

Research Article

Stenting of Dural Sinuses for Pseudotumor Cerebri: The “Conduit” Technique

Imran Chaudry^{1*}, Alejandro Spiotta², Harris E. Hawk¹,
Amrendra Miranpuri², Aquilla S. Turk¹ and Raymond Turner²

¹Department of Radiology, Medical University of South Carolina, Charleston, SC, USA

²Department of Neurosciences, Medical University of South Carolina, Charleston, SC, USA

*Corresponding author

Imran Chaudry, Department of Radiology, Medical University of South Carolina, 96 Jonathan Lucas St, MSC 323, Charleston, SC 29425, Tel: 843-792-4586; Fax: 843-792-1705, E-mail: chaudry@musc.edu

Submitted: 18 October 2013

Accepted: 15 November 2013

Published: 18 November 2013

Copyright

© 2013 Chaudry et al.

OPEN ACCESS

Keywords

- Pseudotumor cerebri
- Stent
- Guide catheter

Abstract

Introduction: Carefully selected pseudotumor cerebri patients with dural sinus stenosis and pressure gradients can be considered for sinus stenting. The tortuous sigmoid sinus-jugular bulb junction and transverse-sigmoid sinus stenosis can contribute to the complexity of stent delivery.

Materials and Results: Novel, distal access guide catheters such as 6 Fr 070 Neuron and 6 Fr Chaperon (Microvention-Terumo, Irvine, CA), and the 6 Fr 088 Neuron Max sheath (Penumbra, Inc., Alameda, CA), over a diagnostic insert catheter can provide distal access to the dural sinuses and provide a stable platform for the delivery of relatively stiff carotid stents. We report a technical nuance, “the conduit technique” that facilitated the deployment of a carotid stent to the dural sinus in nineteen cases. No guide catheter or stent complications were encountered in our series.

Conclusion: We outline our “conduit” approach in sinus stenting using distal access guide catheters which allows for superior navigability and trackability of the guide catheters across the tortuous and stenotic sinus system with successful deployment of a carotid stent.

INTRODUCTION

As technology continues to advance, many intracranial lesions previously felt to be unsuitable for interventional treatment are now approached by endovascular means. Historically, the main limitation has been access to these lesions through tortuous vasculature [1-6]. The introduction of novel, supportive yet flexible, intracranial 6 French guide catheters, such as the Neuron (Penumbra, Inc., Alameda, CA) and Chaperon (Microvention-Terumo, Irvine, CA) as well as the 6 Fr 088 Neuron Max sheaths (Penumbra, Inc., Alameda, CA) has significantly improved our ability to access the distal cerebrovasculature. Their use has been documented in achieving a stable platform for distal delivery of neurovascular devices [7-9].

Recently, there has been interest in treating idiopathic intracranial hypertension, or pseudotumor cerebri, with dural sinus stenting in carefully selected patients [10-19]. In these instances, the target lesion is usually the transverse-sigmoid sinus junction. However, proximal tortuosity and the presence of venous stenosis can limit the ability to deliver a stent distally into the venous system. We describe a technical nuance that facilitates stenting of the dural sinus utilizing a “conduit technique” with

novel distal access guide catheters. This novel breed of distal access guide catheters affords stability by providing distal catheter access, functioning by bridging the target lesion.

Penumbra 6Fr 070 Neuron guide catheter and 6fr 088 Neuron Max sheath

The 070 Neuron guide catheter is composed of proximal 6 French (Fr) 81 cm or 91 cm support zone followed by a 6-8 cm transitional zone with a distal, 6-8 mm flexible tip. The inner diameter is 070 inches proximally to distally with no tapered segments. The delivery catheter accommodates a 5.6 Fr diagnostic Neuron select catheter (Penumbra, Inc., Alameda, CA), the inner diameter of the 5.6 Fr diagnostic catheter is 0.40 inches, and accommodates a 0.038-inch wire. We have found that the combination of the Neuron delivery catheter over the Neuron select catheter with a 0.038-inch wire provides ample support to readily catheterize the dural sinuses to the level of the superior sagittal sinus. Additionally, the support and smooth taper of the system allows for the advancement of a 6 Fr Shuttle sheath (Cook Medical, Inc., Bloomington, IN) tri-axially into the dural sinuses up to the transverse sinus as length will allow. The 6 Fr 088 Neuron Max sheath (Penumbra, Inc., Alameda, CA) is

designed with a proximal support zone composed of a supportive polymer over round wire stainless steel tight pitch braid followed by a round wire braid transitional zone with increasing polymer flexibility and an open pitch round wire braid flexible zone designed for maximum flexibility. The 6 Fr 088 Neuron Max sheath has an inner diameter of 0.88 inches and accommodates a 6 Fr diagnostic Penumbra select catheter that has an inner diameter of 0.40 inches. Currently the 070 Neuron catheter is available in 105 and 115 cm lengths while the 088 Neuron Max is available in 80 and 90 cm lengths. The 80 cm 088 Neuron Max is often too short to reach the dural sinus system, the 90 cm will traverse the jugular bulb and commonly reach the transverse sinus and the 105 cm 070 Neuron will reach the superior sagittal sinus. The 070 Neuron will accommodate a 8 mm Cordis Precise stent or smaller (Cordis Corporation, Bridgewater, NJ) while for larger stents either a 6 Fr shuttle sheath or the 088 Neuron Max must be used.

Microvention 6 fr Chaperon guide catheter

The 6 Fr Chaperone guide catheter is composed of a proximal 6 Fr support zone followed by a distal, 7 mm flexible tip. The inner diameter is 0.71 inches proximally to distally with no tapered segments. The delivery catheter accommodates a 5 Fr diagnostic vertebral, JB or Simmons select catheter (117 cm). The inner diameter of the diagnostic catheter is 0.48 inches. We have found that the combination of the Chaperon delivery catheter over the diagnostic select catheter with a 0.038-inch long taper wire provides ample support to readily catheterize the dural sinuses to the level of the superior sagittal sinus. The soft flexible diagnostic insert allows for atraumatic access across the tight "Z" turn of the sigmoid-jugular bulb and allows for smooth access across the transverse-sigmoid junction stenosis commonly seen in patients with pseudotumor cerebri. The diagnostic insert combined with a 0.038-inch LT glidewire provides a stable low-profile, low-shelf platform for advancement of the guide catheter across the turns and stenosis into the transverse sinus.

PROCEDURE

All patients underwent prior diagnostic venography with pressure measurements proximal and distal to the stenosis. Carefully selected patients were offered sinus stenting for treatment of pseudotumor cerebri. The discussion of patient selection and outcomes is beyond the scope of this paper and will not be addressed here.

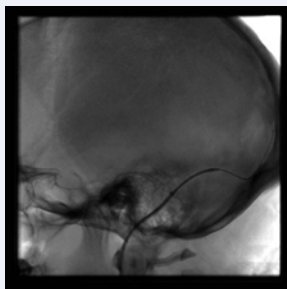


Figure 1 Lateral native view of the skull demonstrates an 088 Neuron Max (black arrow) in the sigmoid sinus, a 6 fr. Penumbra Berenstein insert (open black arrow) in the transverse sinus over a 0.038 glidewire in the Superior sagittal sinus (open white arrow).

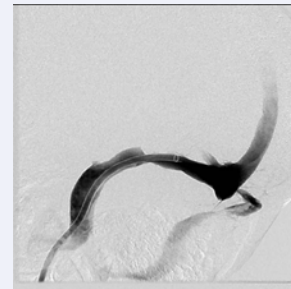


Figure 2 Retrograde venogram after removal of the diagnostic insert demonstrates the 088 Neuron Max across a transverse-sigmoid sinus junction stenosis.

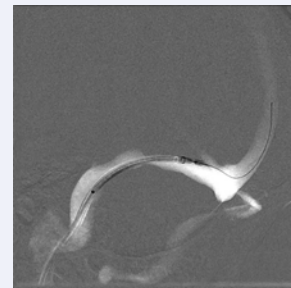


Figure 3 A 9 mm x 40 mm Cordis Precise ProRx stent delivery system is advanced through the "conduit" across the stenosis. Note the relatively straight path across the sigmoid sinus-jugular bulb transition.

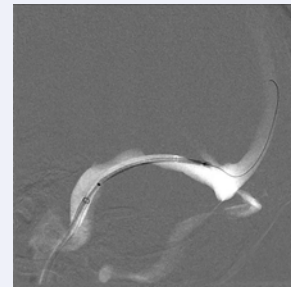


Figure 4 The stent is "unsheathed" by withdrawing the 088 Neuron Max to the sigmoid sinus. Maintaining distal access improves the accuracy of stent deployment.

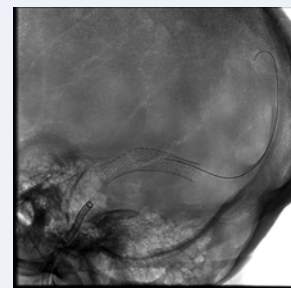


Figure 5 Stent deployed across stenosis.

Dural sinus stenting for pseudotumor cerebri was performed under general anesthesia. Measurements of target sinus diameter and stenosis lengths were made from the initial diagnostic

Table 1: Summary of the patient demographics, site of stenosis, conduit catheter system employed and stent delivered. There were no aborted procedures or procedural complications.

| Patient age | Site of Stenosis | Conduit | Stent | Complications |
|-------------|---|-------------------------------|---|---------------|
| 45 | Distal tranverse sinus, Left | 8 Fr Cook Guide/ 6 Fr Shuttle | Cordis Precise 10 mm x 3 cm | - |
| 35 | Transverse-sigmoid junction, Right | 6 Fr Shuttle/ 6 Fr Chaperone | EV3 Protégé 8 mm x 4 cm | - |
| 28 | Distal tranverse sinus, Right | 6 Fr Shuttle/ 070 Neuron | Cordis Precise 8 mm x 4 cm | - |
| 30 | Transverse-sigmoid junction, Right | 6 Fr Shuttle/ 070 Neuron | Cordis Precise 9 mm x 3 cm | - |
| 28 | Transverse-sigmoid junction, Right | 6 Fr Shuttle/ 070 Neuron | Cordis Precise 10 mm x 4 cm | - |
| 43 | Transverse-sigmoid junction, Left | 6 Fr Shuttle/ 6 Fr Chaperone | Cordis Precise 7 mm x 4 cm | - |
| 31 | Transverse-sigmoid junction, Right | 070 Neuron | Cordis Precise 8 mm x 4 cm | - |
| 48 | Distal tranverse sinus, Right | 6 Fr Shuttle/ 070 Neuron | Cordis Precise 10 mm x 4 cm | - |
| 47 | Transverse-sigmoid junction, Right | 6 Fr Shuttle/ 070 Neuron | Cordis Precise 10 mm x 3 cm | - |
| 48 | Distal tranverse sinus, Right | 070 Neuron | Cordis Precise 8 mm x 3 cm | - |
| 33 | Distal tranverse sinus, Right | 6 Fr Shuttle/ 6F Chaperone | Cordis Precise 10 mm x 4 cm | - |
| 44 | Distal tranverse sinus, Left | 6 Fr Shuttle/ 070 Neuron | Cordis Precise 10 mm x 4 cm | - |
| 35 | Distal tranverse sinus, Right | 088 Neuron Max | Cordis Precise 10 mm x 4 cm | - |
| 28 | Distal tranverse sinus, Right | 6 Fr Shuttle/ 070 Neuron | Cordis Precise 10 mm x 4 cm | - |
| 48 | Distal tranverse sinus, Right | 088 Neuron Max | Cordis Precise 10 mm x 4 cm | - |
| 33 | Distal tranverse sinus, Right | 6 Fr Shuttle/ 6 Fr Chaperone | Cordis Precise 10 mm x 4 cm | - |
| | 1) Superior sagittal sinus 2) Distal tranverse sinus, Left | 6 Fr Shuttle/ 070 Neuron | 1) Cordis Precise 8 mm x 4 cm 2) Cordis Precise 10 mm x 4 cm | - |
| 24 | Distal tranverse sinus, Right | 088 Neuron Max/ 070 Neuron | Cordis Precise 8 mm x 4 cm | - |
| 23 | Transverse-sigmoid junction, Left | 088 Neuron Max | Cordis Precise 9 mm x 4 cm | - |

venogram. All patients were pre-medicated with dual anti-platelet therapy. A 6 or 8 Fr Pinnacle sheath was placed into the right common femoral vein utilizing a Seldinger technique. All patients were administered a 5,000 unit heparin bolus after groin access. At our institution we primarily use the Cordis Precise Pro Rx stent system because of the open cell design and that 8 mm diameter stents will pass through a 070 guide catheter. Therefore, if the target lesion required a stent less than or equal to 8 mm in diameter, a 070 Neuron guide catheter or a 6 Fr Chaperone catheter was advanced over a diagnostic insert and a 0.038-inch Terumo guidewire into the dural sinus just proximal to the target lesion. If the target lesion required a 9 mm or larger stent an 8 Fr sheath was placed in the common femoral vein and a 6 Fr Shuttle sheath or an 6 Fr 088 Neuron Max sheath was advanced to the target lesion over a diagnostic insert and Terumo guidewire. The goal is to achieve access just proximal to the target lesion. The diagnostic insert was removed and retrograde venography and road map was performed and a one tip Renegade Hi Flo catheter was advanced over a 0.014-inch microguidewire into the superior sagittal sinus and antegrade venography and repeat pressure measurements were performed across the target stenosis. Utilizing the diagnostic insert and guidewire the guide catheter or sheath is then advanced beyond the stenosis. Traversing of the lesion is aided by the tapered design provided by the diagnostic insert and the smooth transition between diagnostic insert and guide catheter. After achieving distal access, the diagnostic insert and guidewire are removed and the appropriately sized stent is advanced through the "conduit" beyond the stenosis. The placement of the guide beyond the stenosis allows for the smooth

passage of the stent beyond the sharp turns of the sigmoid sinus-jugular bulb transition as well as through the stenosis and limits the hold up of the stent on the stenosis and/or large arachnoid granulations. With the stent across the stenosis the guide is carefully withdrawn proximal to the stenosis and the stent is deployed across the stenosis. The stent is again crossed with the one tip Renegade Hi Flo catheter and control venography and repeat pressure measurements are performed. At the conclusion all catheters are removed and hemostasis is achieved with either a closure device or manual pressure.

RESULTS

From 2009-2012 19 cases of sinus stenting have been performed for pseudotumor cerebri. Stent diameters ranged from 7 – 10 mm and 30 – 40 mm in length. The site of stenosis included the transverse-sigmoid sinus junction most commonly as well as the transverse sinus and the superior sagittal sinus. 9 cases were performed with a 6 fr. Shuttle sheath over a 070 Neuron guide catheter with a diagnostic insert, three cases were performed with a 6 fr. Shuttle sheath over a 6 fr. 070 Chaperon guide catheter, two cases were performed primarily with an 070 Neuron guide catheter over a diagnostic insert, four cases were performed with an 088 Neuron Max and a diagnostic insert and one early case with an 6 fr. Shuttle sheath. This was advanced over an exchange guidewire and the accompanying straight insert.

In all nineteen cases the guide catheter was able to achieve access beyond the jugular bulb and in all cases the stent was deployed across the target lesion. No guide catheter or stent complications were encountered in our series.

DISCUSSION

Endovascular venous sinus stenting has been described as a successful treatment for acute sinus venous thrombosis [20-21] and idiopathic intracranial hypertension with venous stenosis [10-19]. Typically, the stents employed are larger, stiffer, self-expanding carotid stents or balloon mounted stents which were designed primarily for delivery to relatively less tortuous vessels and are therefore relatively stiff with low compliance. Due to these limitations the delivery of these devices to the dural sinuses was technically challenging and was often limited by the navigability and trackability of the stents through the tight turns of the sigmoid sinus-jugular bulb junction and the turn from the torcula to the superior sagittal sinus. Stents would also commonly be held up by the arachnoid granulations of the transverse sinus. We describe a 'conduit' technique that facilitates access to distal venous pathology for the goal of delivering these stents efficiently and effectively. This technique relies on distal access of a guide catheter system to provide adequate proximal and distal support. There are two critical advantages to this technique. First, it allows for the placement of the guide catheter distal to the target lesion, as far as the superior sagittal sinus if needed. This enables the delivery of large stents required to treat the lesion within the lumen of the catheter, negating the effects of proximal tortuosity such as at the sigmoid-transverse junction. Secondly, once the stent has been delivered distal to the lesion, the guide catheter can be withdrawn and positioned immediately proximal to the lesion. The close proximity allows for catheter stability during stent unsheathing for precise delivery.

Current generation guide catheters were created to address the challenges produced by insufficient support provided by conventional guide catheters. By delivering the newer guide catheters more distally, the effective distance between a traditional stiff guide catheter and the target lesion is substantially reduced. These current generation guide catheters also capitalize on the increased support afforded by geometrical anchoring of the catheter around sharp vascular bends, thereby allowing the guide catheter to become softer and more trackable while providing similar support. The end result is improved and deeper distal access. These benefits have been realized for addressing arterial lesions, with guide catheters commonly placed into the carotid siphon and closer to the target lesion. Previous reports have discussed initial experience, theoretical benefits, potential uses and reported low complication rates of employing these devices for this strategy along the arterial vasculature [57-9]. We have applied these lessons learned from arterial access to the venous sinuses for stenting for pseudotumor cerebri and found the application of these principles to result in an expedient, safe and effective delivery of a variety of stent diameters relatively distally into the venous sinus system.

The two most commonly employed guide catheter systems described in this report are equally effective but for different reasons. The 0.070-inch Neuron guide catheter is relatively supple whereas the insert of the 0.070-inch Neuron is relatively stiff. This combination allows stable selective catheterization of the internal jugular veins as well as for straightening the Z turn of the sigmoid bulb. The Chaperone guide catheter is relatively stiff while the insert is relatively supple. This makes navigation

of the Z sigmoid turn more atraumatic and as more distal access is achieved provides a low shelf platform for advancement of the guide to the target lesion.

We have refined our technique to using either the 6 Fr 070 Neuron or Chaperon for cases that require an 8 mm or less stent or using the 6 Fr 088 Neuron Max sheath over a diagnostic insert for cases that require a 9 mm or larger stent.

CONCLUSION

We have described a technical nuance, the 'conduit' technique, for more efficient and effective venous stenting in the treatment of pseudotumor cerebri. This procedure is now facilitated by the use of novel, neuro-specific, intracranial guide catheters designed to access tortuous distal cerebrovasculature. The use of these catheters provides a stable platform to deliver devices to the cerebrovasculature that were previously unobtainable or technically challenging.

REFERENCES

1. Aletich VA, Debrun GM, Misra M, Charbel F, Ausman JI. The remodeling technique of balloon-assisted Guglielmi detachable coil placement in wide-necked aneurysms: experience at the University of Illinois at Chicago. *J Neurosurg.* 2000; 93: 388-396.
2. Blanc R, Piotin M, Mounayer C, Spelle L, Moret J. Direct cervical arterial access for intracranial endovascular treatment. *Neuroradiology.* 2006; 48: 925-929.
3. Eckard DA, Krehbiel KA, Johnson PL, Raveill TG, Eckard VR. Stiff guide technique: technical report and illustrative case. *AJNR Am J Neuroradiol.* 2003; 24: 275-278.
4. Nii K, Kazekawa K, Onizuka M, Aikawa H, Tsutsumi M, Tomokiyo M, et al. Direct carotid puncture for the endovascular treatment of anterior circulation aneurysms. *AJNR Am J Neuroradiol.* 2006; 27: 1502-1504.
5. Spiotta AM, Hussain MS, Sivapatham T, Bain M, Gupta R, Moskowitz SI, et al. The versatile distal access catheter: the Cleveland Clinic experience. *Neurosurgery.* 2011; 68: 1677-1686.
6. Yuzawa I, Kurata A, Suzuki S, Ozawa H, Hagiwara H, Niki J, et al. Efficacy of a direct puncture approach for anterior circulation aneurysms using a newly developed guiding catheter - especially for geriatric patients. *Surg Neurol.* 2007; 67: 30-34.
7. Chaudhary N, Pandey AS, Thompson BG, Gandhi D, Ansari SA, Gemmete JJ. Utilization of the Neuron 6 French 0.053 inch inner luminal diameter guide catheter for treatment of cerebral vascular pathology: continued experience with ultra distal access into the cerebral vasculature. *J Neurointerv Surg.* 2012; 4: 301-306.
8. Park MS, Stiefel MF, Fiorella D, Kelly M, McDougall CG, Albuquerque FC. Intracranial placement of a new, compliant guide catheter: technical note. *Neurosurgery.* 2008; 63: E616-617.
9. Turk A, Manzoor MU, Nyberg EM, Turner RD, Chaudry I. Initial experience with distal guide catheter placement in the treatment of cerebrovascular disease: clinical safety and efficacy. *J Neurointerv Surg.* 2013; 5: 247-252.
10. Ahmed R, Friedman DI, Halmagyi GM. Stenting of the transverse sinuses in idiopathic intracranial hypertension. *J Neuroophthalmol.* 2011; 31: 374-380.
11. Ahmed RM, Wilkinson M, Parker GD, Thurtell MJ, Macdonald J, McCluskey PJ, et al. Transverse sinus stenting for idiopathic intracranial hypertension: a review of 52 patients and of model predictions. *AJNR Am J Neuroradiol.* 2011; 32: 1408-1414.

12. Albuquerque FC, Dashti SR, Hu YC, Newman CB, Tebb M, McDougall CG, et al. Intracranial venous sinus stenting for benign intracranial hypertension: clinical indications, technique, and preliminary results. *World Neurosurg.* 2011; 75: 648-652.
13. Arac A, Lee M, Steinberg GK, Marcellus M, Marks MP. Efficacy of endovascular stenting in dural venous sinus stenosis for the treatment of idiopathic intracranial hypertension. *Neurosurg Focus.* 2009; 27: E14.
14. Biousse V, Bruce BB, Newman NJ. Update on the pathophysiology and management of idiopathic intracranial hypertension. *J Neurol Neurosurg Psychiatry.* 2012; 83: 488-494.
15. Urchiel KJ. Idiopathic intracranial hypertension and sinus stenting. *J Neurosurg.* 2012; 116: 536-537.
16. Bussière M, Falero R, Nicolle D, Proulx A, Patel V, Pelz D. Unilateral transverse sinus stenting of patients with idiopathic intracranial hypertension. *AJNR Am J Neuroradiol.* 2010; 31: 645-650.
17. Dykhuizen MJ, Hall J. Cerebral venous sinus system and stenting in pseudotumor cerebri. *Curr Opin Ophthalmol.* 2011; 22: 458-462.
18. Kumpe DA, Bennett JL, Seinfeld J, Pelak VS, Chawla A, Tierney M. Dural sinus stent placement for idiopathic intracranial hypertension. *J Neurosurg.* 2012; 116: 538-548.
19. Zheng H, Zhou M, Zhao B, Zhou D, He L. Pseudotumor cerebri syndrome and giant arachnoid granulation: treatment with venous sinus stenting. *J Vasc Interv Radiol.* 2010; 21: 927-929.
20. Hirata E, Higashi T, Iwamuro Y, Watanabe Y, Ando M, Arakawa Y, et al. Angioplasty and stent deployment in acute sinus thrombosis following endovascular treatment of dural arteriovenous fistulae. *J Clin Neurosci.* 2009; 16: 725-727.
21. Malek AM, Higashida RT, Balousek PA, Phatouros CC, Smith WS, Dowd CF, et al. Endovascular recanalization with balloon angioplasty and stenting of an occluded occipital sinus for treatment of intracranial venous hypertension: technical case report. *Neurosurgery.* 1999; 44: 896-901.

Cite this article

Chaudry I, Spiotta A, Hawk HE, Miranpuri A, Turk AS, et al. (2013) Stenting of Dural Sinuses for Pseudotumor Cerebri: The "Conduit" Technique. *JSM Neurosurg Spine* 1(1): 1003.