



Transvenous Shunting Point Embolization of a Superior Sagittal Sinus Dural Arteriovenous Fistula

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Objective: We report a patient in whom coil embolization of a dural arteriovenous fistula with a shunting point at the venous lacuna of the superior sagittal sinus led to radical cure.

Case Presentation: The patient was a 45-year-old female. She had a 4-month history of pulsatile tinnitus. For the purpose of treatment, she was referred to our hospital. Angiography showed blood flow from the bilateral middle meningeal arteries to the superior sagittal sinus (SSS) through the venous lacuna. The tip of a 4 Fr intermediate support catheter was inserted into the venous lacuna, and a microcatheter was retrogradely inserted into the right middle meningeal artery. Coil embolization involving the venous lacuna was performed. The disappearance of a shunt was confirmed.

Conclusion: In a patient with a shunting point at the venous lacuna of the SSS, the insertion of an intermediate support catheter with an S-shaped tip into a venous lacuna facilitated embolization.

Keywords ► dural arteriovenous fistula, superior sagittal sinus, coiling, intermediate catheter

Introduction

The incidence of symptomatic superior sagittal sinus (SSS) dural arteriovenous fistulae is significantly higher than in other sites, and this disease requires positive treatment. In this study, we report a patient in whom venous-pouch-selective coil embolization of a dural arteriovenous fistula, with a shunting point at the venous pouch of the proximal SSS in the presence of inflow from the bilateral middle meningeal arteries (MMAs), via a transvenous approach led to radical cure, and review the literature.

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Case Presentation

The patient was a 45-year-old female. She had a 4-month history of pulsatile tinnitus. She consulted another hospital. Cephalic CTA and MRA suggested a dural arteriovenous fistula, and she was referred to our hospital for the purpose of treatment. There was no neurological deficit. Neither her medical nor family histories were contributory, although she had developed a lower limb varix 13 years previously.

Angiography revealed a feeder flowing in the venous lacuna of the SSS with the bilateral MMAs as inflow arteries. At the SSS as a drainer, there was no occlusion, and antegrade blood flow with the formation of the venous lacuna was observed. There was no marked cortical venous regurgitation, and a diagnosis of a Borden type 1, Cognard type 2a dural arteriovenous fistula was made (**Fig. 1A–1D**). On bilateral external carotid angiography (ECAG), 3D fusion images showed that a shunting point was localized in the left venous lacuna, and that the right MMA was localized at the shunting point through several microvessels (**Fig. 1E–1F**). The SSS was visualized even in the venous phase after internal carotid angiography; it may be responsible for normal venous return.

Treatment for pulsatile tinnitus was selected based on the patients' wishes. An Axcelguide 6 Fr 80-cm STR

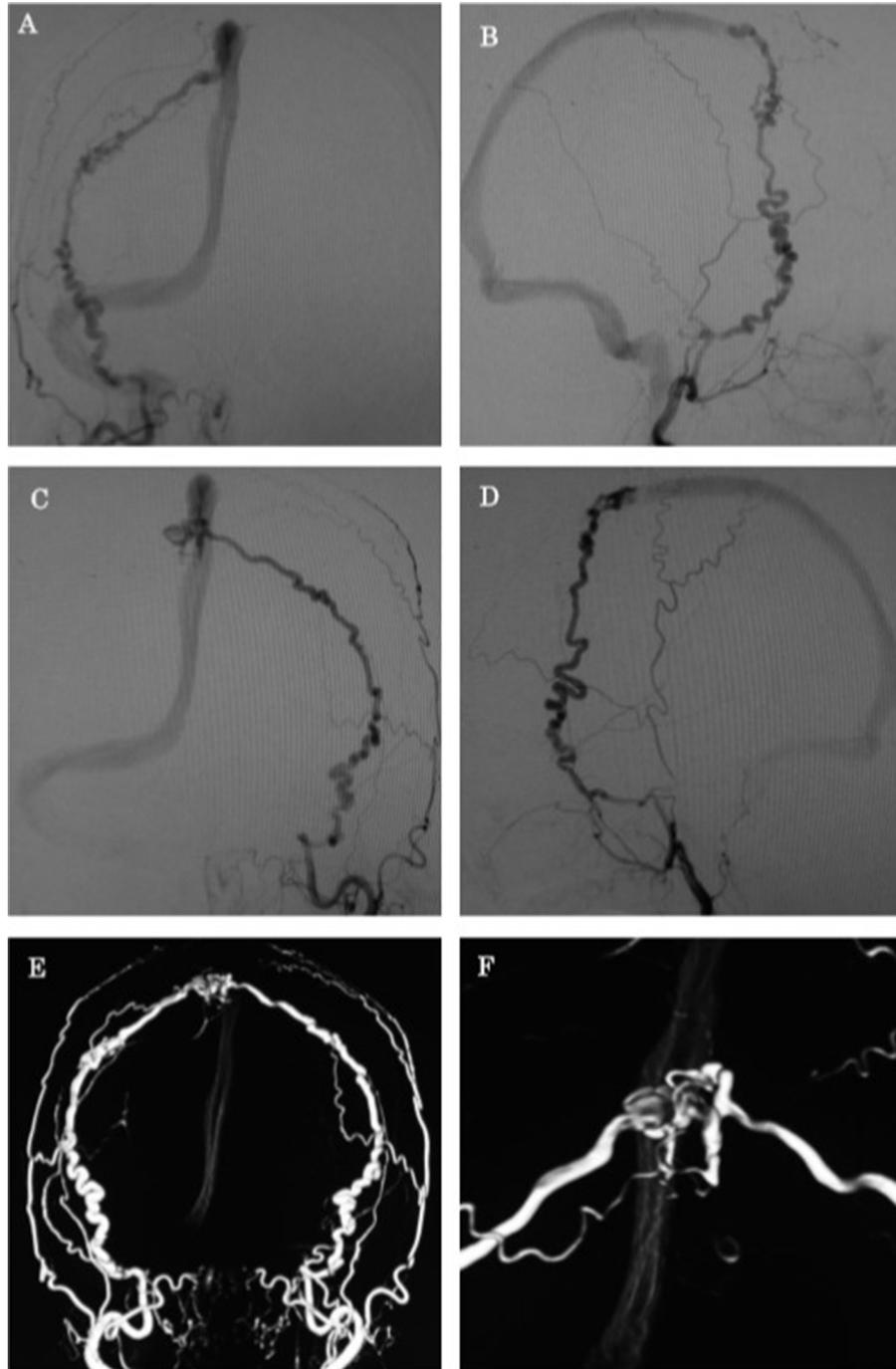


Fig. 1 (A and B) Right ECAG showed the arteriovenous fistula between right MMA and right venous lacunae. There was no obstruction SSS to sigmoid sinus. (C and D) Left ECAG showed the arteriovenous fistula between left MMA and right venous lacunae. (E and F) The fusion 3D image of right and left ECAG showed the shunt point was right venous lacunae. The left MMA shunted to right venous lacunae via the same shunt point was fed by right MMA. ECAG: external carotid angiography; MMA: middle meningeal arteries; SSS: superior sagittal sinus

(Medikit Co. Ltd., Tokyo, Japan) was inserted into the right internal jugular vein through the right femoral vein. Coaxially, Cerulean G 6 Fr 115-cm STA/Cerulean G 4 Fr 135-cm STA (Medikit) were inserted to an area adjacent to the shunt through the right sigmoid sinus-transverse

sinus-SSS under guidance with a Radifocus 0.035-inch 150-cm angle E type (Terumo Corporation, Tokyo, Japan). A guidewire was proceeded, reaching the venous lacuna. The tip of the S-shaped Cerulean G 4 Fr 135-cm STA (Medikit) could be inserted (**Fig. 2A**). An Excelsior

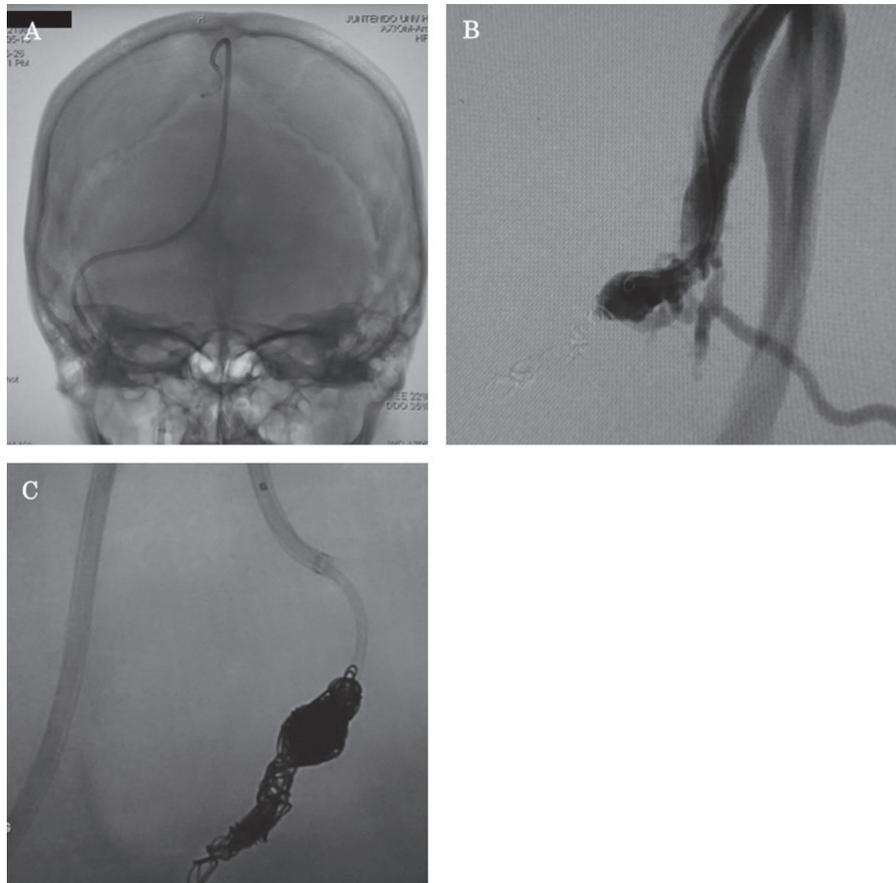


Fig. 2 (A) The intermediate catheter, which was coaxial system Cerulean G 4 Fr (Medikit Co. Ltd., Tokyo, Japan) with Cerulean DD6 6 Fr (Medikit) set the venous pouch with SSS. (B) Left ECAG showed the shunt between left MMA and SSS existed after right MMA coil embolization. (C) The microcatheter inserted the venous pouch and tight coil embolization from right MMA to venous lake was performed. ECAG: external carotid angiogram; MMA: middle meningeal arteries; SSS: superior sagittal sinus

SL-10 2M (Stryker, Fremont, CA, USA) was retrogradely inserted into the right MMA under guidance with a CHIKAI 0.014-inch 200-cm (Asahi Intecc Co., Ltd, Aichi, Japan) and GT wire 0.012-inch preshape double angle (Terumo Corporation), and coil embolization was performed. Subsequently, we also attempted to insert an Excelsior SL-10 2M into the left MMA, but this could not be selected. After embolization of the right MMA, left ECAG confirmed the residual shunt (**Fig. 2B**). Lastly, coil embolization of the venous lacuna was performed (**Fig. 2C**). The disappearance of the shunt was confirmed (**Fig. 3**). Immediately after surgery, pulsatile tinnitus disappeared, and the postoperative course was favorable. The patient was discharged.

Discussion

Dural arteriovenous fistulae at the SSS account for 3.2% to 4.7% of intracranial dural arteriovenous fistulae. Symptoms

such as hemorrhage, venous infarction, and convulsion are frequently observed.^{1,2} According to Hiramatsu et al., the odds ratios of hemorrhage, venous infarction, and convulsion on multivariate analysis were 4.3, 4.3, and 4.0, respectively; the risk of symptomatic arteriovenous fistulae is significantly higher than in other sites.²⁾

In the Guidelines for the Management of Stroke 2015, guidelines to select surgery or endovascular treatment in each site are presented, but there is no description for a consensus regarding the selection of surgery for dural arteriovenous fistulae at the SSS.³⁾ However, as the rules of therapeutic strategies for dural arteriovenous fistulae, endovascular treatment is predominantly adopted for sinus-type fistulae, and surgery for non-sinus-type fistulae. Considering this, endovascular treatment is selected as a first-choice procedure for arteriovenous fistulae at the SSS without occlusion of the affected vein in many cases.⁴⁻⁶⁾ There are two methods of endovascular treatment for

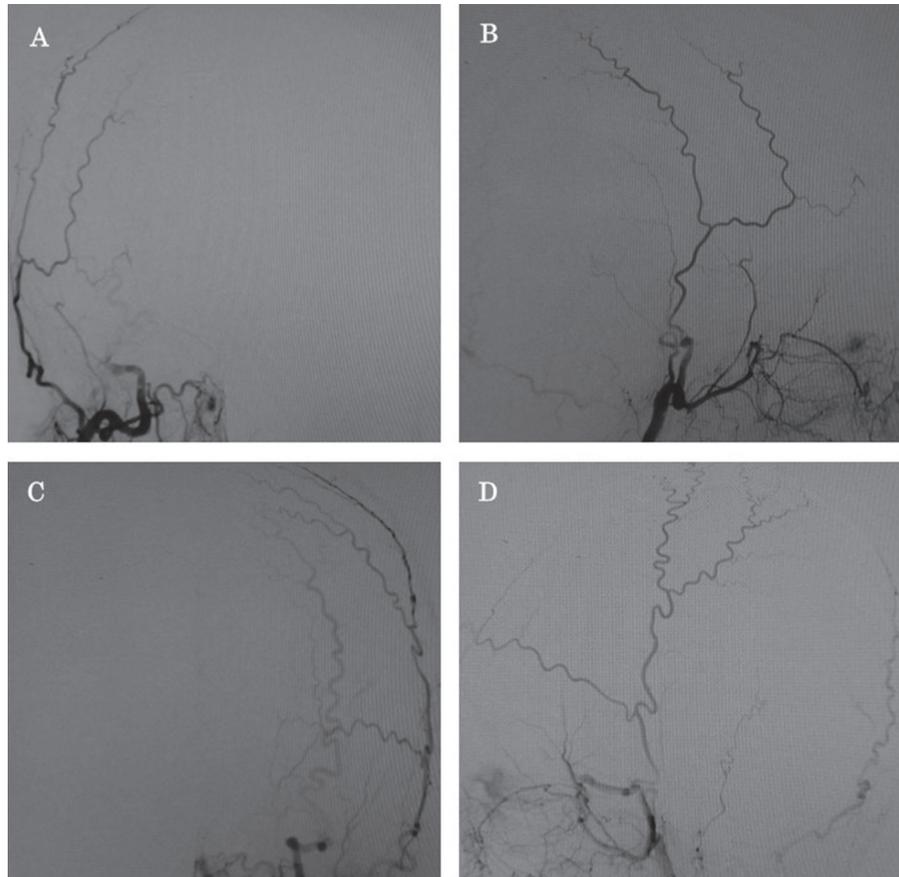


Fig. 3 (A–D) Bilateral ECAG showed the shunt was diminished after coil embolization. ECAG: external carotid angiogram

dural arteriovenous fistulae at the SSS: a method in which a liquid embolization material, such as *n*-butyl-2-cyanoacrylate (NBCA), is transarterially infused into an outflow vein to achieve radical cure, and transvenous embolization (TVE). TVE is classified into two types: outflow occlusion (the outlet of the affected sinus is embolized) and inflow occlusion (a topical area of shunt inflow is embolized). Recently, a method to preserve the affected sinus as long as possible by inflow occlusion of a shunting point has been emphasized.⁴⁾ In the present case, a dural arteriovenous fistula involving the former half of the SSS was present. Considering that the SSS is responsible for normal venous return, outflow occlusion of the affected sinus was difficult. Due to marked flexion/torsion of the bilateral MMAs, it was difficult to guide a microcatheter to an area adjacent to the shunt, and we selected a method to target radical cure by transvenous embolization for the following reasons: embolization using a liquid embolization material may not lead to radical cure, and the shunt involved the MMA to venous lacuna.

With respect to dural arteriovenous fistulae with a shunting point in the venous pouch such as the venous lacuna, there was no literature on dural arteriovenous fistulae at the SSS to our knowledge, but several studies reported dural arteriovenous fistulae at the cavernous sinus.^{7–10)} Among these, Satow et al. performed transvenous coil embolization of dural arteriovenous fistulae at the cavernous sinus, and indicated the presence of a shunting point in the venous pouch in 12 of 14 patients. They reported that coil embolization at this site resulted in complete occlusion in all patients.⁷⁾ The merits of coil embolization of the venous lacuna include a reduction in the mass effects of a coil related to a decrease in the coil volume and a high radical cure rate in the presence of antegrade sinus blood flow. In the present case, it was necessary to maintain antegrade SSS blood flow, but embolization of the venous lacuna was considered to be an effective treatment procedure for achieving radical cure.

In addition, in the present case, the tip of an S-shaped Cerulean G 4 Fr 135-cm STA (Medikit) was directly inserted into the venous lacuna, leading to successful coil embolization.

Some studies reported the usefulness of a method to use an intermediate support catheter as a co-axial system in patients with a specific distance to the lesion site,^{11–13} as demonstrated in the present case. As its merits, the operability of a microcatheter may be improved by reducing microcatheter friction/resistance at the flexed area of an access blood vessel, and an improvement in the supporting performance of a guiding system may facilitate an access to the lesion site. Furthermore, in the present case, the S-shaped formation of the tip of an intermediate support catheter facilitated tip insertion into the venous lacuna. This improved the bearing properties of the microcatheter, facilitating tight packing of the right MMA and venous lacuna through a shunt point existing in the venous lacuna. We also attempted embolization of the left MMA, but narrowing of the shunt point on coil embolization of the right MMA may have affected a route to the left MMA. There has been no case report of transvenous coil embolization through an artery, as performed in the present case. However, previous studies reported transarterial intravenous embolization¹⁴ or embolization of an artery with a liquid embolization material from the venous side after transvenous embolization of a shunt point.¹⁵ As the limitation of coil embolization of an outflow vein, arterial blood flow-related coil-mass migration to the venous side during embolization was indicated.^{16,17} The merits of transvenous embolization of an inflow blood vessel include accurate occlusion of a shunt point, a flow-control-related reduction in arterial pressure in high-flow-shunt patients, and the prevention of coil/microcatheter regurgitation through shunt point coil anchoring. Thus, transvenous coil embolization of an inflow artery may be effective.

Conclusion

In our patient with a shunt point in the venous lacuna of a dural arteriovenous fistula at the SSS, embolization was successfully performed by placing an intermediate support catheter at the shunt point, leading to radical cure. In particular, the S-shaped formation of the catheter tip facilitated tip insertion into the venous lacuna, making tight packing of the inflow artery/shunt point/venous lacuna possible. As few studies have reported treatment for dural arteriovenous fistulae at the SSS, a large number of patients should be investigated in the future.

Disclosure Statement

All coauthors have completed online “conflict of interest” reporting to the Japan Neurosurgical Society. The coauthor,

Hidenori Oishi received an annual daily allowance (such as lecture fees) from Stryker, a donation to the representative of a donated fund laboratory from Stryker, and a donation from Medikit.

There is no conflict of interest for the first author and the other coauthors.

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