Transarterial Onyx embolization with targeted balloon-assisted sinus protection for treatment of dural arteriovenous fistula of the lateral tentorial sinus

Matsuo, Kazuya

Fujita, Atsushi

Kohta, Masaaki

Kohmura, Eiji

(Citation)
Radiology Case Reports,15(4):405-410

(Issue Date)
2020-04

(Resource Type)
journal article

(Version)
Version of Record

Radiology Case Reports 15 (2020) 405–410

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/radcr

Case Report

Transarterial Onyx embolization with targeted balloon-assisted sinus protection for treatment of dural arteriovenous fistula of the lateral tentorial sinus

Kazuya Matsuo, MD, Atsushi Fujita, MD, PhD, Masaaki Kohta, MD, PhD, Eiji Kohmura, MD, PhD*

Department of Neurosurgery, Kobe University Graduate School of Medicine, Kobe, Japan, 7-5-1 Kusunoki-cho, Chuo-ku, Kobe 650-0017, Japan

ARTICLE INFO

Article history:
Received 1 January 2020
Accepted 8 January 2020
Available online 7 February 2020

Keywords:
HyperForm balloon
Lateral tentorial sinus
Onyx
Sinus protection
Tentorial dural arteriovenous fistula

ABSTRACT

We present a unique sinus protection technique that uses a short-length supercompliant balloon during the transarterial Onyx embolization for the dural arteriovenous fistula (DAVF) of the lateral tentorial sinus. With this technique, we temporarily change the Borden classification from type II to type III, avoiding venous compromise and reducing the risk of Onyx migration into the patent sinus. A 54-year-old man presented with left persistent tinnitus of 4 months' duration. Cerebral angiography revealed a Borden type II left lateral tentorial sinus-DAVF associated with retrograde cortical venous reflux draining into the vein of Labbé. In the venous phase, the ipsilateral transverse-sigmoid sinus was recognized as a functional sinus and the posterior temporal vein drained into the transverse sinus near the drainage channel. We planned to perform transarterial Onyx embolization using a short-length sinus protection balloon to protect against Onyx migration. During transarterial Onyx injection, a 7 × 7-mm HyperForm balloon was navigated into the affected sinus and positioned to cover the drainage channel from the shunt. After confirming the change in Borden classification with angiography, transarterial Onyx embolization was performed via the middle meningeal artery. This procedure resulted in complete obliteration of the fistula with good patency of both the transverse-sigmoid sinus and neighboring normal cortical veins. No procedure-related complications were observed and the patient remained free of recurrence during the 24-month follow-up period. Short-length balloon-protected Onyx embolization can be safe and effective for the treatment of Borden type II DAVF.

Acknowledgements: None.
Declaration of Competing Interest: The authors declare that they have no conflict of interests.
* Corresponding author.
https://doi.org/10.1016/j.radcr.2020.01.018

Introduction

Tentorial dural arteriovenous fistulas (DAVFs) are rare, accounting for 2.9%-14.0% of all intracranial DAVFs [1–3]. Most tentorial DAVFs have direct retrograde leptomeningeal venous drainage (i.e., nonsinus type, Borden type III) [4] and exhibit aggressive behavior such as hemorrhage or venous ischemia; these lesions require treatment [1,2,5]. The lateral tentorial sinuses (LTS), located in the lateral half of the tentorium, usually drain into either the transverse sinus (TS)/sigmoid sinus (SS) junction or the anterior two-thirds of the TS [6,7]. Thus, a DAVF located in the LTS may take the form of a Borden type II DAVF draining into these sinuses, and complete obliteration of the fistulous network is difficult to achieve by a simple transarterial approach. A complete sinus occlusive strategy has been advocated for such lesions; however, sacrifice of functional sinuses is associated with a risk of complications [8].

Transarterial embolization (TAE) was recently recognized as a curative therapeutic option for DAVF [3,9], especially after the introduction of Onyx (Medtronic, Irvine, CA). During transarterial Onyx embolization, the transvenous balloon-assisted sinus protection technique has shown encouraging results using a specially designed balloon (Copernic RC balloon; BALT Extrusion, Montmorency, France) [8,10,11]. This balloon is 80 mm long, covering almost the entire sinus (from SS to TS). This raises concerns about venous compromise during protection of the sinus because a long balloon could block the orifice of the normal cortical veins and cause venous infarction [12].

We herein present a case of a Borden type II LTS-DAVF that was successfully treated with transarterial Onyx embolization assisted by targeted sinus protection with a short-length supercompliant balloon. During embolization by Onyx, a short-

E-mail address: afujita@med.kobe-u.ac.jp (A. Fujita).

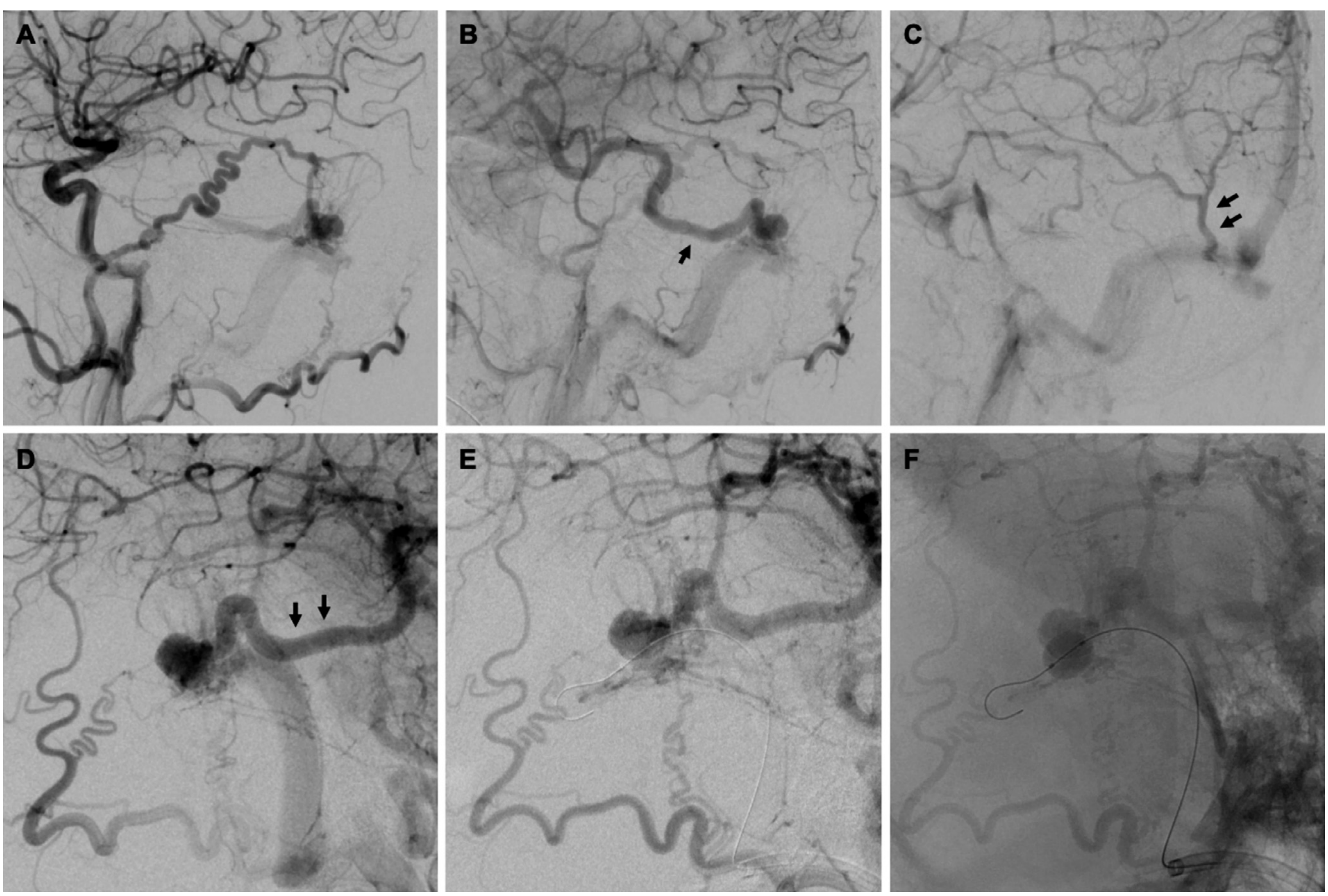

Fig. 1 – (A) Lateral view of a left common carotid angiogram (CCAG) shows a dural arteriovenous fistula (DAVF) of the lateral tentorial sinus (LTS) supplied mainly by the middle meningeal artery and occipital artery. (B) The late arterial phase shows retrograde cortical reflux into the vein of Labbé (arrow) associated with a varix at the origin. Note antegrade flow into the sigmoid sinus (SS). (C) The venous phase shows that the left SS serves as normal cortical venous drainage and that the posterior temporal vein (arrows) drains into the transverse sinus near the drainage channel from the LTS. (D) The right oblique view of the left CCAG also reveals reflux into the vein of Labbé (arrows) and antegrade flow into the SS. (E) The arterial phase of the left CCAG under targeted sinus protection shows that the DAVF has been altered from Borden type II to III. (F) The unsubtracted view of the left CCAG shows a short supercompliant balloon positioned in the SS to cover the drainage channel from the LTS.

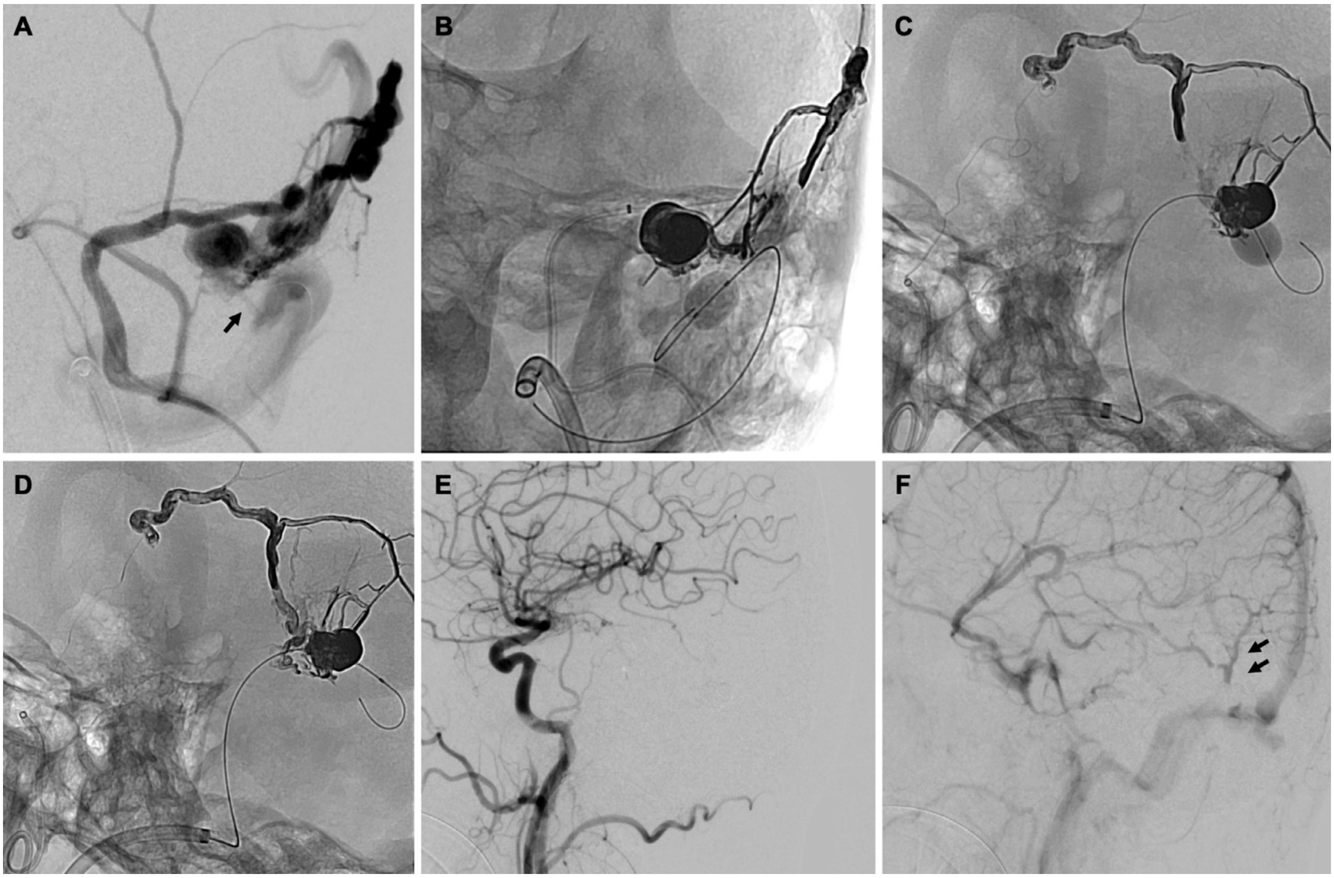

Fig. 2 – (A) Working view (left anterior oblique projection) of left middle meningeal artery angiograms for visualizing the drainage channel (arrow) from the lateral tentorial sinus to the sigmoid sinus (SS). Unsubtracted anterior oblique (B) and lateral (C) views during transarterial Onyx embolization under targeted sinus protection with a short-length supercompliant balloon. Note the Onyx cast filling the varix without migration into the SS. (D) Unsubtracted lateral image shows Onyx cast filling the varix. Lateral arterial (E) and venous (F) phase of the left common carotid angiogram also show complete obliteration of the fistula and preservation of the posterior temporal vein (arrows) draining into the left transverse sinus.

length balloon placed across the drainage point into the sinus temporarily changed the DAVF from Borden type II to type III, preventing not only Onyx migration but also venous compromise because the length of the occluded sinus was very limited.

Case presentation

A 54-year-old man with a history of hypertension presented with left persistent tinnitus of 4 months' duration. His neurologic examination findings were normal. Digital subtraction angiography revealed a left LTS-DAVF supplied by the posterior branches of the left middle meningeal artery (MMA), left occipital artery, left posterior meningeal artery, and left tentorial artery (Fig. 1A). Based on the findings of retrograde cortical reflux into the vein of Labbé (Fig. 1B, arrow) with a varix and drainage into the SS, this lesion was diagnosed as a Borden type II DAVF. In the venous phase, the ipsilateral SS was recognized as a functional sinus, and the posterior temporal vein drained into the TS (Fig. 1C, arrows) near the drainage channel from the shunt. We planned to perform transarterial Onyx embolization using a short-length sinus protection balloon to protect against Onyx migration.

After induction of general anesthesia, a 7-Fr guiding catheter (Roadmaster; Goodman, Aichi, Japan) was placed in the left external carotid artery. A microcatheter (Marathon; Medtronic, Minneapolis, MN) was advanced into the posterior branch of the MMA as close to the fistulous site as possible, supported by a 4-Fr intermediate catheter (Cerulean; Medikit, Tokyo, Japan). A 7- × 7-mm HyperForm balloon (ev3 Neurovascular, Irvine, CA) was carefully positioned to avoid occlusion of the posterior temporal vein through a 9-Fr guiding catheter (Optimo; Tokai Medical Products, Aichi, Japan) and a 6-Fr intermediate catheter (Cerulean DD6; Medikit) coaxially located in the internal jugular vein. A right oblique view of the left common carotid angiography showed a Borden type II DAVF draining into the vein of Labbé (Fig. 1D), which changed to a Borden type III DAVF under inflation of the HyperForm balloon (Fig. 1E and F). During injection of Onyx, the left anterior oblique view (Fig. 2A) was selected for good visualization of the drainage channel from the shunt to the SS. First, Onyx 34 was injected to rapidly create a proximal plug; Onyx 18

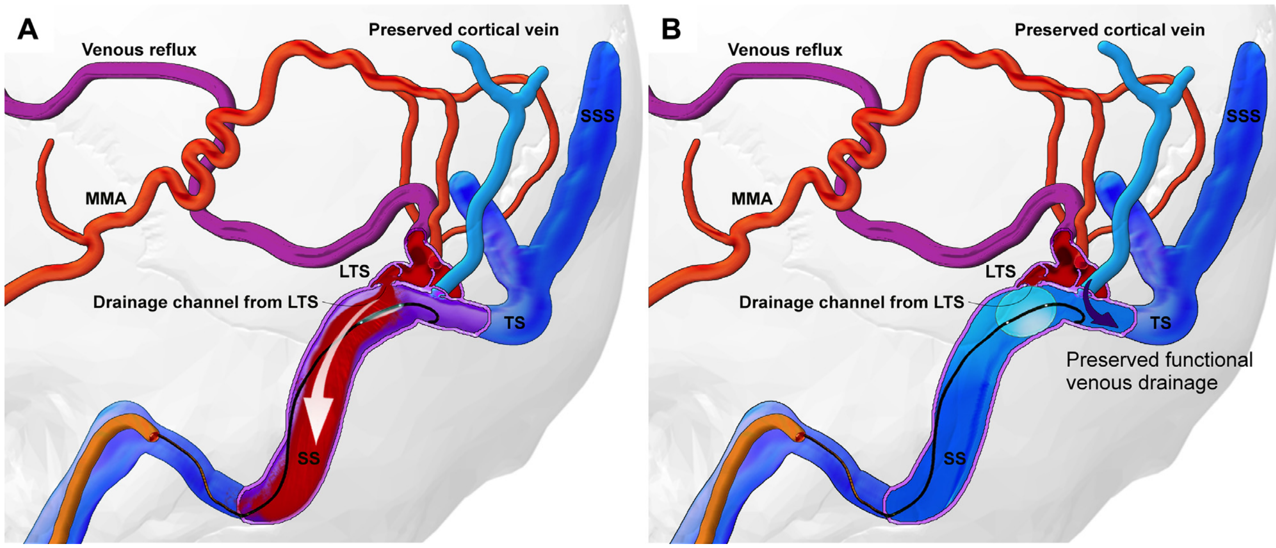

Fig. 3 – Conceptual schema of our technique to alter a dural arteriovenous fistula (DAVF) from Borden type II to type III. (A) Borden type II lateral tentorial sinus (LTS)-DAVF with retrograde cortical venous reflux. Note the antegrade flow (arrow) into the transverse sinus through the drainage channel from the LTS. The orifice of the posterior temporal vein and the drainage channel are very close to each other. (B) The short balloon is inflated to cover only the drainage channel from the LTS to preserve the normal venous return of the sinus and posterior temporal vein. This balloon temporarily changes the Borden classification from type II to III, avoiding venous compromise and reducing the risk of Onyx migration into the sinus.

was then injected. When advancement of Onyx was observed, the targeted sinus protection technique was applied (Fig. 2B and C), and the injection of Onyx was continued. No Onyx migrated into the drainage channel and to the SS throughout the procedure (Fig. 2D). A postembolization angiogram revealed complete obliteration of the fistula (Fig. 2E) with good patency of the SS and preservation of normal flow through the posterior temporal vein (Fig. 2F). The total inflation time of the HyperForm balloon in the TS was 17 minutes. After injection of Onyx, microcatheter removal was attempted; however, the Marathon microcatheter was firmly trapped by Onyx in the MMA and ruptured during forceful retrieval. Retrieval of the microcatheter fragment was successfully performed with a 4-mm gooseneck snare (Covidien, Minneapolis, MN). The patient's tinnitus completely disappeared, and his postoperative course was uneventful with no recurrence at the 12-month follow-up digital subtraction angiography.

Discussion

Successful treatment of a Borden type II DAVF is related not only to complete shunt obliteration but also to the preservation of normal venous drainage. In this report, we showed that short-length sinus-protection balloon-assisted TAE was effective for the treatment of a Borden type II DAVF. A conceptual schema of our technique is shown in Figure 3. With coverage of the small drainage channel from the LTS, the Borden type II DAVF (Fig. 3A) was temporally altered to a type III lesion (Fig. 3B). During positioning of the balloon, careful attention is required to avoid interference with the normal cortical venous drainage (Fig. 3B) by ensuring that the balloon covers only the small drainage channel from the LTS. We believe that a DAVF of the LTS may be an especially good candidate for this technique because the LTS physiologically drains into the TS/SS [7], resulting in a single drainage channel that can be covered by a short-length balloon. The advantage of targeted sinus protection using a short-length balloon is the avoidance of potential sequelae such as venous infarction or hemorrhage because the functional sinuses are patent during inflation of the balloon.

Transvenous balloon-protected TAE was first reported by Shi et al [13]. They treated 1 superior sagittal sinus DAVF and 2 TS-DAVFs with Onyx TAE with sinus protection using a short-length supercompliant balloon. However, the authors provided no description of the targeted sinus protection presented herein. An 80-mm-long venous remodeling Copernic RC balloon (BALT Extrusion) has recently become available, and the application of this balloon for complex DAVFs has been described [10–12,14]. The reported advantages of using a long balloon are that it protects the entire length of the affected sinus, minimizing the possibility of Onyx leakage into the dural sinus, and that it avoids the need to stop Onyx injection and relocate the balloon during the golden period when Onyx begins to penetrate compartments of the fistula [11]. The use of this long sinus-protection balloon involves intermittent sinus protection covering the entire length of the TS and SS. The major concern is that the long balloon can block the orifice of normal cortical veins, which might result in intracranial hypertension or venous infarction. To avoid venous infarction, an inflation time of 2-5 minutes has been used [11,15] during Onyx injection; however, the most appropriate time for temporary sinus occlusion has not been established. Guo et al [12] recently reported procedure-related complications of Onyx TAE using a long sinus-protection balloon. Among

14 patients treated, 3 developed complications (epidural hemorrhage, cerebellar hemorrhage, and cerebellar infarction, respectively), which may have been caused by occlusion of cortical draining veins into the sinuses. The authors emphasized the importance of controlling the duration of temporary occlusion and monitoring the normal venous flow by angiography. Our technique further minimizes the risk of venous infarction because the sinus is protected only at the point of the drainage channel from the LTS, and almost the entire sinus can function even during the TAE procedure. We believe that targeted occlusion of the point of connection between the sinus and shunt seems more reasonable than occlusion of the entire ipsilateral sinus, especially when the sinus is patent and functional. The key to success of our technique was appropriate patient selection, and our 3 criteria for use of short-length balloon protection were the presence of a Cognard type I or II fistula, localization of the fistula at the major functional sinuses, and the presence of a single fistula on the sinus wall or close to the sinus draining into by a single channel. We excluded patients with multiple or diffuse fistulous points on the sinus wall because a short-length balloon could not protect sinus completely.

Although a relatively high occlusion rate has been reported with TAE using Onyx, long-term recurrence is a potential issue. Ambekar et al [16] reported that 14.3% of patients exhibited angiographic recurrence at a mean follow-up period of 14 months after undergoing curative TAE using Onyx and were angiographically judged to have been "cured." These recurrences were frequently observed within 1 year after treatment. The authors suggested insufficient penetration of the embolic material to the shunting network and entire venous drainage as factors responsible for this recurrence. We believe that our technique of occluding diseased connections between the shunt and normal sinus by targeted sinus protection is effective and improves Onyx penetration into the fistula. However, further investigation is warranted to validate the long-term effect of this short-length balloon in selected patients.

Conclusion

Short-length sinus-protection balloon-assisted TAE may be an effective treatment for Borden type II DAVFs. LTS-DAVFs may be good candidates for this technique because the LTS physiologically drains into the TS/SS, resulting in a single drainage channel that should be covered. The most important factor to achieve satisfactory embolization is precise placement of the short-length balloon at the point of the drainage channel from the LTS to the TS/SS without obstruction of the normal cortical venous drainage.

Disclosure of funding and financial support

The authors have no personal, financial, or institutional interest in any of the drugs, materials, and devices described in this article.

Ethical considerations

This report is in accordance with the Declaration of Helsinki and International Council for Harmonisation/Good Clinical Practice guidelines. Institutional Review Board approval was obtained for this study. An informed written consent was obtained from a patient and patient information was anonymized and deidentified prior to the analysis.

REFERENCES

[1] Davies MA, TerBrugge K, Willinsky R, Coyne T, Saleh J, Wallace MC. The validity of classification for the clinical presentation of intracranial dural arteriovenous fistulas. J Neurosurg 1996;85(5):830–7. doi:10.3171/jns.1996.85.5.0830.

[2] Hiramatsu M, Sugiu K, Hishikawa T, Haruma J, Tokunaga K, Date I, et al. Epidemiology of dural arteriovenous fistula in Japan: analysis of Japanese Registry of Neuroendovascular Therapy (JR-NET2). Neurol Med Chir (Tokyo) 2014;54(1):63–71. doi:10.2176/nmc.st.2013-0172.

[3] Rangel-Castilla L, Barber SM, Klucznik R, Diaz O. Mid and long term outcomes of dural arteriovenous fistula endovascular management with Onyx. Experience of a single tertiary center. J Neurointerv Surg 2014;6(8):607–13. doi:10.1136/neurintsurg-2013-010894.

[4] Borden JA, Wu JK, Shucart WA. A proposed classification for spinal and cranial dural arteriovenous fistulous malformations and implications for treatment. J Neurosurg 1995;82(2):166–79. doi:10.3171/jns.1995.82.2.0166.

[5] Awad IA, Little JR, Akarawi WP, Ahl J. Intracranial dural arteriovenous malformations: factors predisposing to an aggressive neurological course. J Neurosurg 1990;72(6):839–50. doi:10.3171/jns.1990.72.6.0839.

[6] Z1 M, R M, Rohrer SE, Hoeffner EG, Vandorpe R, Berk CM, et al. Delineation of lateral tentorial sinus with contrast-enhanced MR imaging and its surgical implications. AJNR Am J Neuroradiol 2004;25(7):1181–8.

[7] Oka K, Rhoton AL Jr, Barry M, Rodriguez R. Microsurgical anatomy of the superficial veins of the cerebrum. Neurosurgery 1985;17(5):711–48. doi:10.1227/00006123-198511000-00003.

[8] Ertl L, Brückmann H, Kunz M, Crispin A, Fesl G. Endovascular therapy of low- and intermediate-grade intracranial lateral dural arteriovenous fistulas: a detailed analysis of primary success rates, complication rates, and long-term follow-up of different technical approaches. J Neurosurg 2017;126(2):360–7. doi:10.3171/2016.2.JNS152081.

[9] Cannizzaro D, Brinjikji W, Rammos S, Murad MH, Lanzino G. Changing clinical and therapeutic trends in tentorial dural arteriovenous fistulas: a systematic review. AJNR Am J Neuroradiol 2015;36(10):1905–11. doi:10.3174/ajnr.A4394.

[10] Alturki AY, Enriquez-Marulanda A, Schmalz P, Ogilvy CS, Thomas AJ. Transarterial Onyx embolization of bilateral transverse-sigmoid dural arteriovenous malformation with transvenous balloon assist-initial U.S. Experience with copernic RC venous remodeling balloon. World Neurosurg 2018;109:398–402. doi:10.1016/j.wneu.2017.10.083.

[11] Piechowiak E, Zibold F, Dobrocky T, Mosimann PJ, Bervini D, Raabe A, et al. Endovascular treatment of dural arteriovenous fistulas of the transverse and sigmoid sinuses using transarterial balloon-assisted embolization combined with transvenous balloon protection of the venous sinus. AJNR Am J Neuroradiol 2017;38(10):1984–9. doi:10.3174/ajnr.A5333.

[12] Guo F, Zhang Y, Liang S, Liang F, Yan P, Jiang C. The procedure-related complications of transarterial Onyx embolization of dural arteriovenous fistula using transvenous balloon protection. World Neurosurg 2018;116:e203–10. doi:10.1016/j.wneu.2018.04.163.
[13] Shi ZS, Loh Y, Duckwiler GR, Jahan R, Viñuela F. Balloon-assisted transarterial embolization of intracranial dural arteriovenous fistulas. J Neurosurg 2009;110(5):921–8. doi:10.3171/2008.10.JNS08119.
[14] Ponomarjova S, Iosif C, Mendes GA, Mounayer C. Endovascular treatment of transverse-sigmoid sinus type I dural arteriovenous shunts with sinus preservation for patients with intolerable symptoms: four case reports. Clin Neuroradiol 2015;25(3):313–16. doi:10.1007/s00062-014-0343-1.
[15] Jittapiromsak P, Ikka L, Benachour N, Spelle L, Moret J. Transvenous balloon-assisted transarterial Onyx embolization of transverse-sigmoid dural arteriovenous malformation. Neuroradiology 2013;55(3):345–50. doi:10.1007/s00234-012-1107-8.
[16] Ambekar S, Gaynor BG, Peterson EC, Elhammady MS. Long-term angiographic results of endovascularly "cured" intracranial dural arteriovenous fistulas. J Neurosurg 2016;124(4):1123–7. doi:10.3171/2015.3.JNS1558.