sheath. A wire was advanced through each arm sheath and inserted into the neck sheath. **C** All sheaths were removed, and side-by-side extra-anatomic venous bypasses were created from the arteriovenous graft and brachial vein to the brachiocephalic vein using overlapping Viabahn stent-grafts

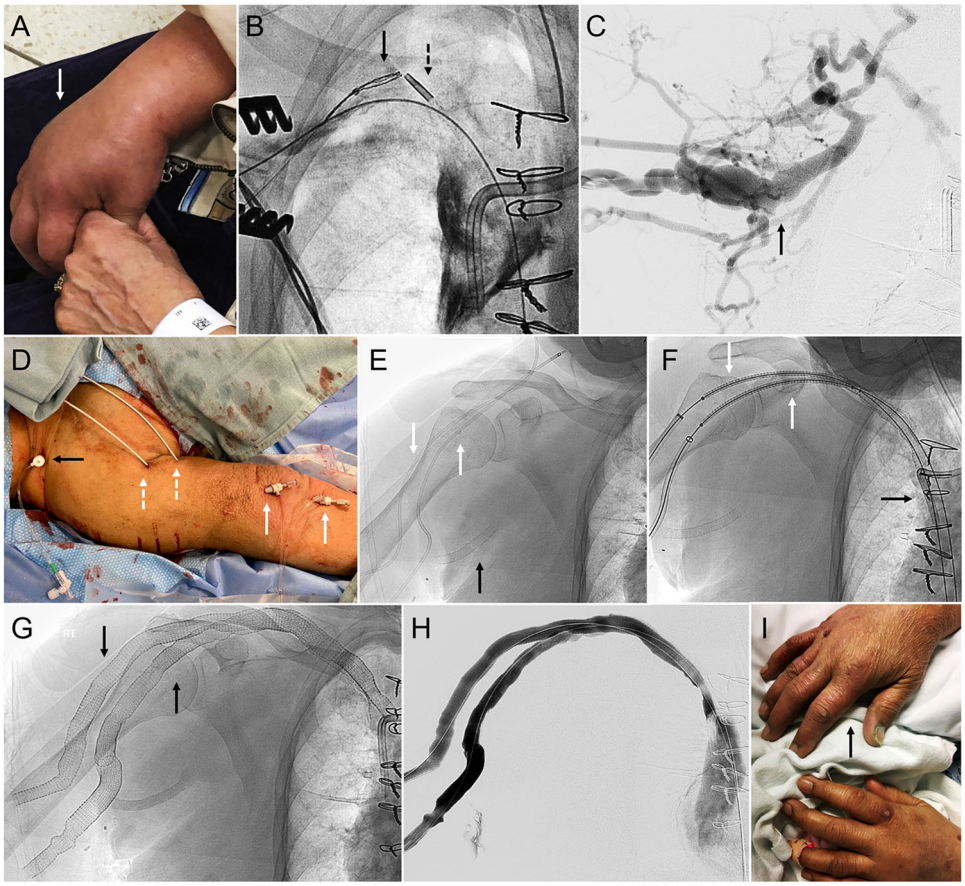

Fig.2. *Extra-Anatomic Bi-Bypass Creation*. **A** Marked swelling of the right (solid white arrow), compared to the left, upper extremity prior to bypass creation. **B** Attempted open venous recanalization using a snare (solid black arrow) and support catheter (dashed black arrow). **C** Right upper extremity venography demonstrating chronic axillosubclavian occlusion (solid black arrow). **D** Sheaths were placed across antegrade (solid white arrows) and retrograde (dashed white arrows) accesses along the brachioaxillary graft and brachial vein. A right neck sheath (solid black arrow) was also placed into the superior vena cava. **E** Sheaths (solid white arrows) were progressively tunneled from the antegrade accesses to the right neck sheath. A stent-graft (solid black arrow) from a prior abandoned access is visualized. **F** Double-barrel, extra-anatomic, Viabahn stent-grafts (solid white arrows) were deployed extending from the brachiocephalic vein to the arteriovenous graft and brachial vein. A left-sided dialysis catheter is partially visualized (solid black arrow). **G** Extra-anatomic venous bi-bypass creation (solid black arrows). **H** Venography demonstrating brisk in-line flow through the double-barrel venous bypass without filling of collateral venous channels. **I** Resolution of the right hand (solid black arrow) swelling 48 h after the intervention

placement of interrupted absorbable sutures and surgical glue at each access site. There were no adverse outcomes in the perioperative period. Clopidogrel 75 mg daily was started on postoperative day 1.

Follow-Up Evaluations

The bypass graft was successfully used for hemodialysis after the procedure, and the tunneled hemodialysis catheter was removed following successful dialysis. Upper extremity swelling and numbness resolved within 48 h (Fig. 2I) and did not recur over a total clinical follow-up of 118 days. The patient suffered a fall on postoperative day 36 resulting in a subdural hemorrhage, and her anti-platelet regimen was discontinued. Venous duplex examination, performed on day 89, demonstrated patency of the venous bi-bypass. At that time, clopidogrel 75 mg daily was restarted.

Discussion

This report describes the first double-barrel technique for creating an extra-anatomic venous bypass to both salvage a failed dialysis graft and manage symptomatic central venous occlusion. As mentioned previously, there are several recent reports that have demonstrated the efficacy and safety of endovascular extra-anatomic bypass grafts for various venous occlusions in dialysis patients [7–11]. More recently, *Hull and Snyder* expanded on the feasibility of the percutaneous costoclavicular bypass procedure by demonstrating 100% technical success in nine patients with one-

year primary and secondary patencies of 67% and 89%, respectively [11]. As opposed to the patient described in this report, these procedures were performed in patients with upper extremity AV fistulas. Similar to this patient, Viabahn stent-grafts were used in 8 of 9 patients; the one patient with a Gore hybrid vascular graft encountered difficulty with kinking and ultimately thrombosed.

The combination of venous thoracic outlet syndrome and chronic central venous occlusions is management challenge. With respect to venous thoracic outlet syndrome, surgical decompression offers better long-term patency rates compared to angioplasty and stenting [11]. The value of first rib resection in the presence of an axillosubclavian occlusion that cannot be recanalized; however, remains questionable. In such situations, extravascular bypass techniques may serve to re-establish the venous flow over the clavicle. The idea of a double-barrel technique aims to solve both problems with one procedure, a proposal that is not insignificant to a patient with multiple comorbidities. Rather, if a functioning hemodialysis AV access remains on the symptomatic side, treatment challenges with conventional techniques include preserving venous outflow for dialysis in the setting of absent central venous return. Although surgical ligation or outflow reduction may relieve symptoms, these approaches either sacrifice or risk sacrificing hemodialysis access. A double-barrel venous bypass technique preserves hemodialysis access and improves upper extremity symptoms.

In this case, the patient had a complex central venous occlusion which had failed multiple prior endovascular recanalization attempts. Additionally, there was no single venous outflow segment which would restore both the AV graft outflow and native venous drainage from the arm. For this reason, a double-barrel technique was employed to re-establish adequate outflow for both the AV graft and the extremity.

Potential criticisms of the double-barrel technique may be that arm symptoms may have improved with construction of a technically simpler single-barrel conduit from the dialysis access. In this instance; however, the double-barrel approach has merit as it offered a single-session approach to restoring hemodialysis access and addressing the upper extremity symptoms as well. Additionally, given the extent of disability, it was thought that a single conduit may be inadequate. Rather than a staged approach, a single-session option negates potential added risk from an additional procedure and radiation exposure.

This is the first report of a totally percutaneous venous bi-bypass creation which restored a functional hemodialysis AV graft and provided symptomatic relief through improved upper extremity venous drainage through 118 days of follow-up. Given the promising outcome in this patient, further studies are needed to evaluate long-term safety and patency rates.

Author Contributions All authors have read and contributed to this manuscript.

Funding None.

Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies 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.

Informed Consent For this type of study formal consent was not required. Informed consent and family consent were obtained for this procedure and publication.

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