Solitaire FR device for treatment of dural sinus thrombosis

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SUMMARY

Dural venous sinus thrombosis is a rare and potentially devastating disease. Several predisposing factors exist, including oral contraceptive therapy and colitis. First-line therapy consists of systemic anticoagulation. If first-line therapies fail, more aggressive endovascular therapies may be performed. We report our initial experience with the Solitaire FR device for treatment of refractory symptomatic dural venous sinus thrombosis.

BACKGROUND

Dural venous sinus thrombosis (DVST) is a rare but potentially fatal disease. The incidence of dural venous sinus thrombosis is estimated at 5 per million, accounting for 0.5% of all strokes,¹ with an acute phase death rate of 4%² and overall mortality rates of 5–30%.^{3–6} Predisposing factors include oral contraceptive use, infection, dehydration, systemic inflammatory disorders, thrombophilia and malignancy. The superior sagittal sinus is the most commonly affected sinus (62%), followed by the lateral sinuses (45% left, 41% right) and straight sinus (18%), with deep venous involvement resulting in an outcome of death or dependency in 29% of patients.⁷

First-line treatment consists of anticoagulation (low molecular weight heparin or unfractionated heparin).³ If anticoagulation therapy fails or if there is a contraindication to anticoagulation, other treatment options include local thrombolysis with intrasinus recombinant tissue plasminogen activator (rt-PA),⁸ mechanical thrombectomy with rheolytic thrombectomy catheters (AngioJet)⁹ and thromboaspiration (Penumbra aspiration catheters).¹⁰ We describe a novel endovascular technique using the Solitaire FR device for treatment of superficial and deep venous sinus thrombosis.

CASE PRESENTATION

A 20-year-old woman with a past medical history significant for a WHO grade II astrocytoma status after two resections, resultant hydrocephalus requiring ventriculoperitoneal shunt and panhypopituitarism treated with hydrocortisone and desmopressin (DDAVP) was transferred from an outside hospital emergency room to the neurological ICU with hand clumsiness progressing to lethargy and left hemiparesis. Three weeks prior to admission she was treated for presumed upper respiratory tract and sinus infections. Due to the associated malaise, she had missed several doses of DDAVP. A systems review revealed a history of bloody diarrhea and she recently had been prescribed oral contraceptive therapy for amenorrhea.

On arrival at the neurological ICU her clinical examination was significant for lethargy, confusion, dysarthria and a left hemiparesis. Admission head CT demonstrated a hyperdense straight sinus (figure 1), and CT venography demonstrated occlusion of the straight sinus with extension of thrombosis into the right transverse and sigmoid sinus and right internal jugular vein (figure 2). MRI of the brain showed edema in the bilateral thalami (figure 3). Systemic anticoagulant therapy was initiated.

While in the neurological ICU, the patient developed significant bloody diarrhea. An abdominal CT scan revealed pan colitis; *Clostridium difficile* toxin and assay were obtained given her recent course of antibiotics but were negative. Colonoscopy revealed lesions consistent with idiopathic inflammatory bowel disease, probably Crohn's type. It was felt that this was the likely etiology of the sinus thrombosis, although dehydration from central diabetes insipidus, hypercoagulability from the CNS malignancy and treatment with oral contraceptives may also have contributed. In the interim she developed a right hemiparesis despite therapeutic anticoagulation, and endovascular treatment was performed.

TREATMENT

The right common femoral vein was accessed and a 6 F Flexor Shuttle-SL sheath (Cook Medical, Bloomington, Indiana, USA) was positioned in the right jugular bulb over a 5 F Berenstein (Boston Scientific, Natick, Massachusetts, USA) and a 0.035 inch guidewire. The catheter and wire were removed. An Excelsior SL-10 microcatheter (Boston Scientific) and an exchange length Luge 0.014 inch microwire (Boston Scientific) were advanced through the thrombus into the contralateral internal jugular vein. A right jugular venogram demonstrated minimal retrograde flow into the right sigmoid sinus. Rheolysis was performed for 5 min in the right sigmoid sinus with an AngioJet 4 F XMI Thrombectomy Set (Medrad, Warrendale, Pennsylvania, USA) and a post rheolysis angiogram demonstrated minimal recanalization of the right sigmoid sinus (figure 4). The XMI catheter was removed and the Luge microwire was left in place.

Next, a Marksman catheter (ev3, Irvine, California, USA) was advanced over a 0.016 inch Fathom microwire (Boston Scientific) into the right transverse sinus and a 6×30 mm Solitaire FR revascularization device (ev3) was deployed (figure 5). An immediate venogram demonstrated restoration of flow through the Solitaire device. After 5 min the Solitaire device was retracted while aspiration was performed through the Shuttle sheath. This

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Figure 1 Axial non-contrast head CT scan performed on admission demonstrating hyperdensity in the straight sinus, consistent with thrombus.

process was repeated four times, each time progressively deploying the stent more centrally. The fourth deployment was across the torcular into the left transverse sinus, with complete restoration of flow in the transverse sinuses (figure 6). Attention was then turned to the straight sinus, which was selectively catheterized with the Marksman catheter and Fathom microwire. A new 6×30 mm Solitaire FR revascularization device was deployed in the straight sinus, extending into the right transverse sinus.

Figure 2 Axial MIP CT venogram demonstrating the absence of flow-related enhancement in the right transverse sinus (arrows).

Figure 3 Axial FLAIR MRI demonstrating bilateral thalamic edema (arrows). Postoperative right lateral ventricular dilation is also present.

After 5 min the Solitaire device was removed, but residual flow-limiting thrombus was present in the straight sinus, near the torcular. The Solitaire device was then positioned across the thrombus and retrieved after 10 min. This resulted in restoration of flow within the deep and superficial sinuses (figure 7). A post-

Figure 4 Anteroposterior right internal jugular venogram after Angiojet rheolysis demonstrating minimal right sigmoid sinus recanalization (arrow). Note the exchange length microwire with tip in the distal portion in the left internal jugular vein, serving as a safety wire (arrowheads).

Figure 5 Right internal jugular venogram immediately following the first Solitaire deployment demonstrating restoration of flow within the right sigmoid sinus.

intervention head CT demonstrated no hemorrhage. Subsequent imaging revealed improvement in the previously noted areas of venous ischemia within the bilateral thalami, internal capsules and corona radiata (figure 8).

OUTCOME AND FOLLOW-UP

The following day the patient opened her eyes to voice and followed commands in all four extremities. At the time of discharge to inpatient rehabilitation the patient was mouthing words and had only trace weakness in her left arm. She was discharged on warfarin for the sinus thrombosis and amantadine and methylphenidate for abulia.

Figure 6 Right internal jugular venogram after the fourth Solitaire recapture demonstrating restoration of flow into the left internal jugular vein.

Figure 7 Final straight sinus venogram demonstrating restoration of flow in the straight sinus, bilateral transverse and sigmoid sinuses and bilateral internal jugular veins.

DISCUSSION

The first-line therapy for cerebral venous sinus thrombosis is systemic anticoagulation with either unfractionated or low molecular weight heparin. This therapy is probably efficacious (level B recommendation),^{11 12} and appears safe even in the presence of associated hemorrhage related to venous infarction.¹³ Endovascular therapy for dural venous sinus thrombosis is an

Figure 8 Axial FLAIR MRI performed on post-procedure day 7 demonstrating improving edema within the thalami.

accepted treatment in those who have failed anticoagulation therapy or have a contraindication to it.¹² Direct endovascular therapy with fibrinolytics has yielded mostly good results; however, in a systematic review, Canhao *et al* reported an 18% hemorrhage rate in those treated with local fibrinolytic infusions.¹⁴

Direct mechanical rheolytic therapy with balloon angioplasty,¹⁵ the AngioJet device^{9 16 17} and thromboaspiration using a Penumbra device¹⁰ have been shown to improve recanalization, potentially reducing hemorrhagic complications by decreasing the amount of required thrombolytic.¹⁶ Using the Bernoulli principle, the AngioJet mechanical thrombectomy catheter allows for thromboaspiration by creating a vacuum using high-pressure saline jets.^{9 18} Chow *et al*¹⁶ first described the combination of AngioJet rheolytic therapy with low-dose intra-arterial urokinase in two patients. Despite the excellent angiographic and clinical outcomes in these patients, the operators experienced difficulty with AngioJet catheter navigation into the mid portion of the transverse sinus and anterior superior sagittal sinus. The AngioJet catheter was successfully manoeuvred more distally after angioplasty in one patient and cervical puncture of the internal jugular vein in the other patient. Similarly, Anger *et al*¹⁷ described their experience with AngioJet rheolysis. Concomitant intravascular alteplase therapy was used in the straight sinus and internal cerebral veins since the AngioJet was unable to be used in these locations. Mechanical clot retrieval with the Merci device has also been reported with variable success in clot extraction and recanalization.^{19 20} More recently, dural venous sinus thromboaspiration using the Penumbra aspiration system has been described with¹⁰ or without²¹ concomitant intrasinus rt-PA. This relatively non-traumatic large-bore catheter may also improve recanalization rates.

The Solitaire device is a laser-cut, self-expanding, fully retrievable split-design nitinol stent,²² FDA approved for flow restoration in patients with ischemic stroke due to large intracranial vessel occlusion. The Solitaire With the Intention for Thrombectomy (SWIFT) trial demonstrated its utility in the treatment of ischemic stroke, with better recanalization rates and outcomes compared with other therapies.²³ Our preliminary experience with the Solitaire FR device for the treatment of intracranial veno-occlusive disease was successful and without complication. Compared with the AngioJet initially used for the rheolysis, the Solitaire FR device was more easily delivered and deployed within the thrombosed sigmoid and transverse sinus segments. Its capacity for repetitive use and rapid flow restoration proved to be beneficial and, because of the size of the vascular channels created, intravascular chemical thrombolysis was not performed. We have also used Penumbra aspiration catheters for the treatment of refractory dural venous sinus thrombosis with good results. However, in cases of subacute/chronic thrombosis, passage of the aspiration catheters into very peripheral segments of the superior sagittal sinus has been difficult without the use of very robust proximal support. In addition, navigation into the straight sinus with Penumbra catheters has at times been difficult. Although in our case the straight sinus was not fully recanalized on follow-up imaging, the amount of thalamic edema decreased and the patient's neurologic status continued to improve (figure 8).

The SWIFT trial allowed operators two passes per Solitaire FR device and three total passes per occluded vessel. Since the sigmoid and transverse sinuses have a relative gentle anatomic curvature, we elected to perform four passes with one device through these segments. Due to the acute angulation at the

torcular/straight sinus junction, a new Solitaire device was used and deployed twice in the straight sinus in order to decrease the chances of inadvertent detachment.²⁴

Learning points

- First-line treatment for dural venous sinus thrombosis consists of systemic anticoagulation.
- Endovascular therapy is reserved for refractory cases.
- Several techniques including local tPA infusion, rheolysis and thromboaspiration have been described.
- The use of the Solitaire FR device is an effective adjuvant endovascular therapy for dural venous sinus thrombosis.

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