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Abstract

OBJECTIVE—To report upon technique of concurrent placement of angioplasty balloon at the internal jugular vein and sigmoid venous sinus junction to facilitate stent delivery in two patients in whom stent delivery past the jugular bulb was not possible.

CLINICAL PRESENTATION—A 21-year-old woman and a 41-year-old woman with worsening headaches, visual obscuration or diplopia were treated for pseudotumor cerebri associated with transverse venous stenosis. Both patients had undergone primary angioplasty, which resulted in improvement in clinical symptoms followed by the recurrence of symptoms with restenosis at the site of angioplasty.

INTERVENTION—After multiple attempts at stent delivery through jugular venous bulb were unsuccessful, a second guide catheter was placed in the ipsilateral internal jugular vein through contralateral femoral venous approach. A 6 mm × 20 mm (left) or 5 × 15 mm (right) angioplasty balloon was placed across the internal jugular vein and sigmoid sinus junction and partially inflated until the inflation and relative straightening of the junction was observed. In both patients, the internal jugular vein and sigmoid sinus junction was successfully traversed by the stent delivery system in a parallel alignment to inflated balloon. Balloon mounted stent was deployed at the site of restenosis with near complete resolution of lumen narrowing delivery and improvement in clinical symptoms.

CONCLUSION—We report a technique for realignment and diameter change with concurrent placement and partial inflation of angioplasty balloon at the jugular venous bulb to facilitate stent delivery into the sigmoid and transverse venous sinuses in circumstances where multiple attempts at stent delivery are unsuccessful.

Keywords

Transverse venous sinus; stent; angioplasty; pseudotumor cerebri; venous stenosis

Inadequate cerebral venous outflow has been identified as one of the reasons for idiopathic intracranial hypertension or pseudotumor cerebri. In one study, 46 of 51 patients with idiopathic intracranial hypertension had bilateral stenoses of transverse venous sinus [1]. Treatment of stenosis using angioplasty and stent placement has been proposed as a method for improving clinical symptoms associated with pseudotumor cerebri [2–4]. In a systematic review of the literature of 24 studies, Masaki et al. [5] reported upon 117 patients with dural venous sinus stenosis presenting as pseudotumor cerebri (n=97), venous sinus thrombosis (n=3), dural arteriovenous fistula (n=15) or venous hypertension due to arteriovenous malformation (n=2). Of the total of 107 patients with clinical symptoms, improvement in symptoms was reported in 100 (93.5%) patients. Technical failures in stent delivery to dural venous sinuses, although not uncommon based on anecdotal experience, were not reported. We report two cases in whom stent delivery to transverse venous sinus was not possible through routine techniques. We report the technique and results of concurrent placement and inflation of angioplasty balloon at the internal jugular vein and sigmoid venous sinus junction to facilitate stent delivery in two patients past the jugular bulb.
CASE DESCRIPTION

Patient #1

A 21-year-old woman with worsening headaches and visual obscuration was referred for the assessment of cerebral venous stenosis after a magnetic resonance venogram demonstrated attenuation of signal within the transverse venous sinuses bilaterally with multiple large collateral cortical veins. Patient had a three year history of pseudotumor cerebri and had received a total of 17 lumbar punctures in the last three years with the highest opening pressure recorded of 65 cm H2O. Patient was also receiving acetazolamide 500 mg bid. On initial ophthalmologic evaluation, patient had a grade-II papilledema. Cerebral angiography demonstrated severe stenosis of the left transverse-sigmoid venous sinuses junction (Figure 1A). A high jugular bulb was noted bilaterally (Figure 1A). A 6 F introducer sheath was placed in the right femoral vein and a 6 Fr Envoy MPD (Codman & Shurtleff, Inc. Raynham, MA) guide catheter was then advanced over the wire under fluoroscopic guidance to the left internal jugular vein. The PROWLER®SELECT™Plus (Codman & Shurtleff, Inc. Raynham, MA) single lumen microcatheter was introduced over a Transcend 300-cm ES microwire (Boston Scientific Co., Natick, MA) to access and navigate through sigmoid and transverse venous sinuses. The microcatheter was connected to pressure monitoring system to sequentially measure intraluminal venous sinus pressures. A gradient of 10 mmHg between the junction of the left transverse sinus and sigmoid sinus was noted which coincided with location of maximum venographic stenosis. Due to severity of tortuosity and the high position of jugular bulb, primary angioplasty was preferred.
A 4 × 15 mm Gateway™ PTA Balloon Catheter (Boston Scientific, Stryker Neurovascular) was advanced over the Transcend 300-cm ES microwire into the transverse venous sinus. Segmental angioplasty was performed with maximal inflation of Gateway angioplasty balloon involving the left transverse sinus, transverse sigmoid junction and sigmoid sinuses. After angioplasty, the microcatheter was connected to fluid coupled pressure sensor and the previously recorded gradient was normalized. Cerebral angiogram in venous phase opacification demonstrated significantly improved flow within the left transverse and sigmoid venous sinuses with resolution of stenosis.

Patient had improvement in severity of headaches and resolution of visual obscuration. After 3 months, patient started experiencing an increase in intensity of headaches. A cerebral angiogram was performed which demonstrated restenosis at the site of primary angioplasty. A 6 F introducer sheath was placed in the right femoral vein and a 6 Fr Envoy MPD (Codman & Shurtleff, Inc. Raynham, MA) guide catheter was then advanced over the wire under fluoroscopic guidance to the left internal jugular vein. Intravenous heparin bolus of 50 U/kg was administered and the maximum recorded ACT was 226 seconds. The PROWLER®SELECT™Plus (Codman & Shurtleff, Inc. Raynham, MA) single lumen microcatheter was introduced over a steerable guidewire to access and navigate through sigmoid and transverse venous sinuses. The Transcend 300 cm ES microwire (Boston Scientific Co., Natick, MA) was introduced through the microcatheter prior to withdrawal of the microcatheter. The transverse sinus and sigmoid sinus in proximity of the stenosis measured 2.0 mm and 1.4 mm with lesion length of 10 mm. A 6 × 20 mm Viatrac 14 plus peripheral balloon angioplasty catheter angioplasty catheter (Abbott Vascular, Santa Clara, CA) was advanced over the microwire. Segmental angioplasty was performed with maximal inflation of the 6 × 20 mm Viatrac 14 plus peripheral angioplasty balloon catheter involving the left transverse sinus, transverse sigmoid junction and sigmoid sinuses. A self-expanding 6 mm × 40 mm Xpert Biliary Stent (Abbott Vascular, Santa Clara, CA) was introduced over the existing Transcend microwire. Multiple attempts to traverse the internal jugular vein and sigmoid sinus junction by the stent delivery system were unsuccessful. The stent was withdrawn and another 4.5 mm × 16 mm balloon expandable Veriflex bare metal stent (Boston Scientific Co., Natick, MA) was introduced over the existing Transcend microwire (Boston Scientific Co., Natick, MA). Multiple attempts to traverse the internal jugular vein and sigmoid sinus junction by the stent delivery system were unsuccessful. The distal end of the stent delivery catheter was unable to move beyond the apex of the jugular bulb (see Figure 1A). The sigmoid sinus and internal jugular vein in proximity of the junction measured 4.3 mm and 5.7 mm, respectively. Severe tortuosity was noted at the junction with acute angle turn within the junction. A second 6 F introducer sheath was placed in the left femoral vein and another 6 Fr Envoy guide catheter was then advanced over the wire under fluoroscopic guidance into the left internal jugular vein. The 6 mm 20 mm Viatrac 14 plus peripheral balloon angioplasty catheter angioplasty catheter (Abbott Vascular, Santa Clara, CA) was advanced over the All Star (Abbott Vascular, Santa Clara, CA) microcatheter and placed across the internal jugular vein and sigmoid sinus junction. The balloon was partially inflated until the inflation and relative straightening of the junction could be visualized. Another attempt to traverse the internal jugular vein and sigmoid sinus junction by the stent delivery system in a coaxial manner to the inflated balloon was successful (Figures 1B–E). The stent was advanced and adequately deployed with maximal inflation of angioplasty balloon in contiguous segments of the left transverse sinus, transverse sigmoid sinuses junction and sigmoid sinuses (Figure 1F). A poststent angioplasty was performed by the 6 × 20 mm balloon angioplasty catheter, which was advanced over the microwire after the stent delivery system had been withdrawn. There was complete resolution of the residual stenosis with excellent flow through the left transverse and sigmoid sinuses. No evidence of dissection or occlusion was observed at the jugular bulb and adjacent region. The patient tolerated the procedure and was discharged home the next day without any new neurological deficits and significant improvement in her headache and visual acuity. Patient reported improvement in severity of headaches without any new neurological deficits at 3 months follow-up.

Patient #2

A 41-year-old woman with worsening headaches and diplopia was referred for the assessment of cerebral venous stenosis after a magnetic resonance venogram demonstrated severe focal attenuation of signal within the right transverse sinus and hypoplasia of the left transverse/sigmoid venous sinuses. Patient had a three year history of pseudotumor cerebri and had multiple lumbar punctures with the highest opening pressure recorded of 38 cm H₂O. Patient was initially treated with acetazolamide but was unable to tolerate it due to diarrhea and skin rash. She also had a history of vertigo, Raynaud phenomenon, and sleep apnea. On initial ophthalmologic evaluation, patient did not have papilledema, but the examination was performed 24 h after a
therapeutic lumbar puncture. Cerebral angiography demonstrated severe stenosis of the right transverse–sigmoid venous sinuses junction (see Figure 2A). A gradient of 11 mm Hg between the junction of the right transverse sinus and sigmoid sinus was noted which coincided with location of maximum venographic stenosis. We decided to proceed with angioplasty and stent placement of the right transverse sinus. A 6 F introducer sheath was placed in the right femoral vein. A 6 Fr Envoy MPD (Codman & Shurtleff, Inc. Raynham, MA) guide catheter was then advanced over the wire under fluoroscopic guidance to into the left internal jugular vein. Transcend microwire (Boston Scientific Co., Natick, MA) guide catheter was then advanced over the wire under fluoroscopic guidance to into the left internal jugular vein. Transcend microwire (Boston Scientific Co., Natick, MA) was introduced through a PROWLER®SELECT™Plus 45 angle tip (Codman & Shurtleff, Inc. Raynham, MA) single lumen microcatheter and navigated through sigmoid and transverse venous sinuses. The microcatheter was connected to pressure monitoring system to sequentially measure intraluminal venous sinus pressures. The Transcend microwire (Boston Scientific Co., Natick, MA) was reintroduced and a 6 x 40 mm Visi-Pro balloon expandable biliary stent (EV3 Plymouth, MN) was introduced over the existing Transcend microwire (Boston Scientific Co.). Multiple attempts to traverse the internal jugular vein and sigmoid venous sinus junction by the stent delivery system were unsuccessful. The distal end of the stent partly traversed the junction but further anterograde movement was not possible (see Figure 2B). The Transcend microwire (Boston Scientific Co., Natick, MA) was replaced by Allstar microwire to provide greater support but stent delivery was still unsuccessful. The stent was withdrawn and 5 x 20 NC Quantum apex monorail angioplasty balloon (Boston Scientific, Maple Grove, MN) was introduced over the exist-

Figure 2. Various phases of stent placement in right transverse venous sinus. The dashed arrow represents distal end of the stent and solid arrow represents the proximal end of the stent. A: The area of stenosis is marked by a double-headed line in anteroposterior view; B: The distal end of the stent delivery catheter is past the jugular bulb but further advancement was not possible; C, D: The anterograde movement of the stent delivery catheter past the partly inflated balloon (dark arrows) in a parallel axis in anteroposterior view; E: Placement of the stent delivery device across site of restenosis in anteroposterior view; F: The area of stenosis is marked by a double headed line in anteroposterior view after deployment of the stent at site of restenosis.
ing All Star (Abbott Vascular, Santa Clara, CA) microwire. Segmental angioplasty was performed with nominal inflation of angioplasty balloon involving the right transverse sinus, transverse sigmoid junction and sigmoid sinuses. Cerebral angiogram in venous phase opacification demonstrated significantly improved flow within the left transverse and sigmoid venous sinuses with resolution of stenosis. Patient had improvement in severity of headaches and was discharged home and increased tolerance to activities of daily living was noted on follow-up.

After 2.5 months, the patient started experiencing an increase in intensity of right-sided headaches and new onset diplopia. A cerebral angiogram was performed which demonstrated early restenosis at the site of the previous primary angioplasty. The transverse sinus and sigmoid sinus in proximity of the stenosis measured 6 mm and 4.6 mm, respectively. A 6 F introducer sheath was placed in the right and left femoral veins. Two 6 Fr Envoy MPD (Codman & Shurtleff, Inc. Raynham, MA) guide catheters were then advanced over the wire under fluoroscopic guidance into the left internal jugular vein. Intravenous heparin bolus of 50 U/kg was administered and the maximum recorded ACT was 257 seconds. The sigmoid sinus and internal jugular vein in proximity of the junction measured 3.5 mm and 4.3 mm, respectively. A 5.0 mm × 15 mm Apex monorail balloon (Boston Scientific, Maple Grove, MN) was advanced over the All Star (Abbott Vascular, Santa Clara, CA) microwire and placed across the internal jugular vein and sigmoid sinus junction. A 6 × 15 mm RX Herculink Elite Renal Stent (Abbott Vascular, Santa Clara, CA) was introduced over the Transcend 300 cm exchange length microwire. After the Transcend wire had been advanced into the superior sagittal sinus, the Apex monorail balloon was partially inflated until the inflation and relative straightening of the junction could be visualized. The 6 × 15 mm RX Herculink Elite Renal Stent was advanced parallel to the inflated balloon through the jugular bulb into sigmoid sinus without any difficulty (Figure 2C, D). The stent was advanced and adequately deployed with nominal inflation of angioplasty balloon after positioning over the stenotic segment was confirmed (Figure 2E). There was complete resolution of the stenosis with excellent flow through the left transverse and sigmoid venous sinuses (Figure 2F). No evidence of dissection or occlusion was observed at the internal jugular vein and sigmoid sinus junction. The patient tolerated the procedure and was discharged home on hospital day 5 without any new neurological deficits, and significant improvement of her diplopia and headache. Patient reported improvement in severity of headaches without any new neurological deficits at 1 month assessment.

**DISCUSSION**

We observed difficulty in traversing the sigmoid sinus and jugular vein junction through the jugular foramen within the temporal and occipital bones. The junction is usually dilated and referred to as the jugular bulb and varies widely in position and dimensions. One of the patients had a high jugular bulb. A high jugular bulb is not an uncommon finding within temporal bones. High lying jugular bulb with associated tortuosity [6–8] can be seen in 13% of the population [9] and pose additional challenges to passage of stent delivery devices. Additional restrictions within the jugular foramen are secondary to dural orifice for passage of jugular bulb [10] and fibrous or bony septum present within the jugular foramen separating the jugular vein and cranial nerves [11]. The jugular bulb is surrounded by a complex venous networks and present prominent variations in connection patterns [12]. The diameter of the jugular bulb can range from 3.3 to 11.7 mm in adults [13] and demonstrate marked asymmetry between the two sides [14]. There can be considerable change in diameter and alignment of the junction of internal jugular vein and sigmoid sinus with change in head position [15,16]. A complete collapse of jugular venous system with predominant drainage through the vertebral plexus is seen in the upright position [17]. Therefore, temporary realignment and enlargement of the junction of internal jugular vein and sigmoid venous sinus by intraluminal balloon inflation is perhaps within the physiologic range of anatomical changes which are adequately tolerated. Neither of the patients demonstrated any evidence of local dissection, occlusion, or rupture with temporary alignment during passage of the stent delivery system.

Alternate options to overcome difficulty in stent delivery may be considered. Percutaneous access through the internal jugular vein has been used previously for the delivery of stents or embolization within the sigmoid and transverse venous sinuses [18,19] Some authors advocate cannulating the internal jugular vein after exposure by direct neck dissection [20]. A direct access may allow for greater maneuverability of stent delivery catheter through the junction of internal jugular vein and sigmoid sinus. The risk of thrombosis and bleeding at site of insertion within internal jugular vein is present in such an approach [21–23]. Infrequent adverse events such as arteriovenous fistulas, [24] intrathecal placement [25] and pneumothorax or hydrothorax [26] have been reported after attempted percutaneous access through the internal jugular vein. Transcranial approach by surgical approach to the venous sinus is a rarely used route for venous sinus embolization [27–29]. These approaches...
are preferable in the presence of proximal venous occlusions. Complications such as perforation of the venous sinuses resulting in subarachnoid hemorrhage or venous thrombosis have been reported with transcatheter approach [30].

We report a technique for realignment and diameter change with concurrent placement and partial inflation of angioplasty balloon at the internal jugular vein and sigmoid venous sinuses junction which allowed stent delivery into the sigmoid and transverse venous sinuses, whereby previous multiple attempts at stent delivery were unsuccessful.

REFERENCES


