The Angle of the Microguidwire on the Lateral Projection: a Prediction of Cannulation of the Occluded Inferior Petrosal Sinuses for the Transvenous Embolization of Cavernous Sinus Dural Arteriovenous Fistulas

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Research

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Abstract

OBJECTIVE: To describe that the angle of the guidwire on lateral projection under fluoroscopic image is a prediction of cannulation of the occluded inferior petrosal sinus in the transvenous embolization of cavernous sinus dural fistulas.

METHODS: From January 2018 through January 2021, 12 consecutive cavernous sinus dural fistulas with ipsilateral inferior petrosal sinus occlusion identified in 12 patients were cured by cannulation of the occluded ipsilateral inferior petrosal sinus. Clinical, radiologic and procedure data of the 12 patients were retrospectively reviewed. The angle of microguidewire between on lateral projection under fluoroscopic image between the inferior petrosal sinus and the internal jugular vein was measured by 180°Protractor(Deli Group Co., LTD, Zhejiang, China).

RESULTS: In the 12 patients, access via the occluded ipsilateral inferior petrosal sinus was primarily attempted as the transvenous approach. During the procedure, the angle of microguidwire on lateral projection under fluoroscopic image between the inferior petrosal sinus and the internal jugular vein was 117° ±7°, which is very useful to confirm the cannulation of the occluded inferior petrosal sinus. Complete occlusion was achieved in all fistulas, with no procedure-related morbidity or mortality. Postprocedural symptom was improved in all patients.

CONCLUSION: Cannulation of an occluded inferior petrosal sinus is possible and reasonable as an initial access attempt for cavernous sinus dural fistulas. The angle of microguidwire on the lateral projection under fluoroscopic image can help to confirm the orifice of the occluded inferior petrosal sinus.

Background

Cavernous sinus (CS) dural arteriovenous fistula (DAVF) is the dural arteriovenous shunts around the CS.[1] This condition usually causes unbearable ocular symptoms and cerebral venous congestion affecting daily life.[2] Due to multiple small feeding arteries to CSDAVFs and some of the feeders supplying the vasa nervorum of cranial nerves, transarterial embolization of CSDAVFs is of a low-cure and high-risk treatment approach.[2,3] The inferior petrosal sinus (IPS) is the most commonly used transvenous approach to obliterate the CSDAVF and provides a relatively direct and shortest route from the internal jugular vein (IJV) to the CS.[4,5] However, IPSs are sometimes thrombosed in CSDAVF patients and angiographically invisible. In such cases, the challenge to transvenous embolization(TVE) is detecting the orifice to the IPS, and this is difficult due to angiographic invisibility and anatomical variations.[6] Although alternative venous approaches, including the facial vein, direct exposure of the superior ophthalmic vein and the superior petrosal sinus, have been reported, the ipsilateral IPS is still considered the first-line approach for CSDAVF, even in the case of occlusion.[7−11] Some authors reported to use 0.035-inch polymer-jacketed guidewires (Radifocus, Terumo, Tokyo, Japan) to enter the IPS for their better controllability and more support than a microguidewire.[12] However, the potential complication of venous injury in the posterior fossa may be encounted.[12] The purpose of this study was to report our experience using the angle of the microguidwire on the lateral projection under fluoroscopic image for cannulating occluded IPSs in patients undergoing TVE of CSDAVFs.

Materials And Methods

From January 2018 through January 2021, 12 consecutive patients of CSDAVF with ipsilateral or bilateral IPS occlusion were treated by the primary TVE via the occluded IPS. The patients' age was 23 to 74 years, mean 56 ± 13 years. There were 9 female and 3 male patients. The most common complaints were ophthalmic symptoms such as proptosis and conjunctival chemosis (n = 9), followed by diplopia resulting from cranial nerve palsy (n = 5), headaches (n = 3), and blurred vision (n = 1). Feeding arteries, fistula locations, and their venous drainage patterns were evaluated by reviewing diagnostic cerebral angiography before endovascular treatment. Cognard classification was used to grade these fistulas.[13] The angle of microguidwire on lateral projection under fluoroscopic image between IPS and IJV was measured by 180°Protractor(Deli Group Co., LTD, Zhejiang, China).

TVE procedure

The procedures were performed with the patient under general anesthesia. A 5-Fr diagnostic catheter was placed in the ipsilateral or contralateral common carotid artery via a left transfemoral approach for control arteriography. A 6-Fr guiding catheter (Envoy, Codman Neurovascular, Raynham, Massachusetts) was placed in the ipsilateral IJV via a right transfemoral approach. The diagnostic catheter and the guiding catheter were flushed continuously with pressurized 3000IU heparin/500ml saline. No additional heparin was given.

The guiding catheter was advanced inferior to the jugular bulb under the guidance of the carotid artery angiographic roadmap on the lateral projection(90°). The tip of the guiding catheter turn anteriorly to face the orifice of the occluded IPS. A microcatheter (45°-shaped Echelon10, Medtronic-ev3, USA) over a microguidewire (Synchro 14, Stryker; Transend 14, Boston Scientific; or Avigo-14, Medtronic-ev3) was used to detect the orifice of the occluded IPS. The occluded IPS was reopened by means of the coaxial technique with the microguidewire and the microcatheter on the lateral projection without any visible structure at the orifice of the IPS. The microcatheter was advanced further into the CS. Small amount of contrast media was injected through the microcatheter to confirm that the microcatheter tip is in the target compartment before embolizaion. Technical success was defined as access into the involved CS with the microcatheter through the occluded IPS and complete obliteration of the CSDAVF. For all transvenous embolizations, Onyx-18 was used with or without additional coils(Fig. 1).

Evaluation of results and outcome

At the end of the procedure, final angiographic results were classified as complete occlusion (no residual shunt), near-complete occlusion (small residual shunt with a marked reduction in volume), and partial occlusion (large residual shunt with slight reduction). Clinical follow-up was scheduled at 3 to 10 months. Follow-up digital subtraction angiography was not performed except the patient with substantial residual symptoms or signs or an aggravated clinical condition. Clinical outcome scores commensurate with 0, absence of any neurological dysfunction compromising daily functioning; 1, mild reduction of neurological function causing mild deficits in daily functioning; 2, moderate reduction of neurological function causing moderate deficits in daily functioning; 3, severe reduction of neurological function causing severe deficits in daily functioning; and 4, death.

Results

Six fistulas were on the left sided, 5 fistulas were on the left side, and 1 fistula involved both sides. The feeders were cavernous branches of external carotid arter or internal carotid artery. Ophthalmic veins (n = 7) usually provided drainage, followed by the superficial middle cerebral vein (n = 3), superior petrosal vein (n = 1), and basal vein of Rosenthal (n = 1). (Table 1). By Cognard classification, 7 fistulas were of type IIa and 5 fistulas were of type IIb.

Table 1
12 cases of consecutive CSDAVFs cured by cannulation of occluded IPS.

	Age(years)/sex	Presentations	Side	Feeders	Drainages	Cognard classification	Microguidewires	Angles(°)	Embolic materials	Results	F/u(mon
1	38/F	Chemosis	L	L, ICA	L, OV	IIa	Synchro-14	128	Coils + Onyx	Com	6
2	55/M	Chemosis	B	B, ICA	B, OV	IIa	Synchro-14	110	Onyx	Com	6
3	64/F	Chemosis, blurred vision	R	B, ECA, ICA	R, OV	IIa	Synchro-14	110	Coils + Onyx	Com	6
4	71/F	Headaches, Diplopia	R	R, ICA	R, BOR	IIb	Synchro-14, Transend-14	110	Coils + Onyx	Com	7
5	32/F	Chemosis	L	L, ICA	L, OV	IIa	Synchro-14	110	Onyx	Com	8
6	52/F	Chemosis, Diplopia	R	R, ECA, ICA	R, SMV; L, OV	IIb	Synchro-14, Transend-14	116	Onyx	Com	6
7	54/F	Chemosis, Diplopia	R	R, ECA	R, OV	IIa	Synchro-14	120	Onyx	Com	6
8	63/F	Headaches	L	L, ECA	L, SMV	IIb	Synchro-14	118	Coils + Onyx	Com	9
9	59/M	Headaches, Diplopia	L	L, ECA, ICA	L, SPV	IIb	Synchro-14	123	Onyx	Com	10
10	61/F	Chemosis	L	R, ICA	L, OV	IIa	Synchro-14, Avigo-14	127	Coils + Onyx	Com	3
11	44/M	Headaches, chemosis	R	R, ECA, ICA	R, SMV	IIb	Synchro-14, Transend-14	109	Onyx	Com	3
12	74/F	Chemosis, Diplopia	L	L, ECA, ICA	L, OV	IIa	Synchro-14	120	Onyx	Com	9

F, female; M, male; R, right; L, left; B, bilateral; ICA, internal carotid artery; ECA, external carotid artery; OV, ophthalmic vein; SMV, superficial middle vein; BOR, basal vein of Rosenthal; SPV, superior petrosal vein; Com, complete; F/U, follow-up.

During the procedure, the microguidewire anglated once the orifice is selected. The angle of guidwire on lateral projection under fluoroscopic image between IPS and IJV was measured 109° to 128°, mean 117°±7°. Once this angle was found, the cannulation of the occluded IPS was confirm. The occluded IPS can be reopened by means of the coaxial technique with a microguidewire and a microcatheter on the lateral projection continuously. Cannulation of the occluded ipsilateral IPS using the angle prediction was attempted and successful in all 12 patients. Accordingly, the technical success rate of the technique was 100%. The 0.014-inch microguidewire could be successfully advanced through the occluded vein in 12 IPSs. The microcatheter system can be advanced into the involved CS compartment in all 12 patients. Onyx were used in 7 patients, and Onyx with coils was used in 5 patients. No procedure-related complications were observed in any of the 12 patients.

Complete occlusion was achieved in 12 patients. Postprocedural symptom improvement was observed in all 12 patients and clinical outcome scores were all 0 at 3 to 10 months (mean 7 months) follow-up.

Discussion

Most patients with CSDAVFs present with intolerable neuro-ophthalmic symptoms, such as diplopia, severe cosmetic disfigurement, or severe headache. Endovascular treatment is usually required to occlude the abnormal arteriovenous shunts, especially in patients with higher risk CSDAVFs with cortical venous drainage or hemorrhage.[1−3] TVE has been accepted as the first-line treatment, including the petrosal sinuses[1], the superior ophthalmic vein[2], the sylvian vein[7] or the pterygoid plexus[7]. These veins are accessable by transfemoral or transjugular approach, by direct puncture or surgical exposure. The IPS approach is the simplest and safest transvenous route to reach the CS and represents the first choice for TVE of CSDAVF. Even the IPS does not serve as a venous outflow on angiograms due to thrombosis, this does not exclude it as a reasonable choice for reaching the fistula site with a microcatheter.

Successful catheterization of angiographically invisible IPS has been reported by some authors with successful rate varying 50–80%[6–9,14]. In previous studies, operators generally rely only on anatomical knowledge and expereince to identify the IPS. According to 3D rotational venography studies[15,16], the drainage patterns of the IPS can be classified into the following 6 types based on the level of the IPS-IJV junction: The IPS drains into the jugular bulb (type A, 1.2%); the IPS drains into the IJV at the level of the extracranial opening of the hypoglossal canal (type B, 34.9%); the IPS drains into the lower extracranial IJV (type C, 37.3%); the IPS forms a plexus and has multiple junctions to the IJV around the jugular foramen (type D, 6.0%); the IPS drains into the vertebral venous plexus with no connection to the IJV (type E, 3.6%); and the IPS is absent (type F, 16.9%). Thus, types B and C are most common and should be considered first. With these types, detecting the orifice of the occluded IPS is impossible or uncertain due to its invisibility and anatomical variations and is time consuming due to multiple attempts.

Some alternative strategies have been promoted in such complex situations. Srivatanakul et al used 3D venography of the IJV to identify the remnant of the IPS.[9] The catheterization of the occluded IPS was performed under the best working angle by analyzing the 3D image. Some authors suggested 0.035-inch guidewire as a frontier-wire for probing the occluded IPS and gave a 70% technical success rates.[12] Yamauchi et al reported the use of intravascular ultrasonography(IVUS) to detect the remnant of occult IPSs in patients with CSDAVFs.[17] The low-orifice IPS could be detected by the IVUS, but detecting an intracranial origin of the IPS was difficult with this technique. Up to date, it is yet possible to predict if a catheter can successfully be navigated through the IPS in a case. We therefore considered this new method for detecting the invisible origin of the IPS.

To perform TVE via a thrombosed IPS, initially, the orifice of the angiographically invisible IPS must be located. In the current study, when the microguidewire showed an angle of about 117° on the lateral projection, we determined that this was the orifice of the IPS. The microcatheter was inserted into the orifice of the IPS, and then continue to open the IPS in this direction. The angle of microguide wire is useful for confirming the thrombosed IPS to save time and avoid unnecessary irradiation. To avoid any risk of perforation, we do not use a 0.0350 wire with stiffer properties. If there is substantial resistance when advancing the microcatheter, switching to a Transend14 or an Avigo14 microguidewires is also a sensible alternative for their higher support. The use of a loop at the tip while advancing the wire within the thrombosed IPS was found to be helpful. The softness of the 0.014 loop allows it to conform to the specific anatomy of the IPS and to avoid getting stuck in the irregular, trabeculated venous walls. Further, advancing a loop of a 0.014 hydrophilic wire is much less traumatic than the tip, particularly if the catheter is already wedged. Microguidewires and microcatheters minimize the risk of perforation of the IPS and of subarachnoid hemorrhage. The angulate theory was found to be useful and associated with a higher technical success rate of reaching the CS with the microcatheter. The thrombosed IPS approach avoids the necessity of more aggressive procedures in so-called intractable dural cavernous sinus fistulas. The IPS approach is a low risk procedure, allowing treatment regardless of the patient’s age if symptoms are progressive, vision loss is imminent, or cortical drainage is evident.

Limitation of this study

Despite the high technical success rate, we may have failed to encounter some difficult cases due to anatomic variations (such as no connection between the IPS and the IJV or an extremely low IPS orifice). In the angle measurement, the image we take is 90° laterally. Due to the position of the patient's head, it may not be the standard lateral position. But, we operated in a 90° lateral position and succeeded in all patients. In future applications, we will continue to use this method to operate and measure on the standard lateral position, and more accurate angle measurement will be obtained. As this report involves only a small number of cases, and represents only a preliminary experience, accumulation of more cases will clarify whether this technique is useful.

Conclusions

Transvenous embolization of CSDAVFs through the occluded IPS is feasible. The difficulty of passing the microcatheter can be minimized by recognition of the angle of the micro-guidewire between IPS and IJV on the lateral projection of fluoroscopy serving as a guide for microcatheter navigation

Declarations

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent was obtained from all individual participants included in the study.

CONSENT FOR PUBLICATION

Not applicable

AVAILABILITY OF DATA AND MATERIALS

Please contact author for data requests.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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References

1. Jiang C, Lv X，Li Y, Liu A, Lv M, Jiang P, Wu Z. Transvenous embolization of cavernous sinus dural arteriovenous fistula with Onyx-18 and plentinum coils: Technical Note. Neuroradiol J. 2007;20(3):47-52
2. Jiang C, Lv X, Li Y, Wu Z, Shi J. Surgical access on the superior ophthalmic vein to the cavernous sinus dural fistula for embolization. J Neurointerv Surg. 2013;5(3):e13.
3. Lv X, Jiang C, Zhang J, Li Y, Wu Z. Complications related to percutaneous transarterial embolization of intracranial dural arteriovenous fistulas in 40 patients. Am. J. Neuroradiol.2009; 30: 462 - 468.
4. Lv X, Jiang C, Li Y, Wu Z. Percutaneous transvenous packing of cavernous sinus with Onyx for cavernous dural arteriovenous fistula. Eur J Radiol. 2009;71:356-362
5. Lv X, Wu Z. Anatomic Variations of Internal Jugular Vein, Inferior Petrosal Sinus and Its Confluence Pattern: Implications in Inferior Petrosal Sinus Catheterization. Interv Neuroradiol. 2015;21(6):769-773.
6. Benndorf G, Bender A, Lehmann R, Lanksch W. Transvenous occlusion of dural cavernous sinus fistulas through the thrombosed inferior petrosal sinus: report of four cases and review of the literature. Surg Neurol. 2000 Jul;54(1):42-54.
7. Rhim JK, Cho YD, Park JJ, Jeon JP, Kang HS, Kim JE, Cho WS, Han MH. Endovascular Treatment of Cavernous Sinus Dural Arteriovenous Fistula With Ipsilateral Inferior Petrosal Sinus Occlusion: A Single-Center Experience. Neurosurgery. 2015 Aug;77(2):192-199.
8. Kawamura Y, Takigawa T, Hyodo A, Suzuki K. Transvenous embolisation via an occluded inferior petrosal sinus for cavernous sinus dural arteriovenous fistulas. Neurol Neurochir Pol. 2020;54(6):585-588.
9. Srivatanakul K, Osada T, Aoki R, Sorimachi T, Matsumae M. Transvenous embolization of cavernous sinus dural arteriovenous fistula through a thrombosed inferior petrosal sinus utilizing 3D venography. Interv Neuroradiol. 2015 Jun;21(3):362-5.
10. Matsumoto A, Okauchi M, Shindo A, Kawanishi M, Tamiya T. Cavernous sinus dural arteriovenous fistula treated by facial vein direct puncture: Case report and review of the literature. Interv Neuroradiol. 2017 Jun;23(3):301-306.
11. Luo CB, Chang FC, Teng MM, Guo WY, Ting TW. Transvenous embolization of cavernous sinus dural arteriovenous fistula via angiographic occlusive inferior petrous sinus. J Chin Med Assoc. 2015 Sep;78(9):526-32.
12. Jia ZY, Song YS, Sheen JJ, Kim JG, Lee DH, Suh DC. Cannulation of Occluded Inferior Petrosal Sinuses for the Transvenous Embolization of Cavernous Sinus Dural Arteriovenous Fistulas: Usefulness of a Frontier-Wire Probing Technique. AJNR Am J Neuroradiol. 2018 Dec;39(12):2301-2306.
13. Cognard C, Gobin YP, Pierot L, Bailly AL, Houdart E, Casasco A, Chiras J, Merland JJ. Cerebral dural arteriovenous fistulas: clinical and angiographic correlation with a revised classification of venous drainage. Radiology. 1995 Mar;194(3):671-80.
14. Cho YD, Rhim JK, Yoo DH, Kang HS, Kim JE, Cho WS, Han MH. Transvenous microguidewire looping technique for breach of ipsilateral inferior petrosal sinus occlusions en route to cavernous sinus dural arteriovenous fistulas. Interv Neuroradiol. 2016 Oct;22(5):590-5.
15. Mitsuhashi Y, Nishio A, Kawahara S, Ichinose T, Yamauchi S, Naruse H, Matsuoka Y, Ohata K, Hara M. Morphologic evaluation of the caudal end of the inferior petrosal sinus using 3D rotational venography. AJNR Am J Neuroradiol. 2007 Jun-Jul;28(6):1179-84.
16. Lv X, Wu Z. Anatomic Variations of Internal Jugular Vein, Inferior Petrosal Sinus and Its Confluence Pattern: Implications in Inferior Petrosal Sinus Catheterization. Interv Neuroradiol. 2015;21(6):769-773.
17. Yamauchi S, Nishio A, Takahashi Y, Kondo K, Kawakami T, Terakawa Y, Mitsuhashi Y, Ohata K. An innovative technique for detecting the caudal end of occluded inferior petrosal sinus in cavernous arteriovenous fistula using intravascular ultrasonography--technical note. Neuroradiology. 2015 Aug;57(8):799-804.

Figures

Figure 1

A representative case showing the technique. A, coronal view, T2-weighted MR imaging, showing flow-void signals of the rigth Sylvian fissure(arrow). B, right external carotid artery angiography showing ipsilateral-IPS occlusion and main venous drainage of the superficial middle cerebral vein(arrows). The CSDAVF was supplied by multiple dural branches of the external carotid artery. C, during the procedure, microguidewire showed a 109° angle under fluoroscopic image, meaning it's the orifice of the IPS. D, fluoroscopic image showing the occluded IPS was reopened by means of the coaxial technique with the microguidewire(arrowhead) and the microcatheter(arrow) on the lateral projection without any visible structure. E, fluoroscopic image showing the microcatheter was advanced into the CS and Onyx18 was injected to occlude the fistula. F, lateral view of the right carotid artery angiography showing the fistula was completely occluded.