Prosthetic brachial artery-external jugular vein arteriovenous grafts as a novel option for hemodialysis access: A case report

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Received March 13, 2023; Accepted October 6, 2023

DOI: 10.3892/etm.2023.12289

Abstract. Following the exhaustion of all conventional hemodialysis access options in the upper extremities, a prosthetic arteriovenous loop was performed between the brachial artery (BA) and the external jugular vein (EJV) as a novel access option for hemodialysis in the present case report. During the procedure, a polytetrafluoroethylene graft was anastomosed to the BA and the EJV, and looped on the upper limb. The safety and reliability of BA-EJV access was evaluated by determining the complications, patency and intervention rates. The patient was then followed up for 20 months. The graft became thrombosed 20 months after the placement. There were no complications, such as infection, bleeding or aneurysmal lesions. Overall, the present study demonstrates that hemodialysis via BA-EJV access represents an unusual, yet effective and safe procedure, which may be conducted with acceptable complications and patency rates.

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Abbreviations: BA, brachial artery; EJV, external jugular vein; AV, arteriovenous; AVG, AV graft; AVF, autogenous AV fistula; PTFE, polytetrafluoroethylene

Key words: prosthetic AV loop, hemodialysis access, AVF, AV bypass graft, complex vascular access

Introduction

End-stage renal disease (ESRD) is a global health concern (1), and hemodialysis access is of utmost importance to patients with ESRD who require renal replacement therapy. According to the Kidney Disease Outcomes Quality Initiative (2), autogenous arteriovenous (AV) fistula (AVF) is the recommended vascular access point for hemodialysis. However, for some patients with exhausted upper limb autogenous access options, neither renal transplantation nor peritoneal dialysis is a suitable option. As a result, the creation of a complex vascular access using an expanded polytetrafluoroethylene (PTFE) graft or access via the lower limbs may be required for such patients (3). Therefore, these patients often require more complex access procedures.

Several complex access procedures have been reported in patients with challenging circumstances. In 2008, Morsy *et al* (4) reported their experience with the utilization of axillary-axillary arteriovenous bypass grafts as a final alternative for patients who have experienced failure of autogenous access sites, and for whom peritoneal dialysis or transplantation are not feasible options. The procedure involves the creation of a necklace graft using internally reinforced prostheses, which are anastomosed end-to-side to the axillary artery and contralateral vein, and then tunneled directly through the subcutaneous space before reaching the sternum. The findings of this study demonstrate that these bypass grafts offer a viable solution for complex cases, with reasonable patency rates and minimal complications (4). Other options include internal jugular vein bypasses, axillary loops, femorofemoral AV crossover bypasses, superficial femoral vein transpositions, axillary artery to popliteal vein bypasses and femoral artery to right atrium bypasses (5,6). When an arteriovenous fistula cannot be established in the upper or lower limb, arterioarterial prosthetic loops have been utilized as an alternative for hemodialysis access in situations where no other option is feasible (7,8).

Although a number of complex access procedures have been described, the use of the external jugular vein (EJV) for outflow in patients with particularly challenging venous disease has rarely been reported. The external jugular vein was identified as a viable outflow conduit for arteriovenous fistulas of the upper extremity in cases where the axillary veins are occluded,

exhibiting acceptable patency rates (9). In another study, the use of an ipsilateral internal jugular vein (IJV) as an AV outflow vein was examined in patients with subclavian or axillary vein stenosis or occlusion (10). The results indicated that a brachial-jugular AV graft may achieve satisfactory results in terms of patency and complication rate, although the primary patency rate decreases significantly over time. The use of the IJV as an outflow vein should be the last option for using a particular arm due to the risk of complications such as steal syndrome, seroma, hematoma, swollen arm, infections, pseudoaneurysm, bleeding from puncture site, stenosis and thrombosis (10). In the present case, a prosthetic AV loop between the brachial artery (BA) and the EJV was used for a patient whose vascular conditions did not allow for the creation of another type of upper limb access. The current study presents the experience of utilizing a PTFE graft loop anastomosis with the BA and EJV as an AV bypass graft for hemodialysis access.

Case report

A 70-year-old male patient had received maintenance hemodialysis for >10 years. In June 2015, the patient presented to Lishui Municipal Central Hospital (Lishui, China) with a complaint of lower extremity dialysis access thrombosis for 25 h. The medical history included diabetes mellitus, diabetic nephropathy, hypertension and peripheral vascular disease. Nine years previously, a left upper extremity arteriovenous fistula was created, but it lost functionality three years post-operatively. Six years previously, a right upper extremity arteriovenous fistula was established. Three years previously, a left lower extremity artificial vascular access was created using a bypass graft from the left femoral artery to the deep femoral artery. However, after 16 months, the artificial vascular access was removed due to bleeding. Two years previously, a lower extremity artificial vascular access was performed using the great saphenous vein.

A percutaneous mechanical thrombectomy was unsuccessful. A pre-operative assessment was initially performed, which included upper extremity and central venograms. Venograms of the upper arm and central veins had excluded central stenosis for the patient. The BAs were evaluated using color Doppler ultrasound (data not included). A temporary right femoral vein catheter was used for hemodialysis. Finally, the EJV was selected as the outflow vein, and inflow was performed from the left BA. It was decided that a BA-EJV AV bypass graft procedure would be performed as a permanent vascular access option.

The procedures were performed under general anesthesia, which was considered appropriate by the surgical team. The surgical procedures included the exposure of the BA and EJV, the subcutaneous placement of an expanded PTFE prosthesis with a 6-mm diameter as the loop, and a PTFE graft loop extending down into the mid-forearm, for which a forearm incision was required. Following the separation of the BA and EJV, a PTFE graft was positioned following the configuration of a subcutaneously tunneled loop on the upper limb. A 6-0 polypropylene suture was used in the creation of side-to-end or end-to-end anastomoses between the BA or EJV and graft. The length of the implanted graft was 60 cm. The duration of the surgery was 90 min, and the amount of blood lost was 100 ml.

Post-operative complications included temporary arm swelling for 2 weeks. Subcutaneous administration of low molecular weight heparin (4,000 units) once daily was initiated for a duration of 3 days and subsequently discontinued. Upon discharge, the patient was prescribed aspirin (100 mg/day) as an antiplatelet therapy. The patient was assessed at a 2-week post-operative follow-up by the surgeon. Subsequently, the access nurse evaluated the graft during dialysis sessions to ensure the patency. In addition, nephrology physicians advise against repeated punctures at the same site and recommend puncturing at different points with intervals of >1 week. Blood flow of the graft was excellent for hemodialysis. Post-operative computed tomography angiography of the access revealed a patent anastomosis (Fig. 1). The patency of the graft continued for 20 months. The graft became thrombosed 20 months after the placement. However, the patient refused to undergo a thrombectomy surgery. A cuffed catheter was placed in the right femoral vein for long-term hemodialysis. The patient succumbed to hypertensive intracerebral hemorrhage unrelated to hemodialysis access, 25 months post-surgery.

Discussion

Optimal vascular access for hemodialysis is characterized by a low rate of associated complications, the ability to deliver adequate flow rates and long-lasting patency. It is generally known that AVF has fewer associated complications, a longer patency, fewer interventions required and lower costs than AVGs or catheters. Therefore, AVF is the primary choice for hemodialysis access (11). However, the number of patients who have multiple AVF failures and require complex vascular access is increasing. In the case described in the present study, the patient had exhausted all other options for upper extremity access. For patients without options via the upper extremities, AV or arterial-arterial grafts on the lower extremities have been previously reported (7,8,12,13). However, a femoral vein transposition or arterioarterial prosthetic loops are associated with a high risk of ischemic complications, and are not suitable for patients with peripheral artery disease. Therefore, lower extremity vascular access should be carefully tailored to each individual patient (12).

For patients in whom upper limb access is not obtainable, thigh AV access has been reported as a viable option (14). It has been shown that prosthetic AV access in the leg is associated with a low risk of Steal syndrome, including symptoms/complaints of pain, numbness, coldness and weakness in the affected limb; however, it is accompanied by low primary and secondary patency rates, a particularly high infection rate and more frequent surgical revisions (15). Axillorenal AVG and right atrial bypass grafting have also been previously reported (16,17). However, the loop requires an anastomosis to the renal vein or to the right atrial appendage through a median sternotomy, which is considered to be a complex access configuration. In addition, chest wall or arm AVGs based on the axillary artery and ipsilateral axillary vein are well described in the absence of central vein occlusion (18-20). In the present case, AVF construction had failed and the creation of complex grafts based on the axillary vein was not feasible for the patient. Thus, a novel AVG procedure for

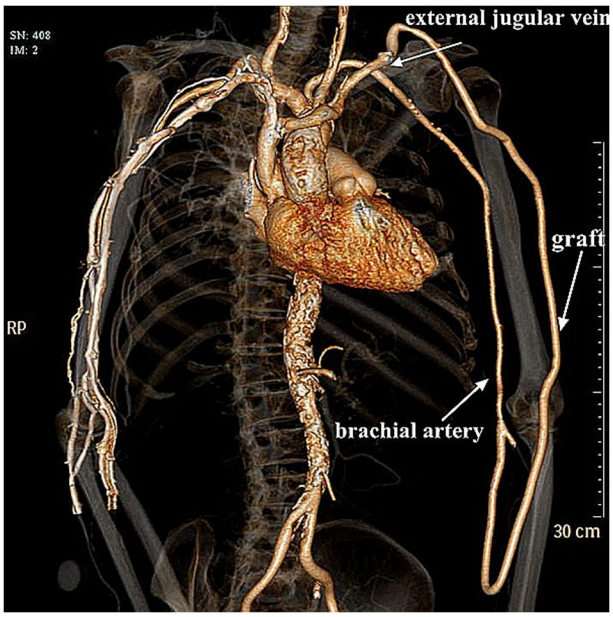

Figure 1. Computed tomography angiography showing the brachial artery-external jugular vein arteriovenous prosthetic loop after placement. RP, right posterior.

hemodialysis based on the EJV and BA was created as the upper body access option.

In the present patient, previous upper or lower limb vascular access and central venous catheter use had failed multiple times, and the incidence of central venous stenosis was high. The presence of central venous stenosis or obstruction is a contraindication to this BA-EJV access. Thus, it is suggested that pre-operative venography is required when the clinical suspicion or history of central venous stenosis exists. If central venous stenosis is identified, percutaneous transluminal angioplasty or a stent is required. If central venous occlusion is identified, re-cannulation of the central vein is necessary. According to previous studies, lower limb access is required in patients whose occlusion cannot be treated (13,18). In the case in the present study, an increase in the risk of developing thrombosis after the BA-EJV procedure was considered; therefore, the patient was treated with a post-operative oral antithrombotic drug. However, the risk of post-operative hemorrhagic complications needs to be carefully evaluated.

In the present patient, the BA-EJV graft maintained patency for >20 months. The patient also did not experience any severe complications, such as hemorrhaging, infection and aneurysmal dilatation. These results were considered acceptable with respect to the lack of vascular access in the patient. Based on the present study, it is considered that the BA-EJV may represent a novel hemodialysis access option.

Although BA-EJV grafting is an acceptable procedure for establishing upper limb hemodialysis access, this process may be accompanied by complications that require early treatment and recognition. For example, graft infection requires the use of systemic antibiotics, or a total or subtotal graft excision (21). In addition, venous anastomotic stenosis leads to prosthetic graft thrombosis. Previous studies have demonstrated that venous anastomotic stenosis typically occurs in the first year after the procedure (22,23). Furthermore, heart failure is the most frequent cardiovascular disease associated with grafting or fistula formation, due to the marked hemodynamic changes related to the large increase in blood flow (24-26). It may be suggested that patients with heart failure classified as New York Heart Association Class IV are not suitable candidates for BA-EJV access (27). Finally, BA-EJV access may result in hematomas, arterial steal syndrome, ischemic monomelic neuropathy or the formation of an aneurysm (27). Previous studies have suggested that pseudoaneurysms occur in ~10% of PTFE grafts (23,28). The use of BA-EJV GRAFT may also lead to the development of pseudoaneurysms resulting from repeated puncture or graft material deterioration. In the present case, pseudoaneurysm formation was not observed, as a careful puncture technique was applied.

It should be noted that although acceptable results were obtained for the patient described in the present study, the lack of a control group was one limitation to the report. There were also specific neck mobility issues in the patient. Furthermore, it was noted that the graft crossed the elbow crease in two areas, which could lead to the kinking of the graft upon flexion at the elbow. The indications for BA-EJV GRAFT need to be clearly defined due to the aforementioned potential complications. AVF remains the preferred access option for hemodialysis, and BA-EJV GRAFT may be utilized as a second line procedure only for patients in whom other upper extremity possibilities for AV access creation are exhausted.

In conclusion, the present study describes the case of a patient in which the BA-EJV GRAFT was used as an alternative approach for hemodialysis access as all other conventional vascular access options had been exhausted. However, further carefully designed studies are required in the future to perform more robust comparisons of BA-EJV GRAFT with other access methods.

Acknowledgements

Not applicable.

Funding

The present study was financially supported by the Medical and Health Science Technology Plan Project from Zhejiang, China (grant no. 2020ZH082).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

WL contributed to the conception and design of the study, treated and followed up patients, and collected the data. JX advised on patient treatment and surgery. HL was responsible for obtaining medical images and analyzing patient data. WL and JX confirm the authenticity of all the raw data. All authors have read and approved the manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Written informed consent was obtained from the patient for the publication of their data and any related images.

Competing interests

The authors declare that they have no competing interests.

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