An expeditious and precise method for diameter reduction of venous aneurysm causing arteriovenous fistula steal syndrome

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ABSTRACT

Clinically significant dialysis access steal syndrome occurs in 1% to 8% of patients. In the present report, we describe an innovative, hybrid option for venoplasty of a cephalic vein aneurysm using a vascular staple device in conjunction with a 6-mm, endovascular balloon placed a few centimeters distal to the brachial artery anastomosis in a 61-year-old man with stage 3 dialysis access steal syndrome secondary to overwhelming venous outflow. The patient experienced immediate postoperative symptom relief. The arteriovenous fistula was immediately accessible for dialysis, circumventing the need for a temporary dialysis catheter. The arteriovenous fistula was functional at 12 months of follow-up. (J Vasc Surg Cases Innov Tech 2023;9:101169.)

Keywords: Arteriovenous fistula revision; Cephalic vein aneurysm; Steal syndrome

CASE REPORT

A 61-year-old man with a 19-month-old right brachiocephalic arteriovenous fistula (BCAVF) presented with right hand pain at rest and blue discoloration of the right fifth finger. The patient had undergone successful hemodialyses using the BCAVF with no operative or endovascular intervention required since its initial placement. His end-stage renal disease was secondary to type 2 diabetes mellitus.

On physical examination of the right upper extremity, he had Doppler signals in the radial, ulnar, and palmer arch arteries. He had delayed capillary refill of all fingers that was more pronounced in the right fifth finger, which had blue discoloration and was concerning for stage 3 dialysis access steal syndrome (DASS; Fig 1). The cephalic vein was aneurysmal in appearance. An ultrasound of the BCAVF demonstrated normal arterial inflow at 329 cm/s and a flow rate that varied between 2.5 L/min and 6.4 L/min (median, 4.5 L/min) with an arteriovenous anastomosis length of 9 mm and a proximal diameter of the cephalic vein of 12 mm (Fig 2).[1]

The digital brachial index of the right hand improved from 0.17 to 0.60 after the BCAVF was compressed (Fig 3). Given his symptoms, physical examination findings, and diagnostic results, cephalic, diameter-reducing venoplasty was recommended. The patient provided written informed consent for the procedure and the report of his case details and imaging studies.

The intraoperative ultrasound findings demonstrated aneurysmal dilation of the cephalic vein ≤25 mm. The cephalic vein was exposed for ∼7 cm in length through a 3-cm incision, starting 2 cm from the brachial artery anastomosis. Under ultrasound guidance, the cephalic vein was percutaneously accessed in the upper arm, and a 4F sheath was placed over a Benston wire. A 6-mm × 40-mm Sterling balloon (Boston Scientific, Marlborough MA) was positioned 2 cm distal to the brachial artery anastomosis. The balloon was inflated to a nominal pressure. A 45-mm-lomg vascular stapler was fired three times over the balloon to remove the redundant cephalic vein wall, resulting in a treatment length of ∼5 cm (Fig 4). The residual diameter was measured by intraoperative ultrasound and found to be between 6 and 8 mm. The staple line was oversewn in a single, running fashion with 5-0 Prolene running suture (Ethicon, Raritan, NJ), and the incision was closed in multiple layers. The estimated blood loss for the procedure was 55 mL, and the total operative time was 120 minutes from the initial skin incision until closure.

The patient was discharged the same day and underwent hemodialysis via the revised BCAVF on postoperative day 1. He was seen in the clinic at 14 and 41 days after his revision. The incision had healed well, and all his symptoms had resolved, except for a small area of numbness in the tip of the fifth finger. His right fingers were all well perfused and pink, with normalized capillary refill. Ultrasound of the revised vein portion demonstrated 4 cm of cephalic vein with a diameter between 6 and 8 mm, which was widely patent (Fig 5). At 12 months of follow-up, the patient was still undergoing successful dialysis with no interim complications of the BCAVF.

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Fig 1. Clinical presentation of the right hand with cyanosis of the distal phalanx of the fifth digit.

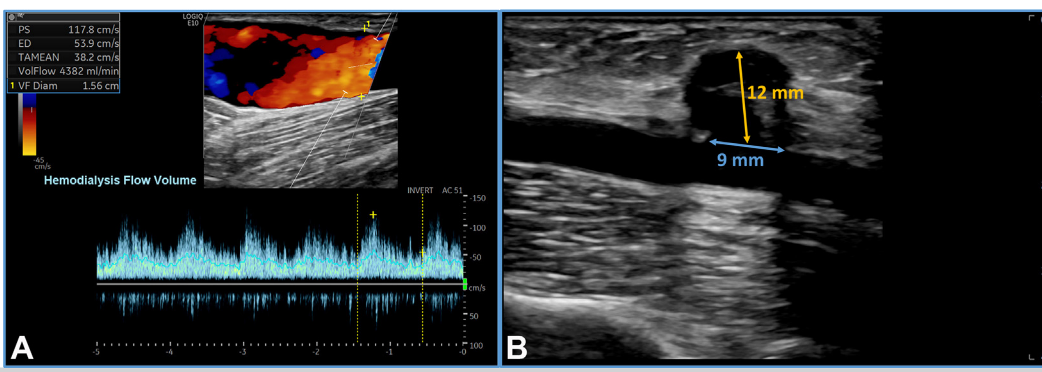

Fig 2. A, Duplex ultrasound of the aneurysmal fistula. The median flow in the fistula was 4.5 L/min. **B,** The arteriovenous fistula (AVF) anastomosis was 9 mm long, and the vein diameter was 12 mm.

DISCUSSION

DASS can be a limb-threatening complication that causes clinically significant symptoms, requiring reoperation in 1% to 8% of patients undergoing dialysis access surgery.[2,3] However, the true incidence of clinically significant DASS, requiring surgical intervention, might be lower than that reported in a prospective cohort of >600 hemodialysis patients.[4] DASS is more commonly seen with brachial artery-based than radial artery-based AV access. The main risk factors for the development of DASS are AV access created from the brachial artery, diabetes mellitus, female gender, coronary artery disease, peripheral vascular disease, and a history of DASS with prior AV access. The hemodynamics behind the steal pathophysiology are rather complex and involve (1) limited arterial inflow; (2) overwhelming venous outflow; (3) an arterial supply distal to the arterial anastomosis of the AV access (atherosclerotic disease of the radial or ulnar arteries); and (4) high resistance in the palmar arch and/or digital arteries (eg, Raynaud's phenomenon, digital embolization, digital atherosclerotic disease from diabetes mellitus).[5] The signs and/or symptoms can vary from painless finger discoloration (stage 1) to intermittent hand pain with exercise (stage 2) or rest pain with (stage 4) or without tissue loss (stage 3).[6] Depending on the underlying cause, several interventional options are available, including treatment of inflow lesions with angioplasty or stenting, AVF banding, ligation, distal revascularization with interval ligation, revision using distal inflow, proximalization of arterial inflow, and minimally invasive limited ligation endoluminal-assisted revision.[2,3,7,8] Fistula ligation, although the more effective in redirecting the flow to the ischemic hand, leaves patients without dialysis access, making it the least attractive option for the management of DASS. However, it remains necessary for patients with severe symptoms such as finger gangrene. Fistula banding carries the risk of excessive or insufficient lumen reduction, resulting in an increased risk of thrombosis and persistent steal, respectively.[9]

Although distal revascularization with interval ligation is an attractive option that often leads to symptom

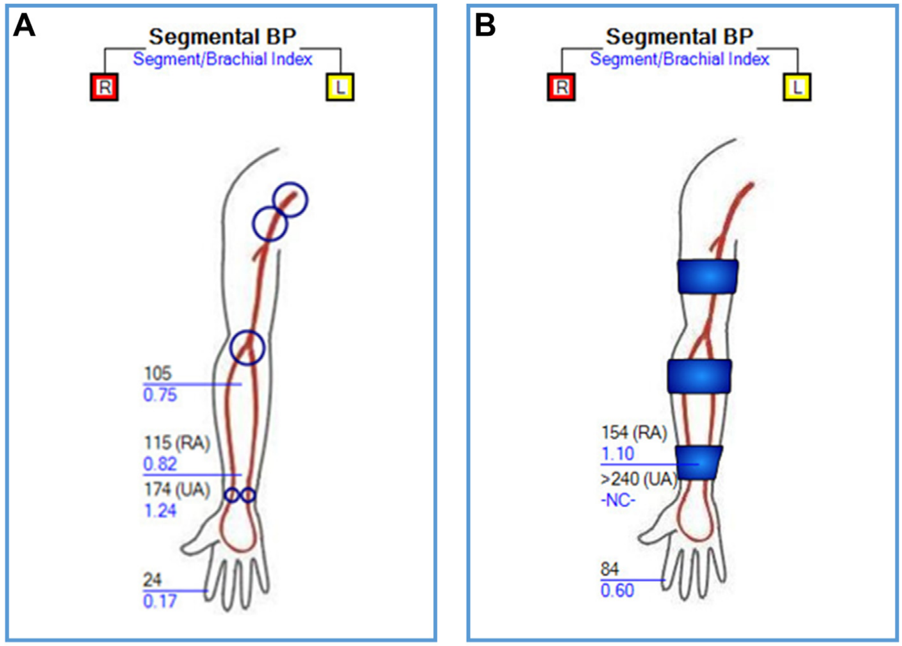

Fig 3. Digital brachial index of the right hand before **(A)** fistula compression (0.17) and after **(B)** fistula compression (0.60). *BP,* Blood pressure; *RA,* radial artery; *UA,* ulnar artery.

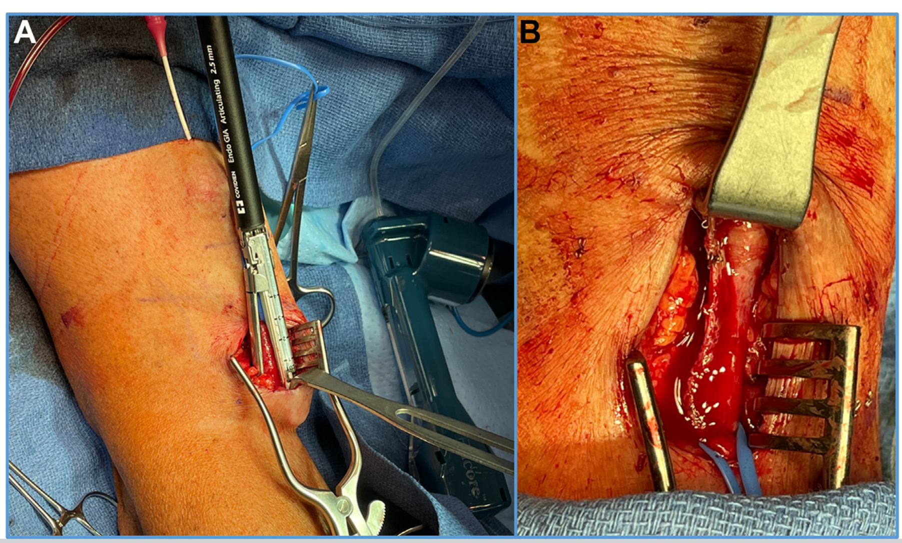

Fig 4. A, Right arm brachiocephalic arteriovenous fistula (BCAVF) anastomosis accessed just proximal to the elbow crease. Intrafistula endovascular access was performed with a 5F sheath and placement of a 6-mm balloon into the fistula. **B,** Diameter-reduced BCAVF with a lateral staple line.

resolution, it requires ligation of the brachial artery and an adequate venous conduit. It is a lengthier option with a longer anesthetic time than a ligation or banding procedure. Similarly, revision using distal inflow and proximalization of arterial inflow are lengthier operations than banding or ligation. Patients with end-stage renal disease requiring dialysis are often medically complex, and additional anesthetic can lead to major cardiopulmonary events.

The use of a vascular stapler[10-13] or an angioplasty balloon[14] has been described as separate adjunct device to treat DASS, although never both in conjunction. Alternatively, dowels can be used (6-10 mm catheters) and sewn over for aneurysm reduction; however, this technique requires venotomy and extension of the incision for vascular control.[15] Minimally invasive control of the aneurysmal fistula combined with stapled aneurysmorrhaphy eliminates the need for full exposure of the AVF

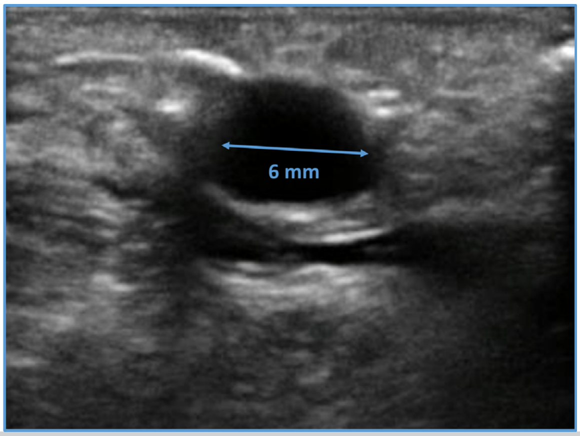

Fig 5. Duplex ultrasound of right arm brachiocephalic arteriovenous fistula (BCAVF) after diameter reduction.

and the risk of infection with the use of a prosthesis and is expeditious.

In our patient, the entire length of the fistula had become dilated but was widely patent. Use of a 6-mm angioplasty balloon helped to avoid excessive or insufficient lumen reduction of the cephalic vein, and the stapler provided a fast and safe method to remove the redundant venous wall. The staple line was kept on the lateral aspect of the vein to not interfere with future dialysis access. Although the entire cephalic vein was aneurysmal for a length of ∼14 cm, from a fluid dynamic standpoint, only a short segment of the vein required treatment to obtain significant, hemodynamic flow reduction that would redirect flow to the ischemic hand. Thus, only a small incision was required, and the rest of the cephalic vein was immediately accessible for dialysis, circumventing the need for temporary dialysis catheter placement.

Although the described technique is promising, there are limitations. Patients can experience complications associated with use of the balloon device, including, but not limited to, device access complications and thromboembolic or fistula stenosis. Additionally, the cost incurred with the use of both a stapler device and reloads and a balloon is not nominal. However, the potential reduction in operative time and durable results could offset these costs.

CONCLUSIONS

A hybrid approach with an angioplasty balloon and a vascular stapler was safe and effective in our patient with DASS secondary to overwhelming venous outflow. It circumvented the need for a temporary dialysis catheter and was associated with promising mid-term primary patency. However, more study is needed to assess the efficacy and safety in a larger population.

REFERENCES

1. Bavare CS, Bismuth J, El-Sayed HF, Huynh TT, Peden EK, Davies MG, et al. Clinical study volume flow measurements in arteriovenous dialysis access in patients with and without steal syndrome. Int J Vasc Med 2013;2013:328601.
2. Leake AE, Winger DG, Leers SA, Gupta N, Dillavou ED. Management and outcomes of dialysis access-associated steal syndrome. J Vasc Surg 2015;61:754-61.
3. Mohamed AS, Peden EK. Dialysis-associated steal syndrome (DASS). J Vasc Access 2017;18(Suppl. 1):68-73.
4. Huber TS, Larive B, Imrey PB, Radeva MK, Kaufman JM, Kraiss LW, et al. Access-related hand ischemia and the hemodialysis fistula maturation study. J Vasc Surg 2016;64:1050-8.e1.
5. Sen I, Tripathi RK. Dialysis access-associated steal syndromes. Semin Vasc Surg 2016;29:212-26.
6. Tordoir JHM, Dammers R, van der Sande FM. Upper extremity ischemia and hemodialysis vascular access. Eur J Vasc Endovasc Surg 2004;27:1-5.
7. Alie-Cusson FS, Bhat K, Ramchandani J, Steerman SN, Dexter DJ, Panneton JM. Distal revascularization and interval ligation for the management of dialysis access steal syndrome. Ann Vasc Surg 2021;74:29-35.
8. Miller GA, Goel N, Friedman A, Khariton A, Jotwani MC, Savransky Y, et al. The MILLER banding procedure is an effective method for treating dialysis-associated steal syndrome. Kidney Int 2010;77:359-66.
9. Vajdič Trampuž B, Arnol M, Gubenšek J, Ponikvar R, Buturović Ponikvar J. A national cohort study on hemodialysis arteriovenous fistulas after kidney transplantation - long-term patency, use and complications. BMC Nephrol 2021;22:344.
10. Vo T, Tumbaga G, Aka P, Behseresht J, Hsu J, Tayarrah M. Staple aneurysmorrhaphy to salvage autogenous arteriovenous fistulas with aneurysm-related complications. J Vasc Surg 2015;61:457-62.
11. Hakim NS, Romagnoli J, Contis JC, Akoh J, Papalois VE. Refashioning of an aneurysmatic arterio-venous fistula by using the multifire GIA 60 surgical stapler. Int Surg 1997;82:376-7.
12. Pierce GE, Thomas JH, Fenton JR. Novel repair of venous aneurysms secondary to arteriovenous dialysis Fistulae. Vasc Endovascular Surg 2016;41:55-60.
13. Tozzi M, Franchin M, Ietto G, Soldini G, Chiappa C, Carcano G, et al. A modified stapling technique for the repair of an aneurysmal autogenous arteriovenous fistula. J Vasc Surg 2014;60:1019-23.
14. Asif A, Leon C, Merrill D, Bhimani B, Ellis R, Ladino M, et al. Arterial steal syndrome: a modest proposal for an old paradigm. Am J Kidney Dis 2006;48:88-97.
15. Woo K, Cook PR, Garg J, Hye RJ, Canty TG. Midterm results of a novel technique to salvage autogenous dialysis access in aneurysmal arteriovenous fistulas. J Vasc Surg 2010;51:921-5.e1.

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