Proximalization through one incision of a wrist arteriovenous fistula and distal revascularization with interval ligation

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ABSTRACT

In the setting of ischemic steal syndrome with tissue loss, patients with radiocephalic fistulas have limited options to preserve their conduit and treat their ischemic symptoms. To address this, we have proposed the technique of proximalization through one incision of a wrist arteriovenous fistula (POWR) with distal revascularization with interval ligation (DRIL) procedure. In the present retrospective, single-center, case series, we evaluated the outcomes of three patients with radiocephalic fistulas who had undergone POWR DRIL from 2017 to 2021. Their ischemic symptoms were monitored for regression. All three patients showed signs of regressing ischemia. The POWR DRIL represents an efficient procedure to address tissue loss and preserve the autogenous conduit. (J Vasc Surg Cases Innov Tech 2023;9:1-5.)

Keywords: DRIL; Ischemic steal; Proximalization; Radiocephalic fistula; Ulcer

As of 2018, end-stage renal disease requiring dialysis has affected ~500,000 patients in the United States.[1] The methods of access have varied from autogenous access conduits, prosthetic grafts, and the use of long- and short-term external catheters. For patients with autogenous conduits, clinically significant steal syndrome will affect 1% to 8%.[2] Their symptoms can range from paresthesia to motor and/or sensory loss, rest pain, and/or ulceration. In prior studies, it has been shown that the potential risk factors for clinically significant steal syndrome include an extensive atherosclerotic burden, the use of brachial artery inflow, and a straight arteriovenous graft configuration.[3-5] The solution will depend on the severity of the symptoms. Solutions have varied from simple hand exercises to procedures such as banding and/or ligation.[6] In the case of a radiocephalic fistula with basilic vein outflow and rest pain, distal radial artery ligation could be an acceptable treatment provided adequate ulnar artery perfusion of the hand is present; however, tissue loss will require more perfusion.[7] The options are limited in such situations. Distal revascularization with interval ligation (DRIL) is a possibility; however, DRIL for small targets has proved difficult. Therefore, we have proposed a novel technique that both preserves the existing conduit and revascularizes the hand through a single surgery involving transposition of the cephalic vein in the forearm to the brachial artery or axillary vein in the upper arm to maintain hemodialysis access and use the basilic vein to create a brachial artery to brachial artery bypass through one incision. This procedure, thus, serves to address both distal ischemia and preservation of the autogenous conduit.

METHODS

Between April 2018 and January 2021, three patients had undergone proximalization through one incision of a wrist arteriovenous fistula (POWR) and DRIL. All patients had had a prior radiocephalic fistula with basilic vein outflow and had had signs of distal extremity ischemia in the form of digit ulceration and/or gangrene. Evidence of steal syndrome was found on physical examination. Additionally, all three patients had undergone fistulography and/or angiography preoperatively (Fig 1), which demonstrated retrograde radial artery flow, an absence of proximal arterial lesions, and/or ulnar artery occlusion. Before the procedure, the patients had undergone vein mapping and arterial duplex ultrasound. Permacaths were not routinely placed in all patients. However, most had had short-term access in place either before or after the procedure. One patient had not returned in a timely fashion for his permacath to be removed. Finally, all three patients had been seen in the office postoperatively and had subsequently undergone fistulography 1 to 2 months afterward. The patient demographics are listed in the Table.

Case techniques

Bypass technique. An incision is made over the cephalic vein arteriovenous fistula (AVF) from the wrist and coursing proximally over the median cubital vein and basilic vein in the upper arm (Fig 2, *a*). The

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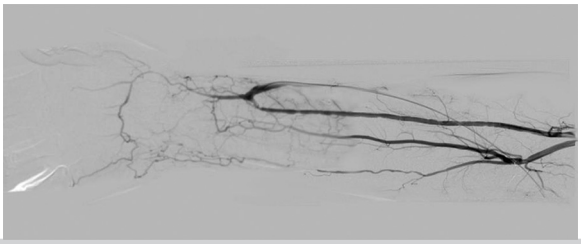

Fig 1. Preoperative fistulogram of radiocephalic fistula showing ulnar artery disease.

cephalic fistula and basilic vein are mobilized with care to not injure the underlying nerves. The cephalic vein is transected from the radial artery distally and oversewn using 5-0 Prolene suture in a running fashion. The proximal basilic vein is transected in a similar fashion, and the vein is then distended with a heparinized saline solution. The brachial artery is dissected out at the level of the antecubital fossa through the same incision used for the vein harvest. The patient is then systemically heparinized. The basilic vein (which has theoretically never been accessed) is measured and cut to length and then reversed. The brachial artery is clamped ~10 to 12 cm proximally to the antecubital fossa for proximal anastomosis of the DRIL. A basilic vein to brachial artery end-to-side anastomosis is created in the standard fashion. The vein is distended and marked. The distal end of the brachial artery is then clamped and transected. An end-to-end anastomosis is created between the vein and the distal brachial artery in the standard fashion. The radial pulse is assessed at this time.

AVF technique. Next, a new AVF is created using the cephalic vein from the prior AVF. The vein is distended with heparinized saline solution and marked. An end-to-end anastomosis is created from the arterial side of the AVF to the proximal end of the previously transected brachial artery with 6-0 Prolene suture. A tunnel is created, and the vein is brought through the tunnel (Figs 2, *b*, and 3), maintaining proper orientation of the vein. Next, an end-to-end anastomosis between the proximal portion of the basilic vein (proximal aspect of the harvested basilic vein for DRIL), and the venous side of the AVF is then created with 6-0 Prolene. The areas are checked for hemostasis, and the skin layers are reapproximated with Vicryl sutures, and the skin is closed with staples. A Jackson-Pratt drain is left in place at the basilic vein harvest site. The AVF is palpated for a thrill, and the radial pulse is then assessed.

Case descriptions

Patient 1. A left radiocephalic AVF had been created on April 30, 2015. On February, 1, 2018, a left upper extremity angiography revealed a stenotic ulnar artery and retrograde flow in the radial artery distal to the fistula with no proximal inflow and stenoses from the axillary artery distally. On April 12, 2018, the patient had undergone POWR DRIL and subclavian vein stent placement. A permacath was placed afterward because the AVF could not be accessed initially. On May 31, 2018, the patient had undergone fistulography with axillary vein and innominate vein venoplasty and permacath removal. The patient underwent fistulograms necessary for maintenance every 3 months (with the last one on September 12, 2019). The patient's necrotic finger had healed during the course of 1 year after surgery. The patient died on September 19, 2019. Regarding the vein, the fistula had had aneurysmal portions in cephalic vein in the forearm that were 8 to 20 mm; the basilic portion was 5 to 7 mm in diameter.

Patient 2. A right radiocephalic AVF had been created on December 19, 2018. The patient had undergone radial artery angioplasty for severe inflow stenosis on February 9, 2019. Subsequently, the patient had undergone perianastomotic angioplasty and coil embolization of a side branch because of a slow to mature AVF on May 23, 2019. Fistulography and right upper extremity angiography on September 17, 2019 revealed no subclavian artery stenosis but an occluded ulnar artery in the forearm and interosseous artery at the wrist. The patient had undergone ulnar artery angioplasty to 2 mm on October 8, 2019, POWR DRIL on October 22, 2019, permacath placement on October 24, 2019, permacath removal on November 17, 2019, fistulography and axillary venoplasty on December 5, 2019, and axillary vein stent placement on March 12, 2020. The patient died on March 18, 2020. Regarding the vein, the fistula had had a 6- to 10-mm cephalic diameter in the forearm; the basilic vein had had a 6- to 8-mm diameter in the arterialized portion.

Patient 3. A left radiocephalic AVF had been created on October 1, 2018. The patient had undergone superficialization on January 30, 2019, perianastomotic plasty for a slow to mature AVF on March 11, 2019, and radial artery angioplasty and right upper extremity angiography, which revealed no inflow disease and no ulnar artery or interosseous artery stenoses, on July 12, 2019. Upper extremity angiography on December 29, 2020 had revealed steal from the AVF, but good flow in the ulnar and interosseous arteries. On January 25, 2021, the patient had undergone Permacath insertion before POWR DRIL, which was performed on January 27, 2021. The patient had undergone fistulography and venoplasty of the axillary vein on March 7, 2021, Permacath removal on April 28, 2021 (late secondary to poor follow-up), percutaneous thrombectomy and axillary vein angioplasty on August 10, 2021, stent placement of the axillary vein on October 4, 2021, and axillary venoplasty on December 29, 2021. Regarding the vein, two aneurysmal cephalic portions were present in the forearm, ranging in diameter from 6 to 15 mm. The largest basilic portion was 6 to 8 mm in diameter (arterialized segment).

Table. Patient demographics

Age, years; sex	Comorbidity	Access creation	Steal diagnosis	Tissue loss	POWR DRIL date	Duration, minutes	EBL, mL
66; M	ESRD, bilateral AKAs	4/2015	2/2018	Left digit ulcers	4/2018	330	250
90; M	CHF, COPD, ESRD, DVT	12/2018	9/2019	Right first digit ulcer	10/2019	240	50
67; M	ESRD, DM, CHF	10/2018	1/2021	Left second digit ulcer	1/2021	257	200

AKAs, Above-the-knee amputations; *CHF,* congestive heart failure; *COPD,* chronic obstructive pulmonary disease; *DM,* diabetes mellitus; *DRIL,* distal revascularization with interval ligation; *DVT,* deep vein thrombosis; *EBL,* estimated blood loss; *ESRD,* end-stage renal disease; *M,* male; *POWR,* proximalization through one incision of a wrist arteriovenous fistula.

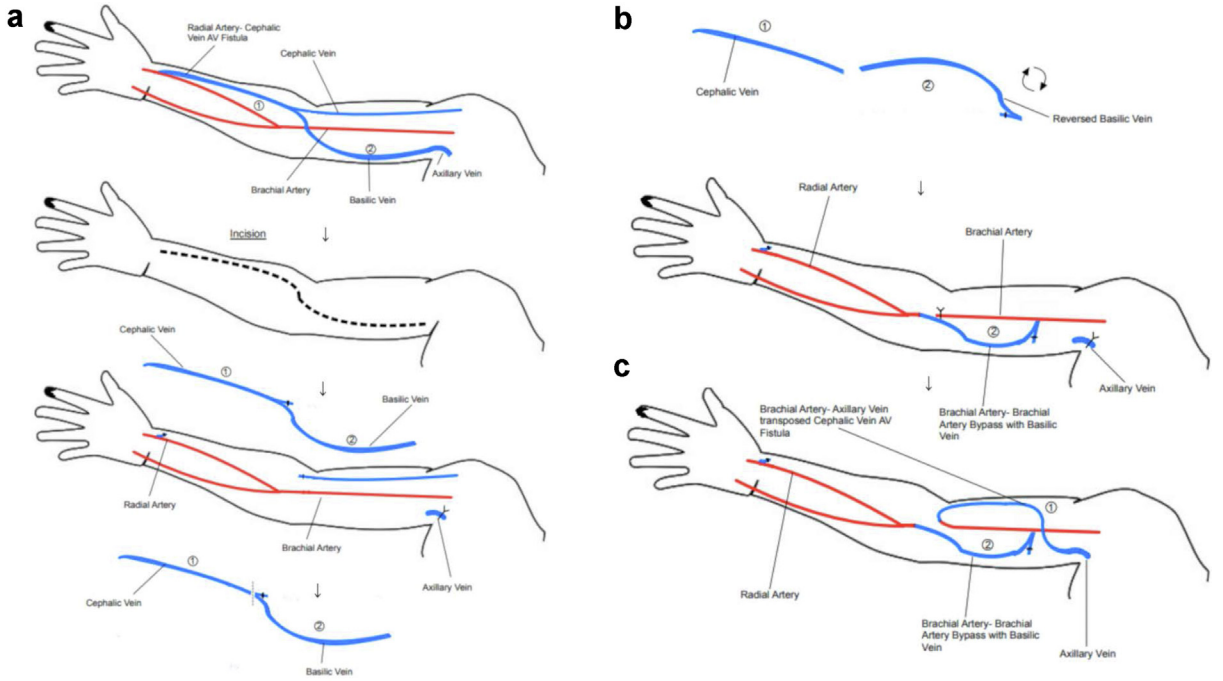

Fig 2. Diagrams showing case technique for ligation of cephalic vein fistula and transposition **(a)** and flip for brachial–brachial artery bypass and brachial artery–axillary vein fistula **(b)**, and final procedure layout **(c)**.

Outcomes

Of the three patients who had undergone POWR DRIL, all three had experienced improvement in extremity pain and the digit ulcers had healed in two patients (Fig 4). All patients had had short-term dialysis catheters placed preoperatively or postoperatively. All AVFs could be used for dialysis in the postoperative period (1-4 weeks). All three patients had had their short-term dialysis catheters removed postoperatively (this was delayed for patient 3 secondary to noncompliance). All three patients had undergone subsequent fistulography, which demonstrated patent bypasses and adequate flow through the AVF.

DISCUSSION

Ischemic steal syndrome in the setting of hemodialysis access represents a limb-threatening condition for which patients will present with rest pain, paresthesia, and progressive tissue loss. However, patients with radiocephalic fistulas will rarely develop signs of ischemic steal syndrome and less often ischemic necrosis or gangrene.[8] However, in this small subset of patients, revascularization efforts have remained limited, given the little room for distal arterial access. The options for dialysis access revascularization include banding, DRIL, revision using distal inflow, proximalization of arterial inflow, and distal radial artery ligation.[6] Of the many options, access banding has been a widely used solution but carries a high risk of thrombosis and reintervention. In addition, access banding will not be effective in the setting of necrosis.[9] Distal radial artery ligation is a possibility for radiocephalic steal syndrome with rest pain. However, in the setting of tissue loss, other interventions for revascularization such as DRIL or proximalization of the arterial inflow

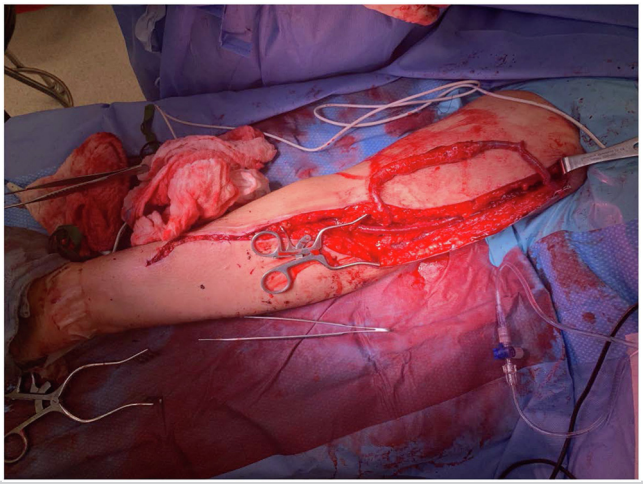

Fig 3. Intraoperative photograph showing final fistula and bypass layout after brachial artery to cephalic vein anastomosis and before tunneling and venous anastomosis.

and revision using distal inflow will be needed. Although these options can be adequate, they have mainly been used for arm AVFs and not distal forearm AVFs.[8] Ligation, which can reverse the ischemic symptoms, will leave the patient without an autogenous access until a new one has been created in a probably other compromised extremity.

In the present case series, we performed a novel procedure for patients with ischemic dialysis associated steal syndrome and tissue loss. We have proposed a cephalic vein transposition combined with a DRIL procedure to preserve the autogenous conduit. We have termed the procedure "proximalization through one incision of a wrist AVF and distal revascularization with interval ligation" (POWR DRIL). All the patients had had a radiocephalic AVF and evidence of digit ischemia. All three patients had undergone preoperative physical examinations, fistulography and/or angiography, and subsequent vein mapping before their procedure. All three patients had had evidence of progressive ulnar and/or interosseous artery disease, which had led to their steal symptoms. The patients were able to undergo dialysis cannulation during the postoperative period (1-4 weeks). All the patients had had a short-term dialysis access catheter placed. The patients had undergone follow-up fistulography and were seen in the outpatient setting. All patients had experienced improvement in their ischemic symptoms as evidenced by the reduced pain and healing of their ulcers. The potential complications of the procedure were limited in our experience, given the small numbers in our case series. However, overall, their potential will be greater with the proposed procedure because the brachial artery is ligated and a bypass created. In our series, one patient had experienced bleeding around the cannulation site on postoperative day 1 that had required permacath placement. Other proposed complications related to this procedure have been reported and include bypass occlusion, ischemic monomelic neuropathy, and recurrent steal syndrome.[6] Postoperatively, patients should undergo fistulography and regular follow-up examinations to ensure the relief of ischemic symptoms. Two of our three patients had had a preoperative diagnosis of congestive heart failure; however, they had had preoperative echocardiograms showing improved or stable findings. Therefore, we considered that high output steal syndrome from a radiocephalic AVF contributing to the congestive heart failure was less likely.

Although the proposed approach has more potential risks and complexity, our approach offers a method of preserving the autogenous conduit for these patients. This is potentially efficient and cost-effective because the patients will save time by undergoing one procedure to address their ischemia and maintain their hemodialysis access. In addition, patients will be able to undergo hemodialysis sooner via their already matured conduit, an important consideration for patients who would otherwise require short-term dialysis access. Use of the POWR DRIL, therefore, can salvage the autogenous conduit and revascularize the extremity to address the tissue loss. The procedure has shown promise as a reproducible technique for improving ischemic steal in a patient with a radiocephalic AVF. However, more cases are required to further study the outcomes and reproducibility of this procedure.

Although our cases series was limited by its relatively small sample size, other limitations were present. In our case series, some pre- and postoperative information was not obtained but would have been valuable in demonstrating an objective improvement in the steal symptoms. Specifically, the flow volumes before and after the procedure would have been an important marker of improvements in steal symptoms after POWR DRIL. As stated, the goal of this procedure compared with others is to preserve the autogenous conduit. However, such preservation will not always be possible for all patients. Using the cephalic vein in the arm for a brachiocephalic fistula (given an adequate diameter), in conjunction with basilic vein for DRIL and ligation of the radial artery, is an option for those patients for whom the POWR DRIL is not feasible. In these scenarios, this would be a valid procedure to both revascularize the hand and provide a new conduit for hemodialysis. However, as discussed previously, the drawback to this procedure is that the patient would lose their already arterialized vein. This would be the main limitation of this procedure compared with the POWR DRIL. Despite this, certain patients who would not be appropriate for the proposed POWR DRIL (ie, an aneurysmal cephalic vein [>2 cm], a small diameter forearm cephalic vein [3-4 mm] with a larger basilic vein) might be better candidates for this simpler procedure.

Fig 4. Photographs showing left hand second digit ischemic ulcer preoperatively (*PREOP*; **a)**, at 1 month (*mo*) postoperatively (*POSTOP*; **b)**, and at 1 year (*yr*) postoperatively **(c)**.

Another treatment method for those who are not candidates for POWR DRIL is distal radial artery ligation (only for patients with excellent ulnar artery perfusion to the hand, without tissue loss).

As stated previously, patients with ischemic steal syndrome of the forearm (radiocephalic) will rarely develop signs of ischemic steal syndrome.[8] This has been hypothesized to be due to the smaller radial and ulnar arteries, which will provide a lower access inflow volume and, thus, reduce the perfusion pressure difference, which takes advantage of the native collateral supply to the hand.[8] Therefore, the presence of ischemic steal can be a potential marker for severe atherosclerotic burden in these patients. Furthermore, given the low likelihood of ischemic steal with radiocephalic AVFs, the atherosclerotic burden can be worse in patients with ischemic necrosis and this configuration of AVF access. It has previously been shown that for patients with ischemic steal syndrome requiring surgical treatment, the mortality rates were 28% and 79% at 1 and 5 years.[10] It is important to weigh the risks and benefits of a more complex operation such as the POWR DRIL vs a less complex and time-consuming procedure for patients who might not tolerate such stress. Therefore, these patients should be screened appropriately and undergo cardiac risk stratification before undergoing surgery.

CONCLUSIONS

For specific patients with ischemic steal syndrome secondary to ulnar artery and/or interosseous artery disease and a distal forearm fistula, the POWR DRIL could be a suitable option to treat severe steal symptoms and maintain autogenous access.

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