Novel use of the ENROUTE transcarotid arterial sheath for antegrade cerebral perfusion during retrograde innominate stenting

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ABSTRACT

Femoral-carotid bypass has been described to preserve antegrade cerebral perfusion during aortic arch and great vessel interventions. We describe a novel use of the ENROUTE transcarotid arterial sheath (Silk Road Medical, Sunnyvale, Calif) as the outflow component of a femoral-carotid shunt for maintenance of antegrade cerebral perfusion during a retrograde innominate stenting procedure. We discuss the unique advantages of this sheath for use in this application. (J Vasc Surg Cases and Innovative Techniques 2020;6:401-4.)

Keywords: Aortic arch; Cerebral perfusion; Endovascular

Endovascular and hybrid aortic arch or great vessel interventions may induce or require transient cessation of antegrade cerebrovascular flow. For example, zone 0 or zone 1 deployment of standard thoracic endografts covers great vessel origins and may induce malperfusion until chimney grafting or in situ fenestration is performed. Alternatively, retrograde great vessel intervention for occlusive disease may require distal clamping for embolic protection. In either case, prolonged reduction or cessation of cerebrovascular flow may cause cerebral ischemia and stroke. Techniques have been described to maintain intraprocedural cerebral perfusion, notably extracorporeal femoral-carotid bypass. In this report, we describe novel use of the ENROUTE transcarotid arterial sheath (Silk Road Medical, Sunnyvale, Calif) as the outflow component of an extracorporeal common femoral artery to internal carotid artery (ICA) shunt, which was used to maintain perfusion during retrograde stenting of a symptomatic innominate artery (IA) lesion.

Consent for publication was obtained from the patient. This report describes off-label use of the ENROUTE system. Use of the ENROUTE system for this purpose is not endorsed by Silk Road Medical.

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CASE REPORT

A 76-year-old woman presented with 2 days of left-sided weakness and dysarthria. Magnetic resonance imaging demonstrated multiple cortical infarctions in the right middle cerebral artery distribution, consistent with microembolization. Computed tomography angiography demonstrated a bulky lesion in the distal IA causing high-grade stenosis involving the origins of the common carotid artery (CCA) and subclavian artery (SCA; Fig 1). Duplex ultrasound demonstrated peak systolic velocities in the distal IA of 616 cm/s consistent with significant stenosis, minimal right ICA disease, and to-and-fro right vertebral artery flow.

Because of the symptomatic and high-grade nature of the stenosis, surgical intervention was deemed superior to medical therapy. Given her age, frailty, and medical comorbidities, including critical limb ischemia, atherosclerotic coronary artery disease, and chronic obstructive pulmonary disease, an endovascular solution was preferable to innominate endarterectomy or bypass. Transfemoral innominate stenting was thought to carry a high risk of intraoperative embolization because of the lesion's bulky, friable, and exophytic nature with extension into the CCA and SCA origins. The patient was consented for retrograde IA to CCA stenting and carotid-subclavian bypass. An L-shaped incision was made along the anterior border of the right sternocleidomastoid muscle and extended laterally above the right clavicle, exposing the CCA and SCA. The right femoral artery was exposed longitudinally. Because of atherosclerotic disease, an iliofemoral endarterectomy and iliac stent were required to allow advancement of a 12F Gore Dry-Seal sheath (W. L. Gore & Associates, Flagstaff, Ariz) into the infrarenal aorta.

The ENROUTE transcarotid sheath (Fig 2) was inserted in the distal right CCA immediately proximal to the carotid bulb, advanced into the proximal ICA (Fig 3), and secured to the artery and soft tissues using the sheath

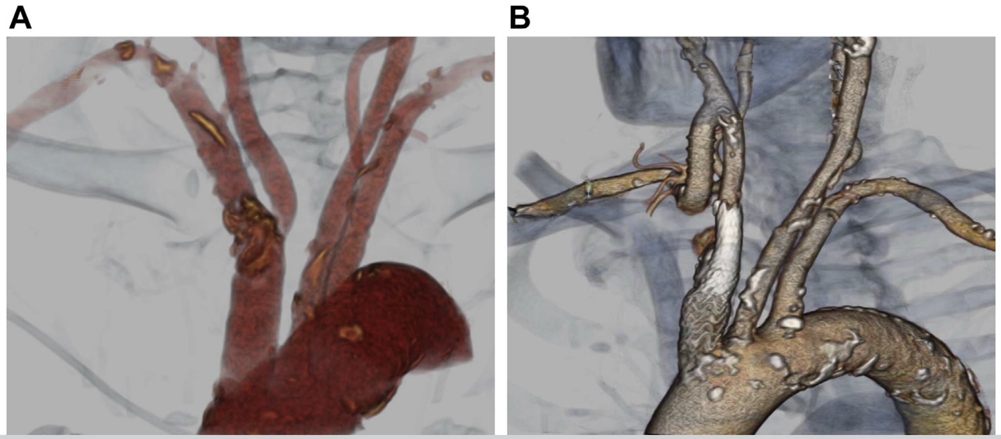

Fig 1. Preoperative and postoperative computed tomography angiography reconstructions. **A,** High-grade distal innominate artery (IA) stenosis involving common carotid artery (CCA) and subclavian artery (SCA) origins. **B,** Patent innominate and right common carotid stent grafts and a patent right carotid-subclavian bypass.

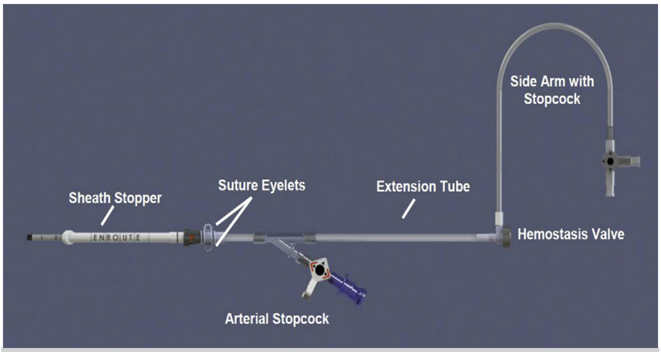

Fig 2. ENROUTE transcarotid arterial sheath. (Reproduced with permission of Silk Road Medical. ENROUTE Transcarotid Neuroprotection System instructions for use. Available at: https://silkroadmed.com/download/enroute-nps-instructions-for-use/)

stopper (Fig 4, *A*). Next, $^3/_4$ -inch cardiopulmonary bypass tubing was attached to the high-flow side port of the femoral sheath and the side port of the ENROUTE transcarotid sheath arterial stopcock using Luer adapters (Fig 4, *B*). The shunt system was deaired before opening to the carotid circulation. The CCA was clamped 2 cm below the ENROUTE sheath insertion point. Angiography confirmed preservation of rapid antegrade flow through the right carotid circulation. Pressure transduction from the ENROUTE sheath side arm confirmed systemic pressure equal to left radial artery pressure at the level of the distal sheath. With momentary shunt inflow occlusion, transduced pressure (equivalent to "stump pressure") dropped to 40 mm Hg, confirming shunt contribution to cerebral perfusion pressure.

Retrograde CCA access was established proximal to the carotid clamp using a micropuncture needle and wire under fluoroscopy. This was upsized in stepwise fashion to a 12F DrySeal sheath, and the lesion was stented with a Gore VBX 8-×39-mm stent graft and a Gore Excluder iliac extender, 16 mm × 10 mm × 7 cm, deployed from the IA origin to the proximal CCA. A right carotid-subclavian bypass was performed using an 8-mm ringed polytetrafluoroethylene graft. The retrograde access site on the proximal CCA was used to create the carotid anastomosis. Antegrade flow was restored first to the right arm to clear any atherosclerotic debris, followed by restoration of antegrade carotid and vertebral flow.

The patient awakened with no new neurologic deficits. Postoperative computed tomography angiography demonstrated widely patent IA to CCA stent grafts and widely patent carotid-subclavian bypass (Fig 1, *B*).

DISCUSSION

As described, IA and CCA stenting was performed through retrograde access from a right carotid artery exposure. The distal CCA was clamped for embolic protection, but cerebral perfusion was maintained to protect recently ischemic penumbra through use of a temporary extracorporeal shunt system. The outflow component of this system used the ENROUTE transcarotid arterial sheath, a component of the ENROUTE Transcarotid Neuroprotection System.

When used in standard fashion, the Neuroprotection System connects the proprietary 8F short-tipped transcarotid arterial sheath to a femoral venous sheath, with arteriovenous flow passing through a unidirectional flow controller with inline filter. After proximal carotid clamping, the system induces carotid flow reversal, providing embolic protection during subsequent distal carotid artery angioplasty and stenting. In our case, however, the system's arterial sheath was used for the opposite purpose: to maintain antegrade flow in the carotid circulation rather than flow reversal.

Fig 3. Carotid arteriogram demonstrating the ENROUTE transcarotid arterial sheath inserted into the distal right common carotid artery (CCA) with the tip advanced into the proximal right internal carotid artery (ICA).

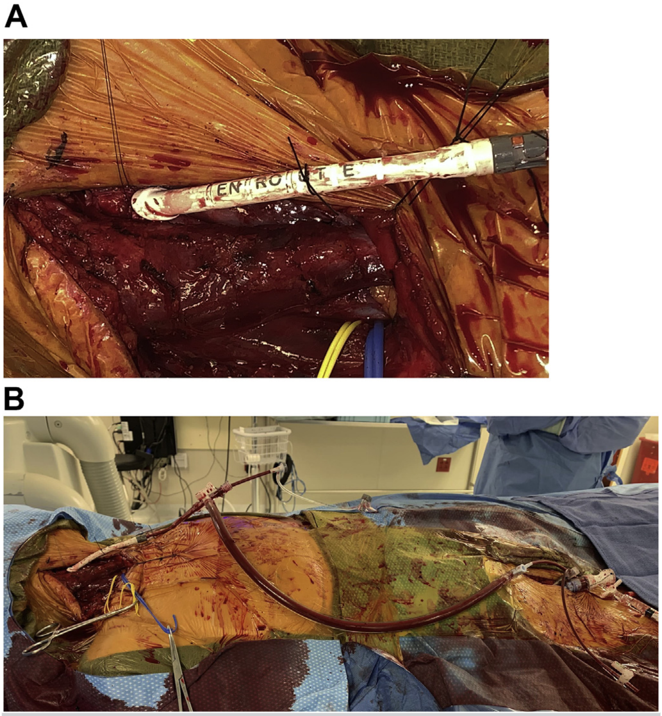

Fig 4. A, ENROUTE transcarotid arterial sheath in the distal right common carotid artery (CCA). **B,** Femoral-carotid shunt composed of 12F Gore DrySeal sheath in the right common femoral artery attached to the ENROUTE transcarotid arterial sheath using $^{3}/_{4}$ -inch bypass tubing.

Extracorporeal femoral-carotid shunting for maintenance of antegrade cerebral perfusion has previously been reported, but with important differences.[1-4] These reports used either surgical bypass or surgical conduits connected to tubing and a centrifugal pump. Comparatively, our approach using endovascular sheaths eliminates the need for two surgical anastomoses and offers the potential for a percutaneous femoral approach, eliminating the need for groin exposure. These factors are likely to significantly decrease operative time.

The ENROUTE transcarotid sheath design provides several important advantages over standard sheaths for use in a perfusion circuit. First, the 8F sheath is designed for carotid artery insertion with a short, beveled tip and a specific wire and introducer system to facilitate safe placement. Once in place, the sheath is securable with its sheath stopper to prevent accidental cephalad migration and associated risks of carotid kinking or dissection. Designed to function in a flow circuit, the sheath has an expanded inner diameter of 9.5F that lowers flow resistance. The side arm of the hemostasis valve may be connected to a pressure monitor, permitting continuous pressure transduction at the distal end of the circuit. Furthermore, if carotid embolic protection above the ENROUTE sheath is desired, a standard filter-type embolic protection device may be introduced through the hemostatic valve on the back of the arterial sheath.

A minor drawback to this system is that arterial flow must pass through the arterial stopcock, with a bore diameter of 8F. Whereas this diameter is identical to the diameter of the sheath tip, it may represent an additional focal point of flow restriction.

CONCLUSIONS

We describe novel use of the ENROUTE transcarotid arterial sheath as the outflow component of an arterioarterial shunt to maintain cerebral perfusion during retrograde great vessel intervention. Certain design features make the ENROUTE transcarotid sheath particularly well suited for this purpose, including a short intraluminal component, low flow resistance, ability to continuously monitor perfusion pressure, and ability to be combined with a filter-type embolic protection device. As endovascular aortic arch and great vessel interventions become more common, these advantageous features may help inform design of future devices intended for this use.

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