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Single-session hematoma removal and transcortical venous approach for coil embolization of an isolated transverse-sigmoid sinus dural arteriovenous fistula in a hybrid operating room: illustrative case

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BACKGROUND Dural arteriovenous fistula (DAVF) can present with massive hematoma, which sometimes requires emergent removal. Therefore, a surgical strategy for single-session hematoma removal and shunt occlusion in the same surgical field is important.

OBSERVATIONS A 73-year-old man was transferred to the authors' hospital with a headache. Brain computed tomography (CT) revealed an intracerebral hematoma in the right temporoparietal lobe (hematoma volume 12 ml). A cerebral angiogram revealed a right isolated transverse-sigmoid sinus (TSS)-DAVF fed by the occipital artery and middle meningeal artery. There was cortical venous reflux into the Labbé vein and posterior parietal vein. Percutaneous transarterial and transvenous embolization were unsuccessful. The following day, his consciousness level acutely declined with a headache, and brain CT showed hematoma expansion (hematoma volume 41 ml) with a midline shift. Therefore, the authors performed single-session hematoma removal and a transcortical venous approach for coil embolization of an isolated TSS-DAVF in a hybrid operating room. His postoperative course was uneventful. No recurrence was observed 3 months postoperatively on cerebral angiography.

LESSONS Single-session hematoma removal and a transcortical venous approach for coil embolization of an isolated TSS-DAVF is considered in cases with massive hematoma. This strategy is useful, considering recent developments in hybrid operating rooms.

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KEYWORDS dural arteriovenous fistula; transverse sinus; transcortical venous approach; cerebral hemorrhage

Cerebral dural arteriovenous fistulas (DAVFs) are abnormal shunts between the artery and dural sinus or leptomeningeal vein within the dura mater, which account for 10%–15% of intracranial vascular malformations.[1,2] Percutaneous endovascular therapy has become the first-line therapy for most DAVFs.[3] Open surgery has often been reserved for the DAVFs that are not amenable to or fail percutaneous endovascular therapy.[4] Although direct sinus packing, disconnection of cortical venous reflux, skeletonization, or sinus resection under surgical craniotomy is performed in transverse-sigmoid sinus (TSS)-DAVF, these surgical fields have a risk of excessive bleeding because many feeding arteries are gathering.[5–8] Furthermore, DAVF can present with massive hematoma and may require emergent hematoma removal.[9] Therefore, a surgical strategy for single-session hematoma removal and shunt occlusion in the same surgical field is important. Here, we report the first case of single-session hematoma removal and a transcortical venous approach for coil embolization of an isolated TSS-DAVF in a hybrid operating room.

Illustrative Case

A 73-year-old man with hypertension was transferred to our hospital with a sudden onset of headache. His consciousness was clear, but neurological examination showed left hemispatial neglect. Brain computed tomography (CT) revealed an intracerebral hematoma in the

ABBREVIATIONS CT = computed tomography; CVR = cortical venous reflux; DAVF = dural arteriovenous fistula; TAE = transarterial embolization; TSS = transverse-sigmoid sinus; TVE = transvenous embolization.

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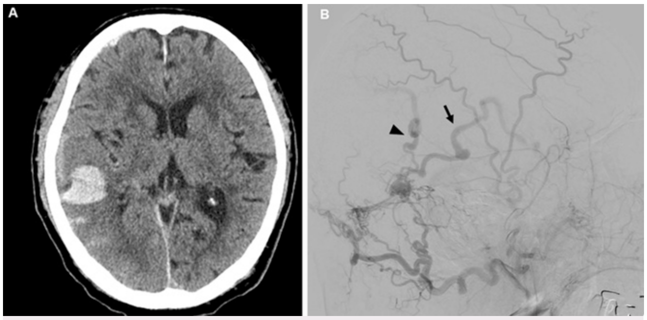

FIG. 1. A: Brain CT performed on the day of hospitalization showing an intracerebral hematoma in the temporoparietal lobe with slight subdural hematoma and subarachnoid hemorrhage. **B:** Right external carotid artery angiogram showing isolated TSS-DAVF with feeding vessels from the occipital and middle meningeal arteries. The fistula drains into the vein of Labbé (*arrow*) and posterior parietal vein (*arrowhead*).

right temporoparietal lobe (hematoma volume 12 ml) with a slight subdural hematoma and subarachnoid hemorrhage (Fig. 1A). A cerebral angiogram revealed a right TSS-DAVF that was fed by the occipital artery and middle meningeal artery (Fig. 1B). There was cortical venous reflux (CVR) into the vein of Labbé and posterior parietal vein with varices. The medial sides of the right transverse sinus and ipsilateral sigmoid sinus were not visualized, suggesting an isolated sinus (Borden type III, Cognard type IV, Lalwani grade IV).

First, percutaneous transvenous embolization (TVE) of the isolated sinus was attempted from the contralateral side. A 6-French FUBUKI Dilator Kit (Asahi Intecc) was positioned in the left internal jugular vein. Using a 0.035-inch guidewire (Terumo), a 4.2-French FUBUKI (Asahi Intecc) was positioned into the torcular herophili through a 6-French coaxial Cerulean DD6 Plus catheter (Medikit). An Echelon microcatheter (Medtronic) was used over the ASAHI CHIKAI 14 microguidewire (Asahi Intecc) to catheterize the isolated sinus, but transvenous access failed due to difficulty in catheterization of the isolated sinus. Second, transarterial embolization (TAE) with Onyx was performed. A 7-French Roadmaster guiding catheter (Goodman) was positioned in the right external carotid artery. A DeFrictor microcatheter (Medico's Hirata Inc.) was positioned into the mastoid branch of the occipital artery over the ASAHI CHIKAI 10 microguidewire (Asahi Intecc) through a 3.4-French TACTICS distal access catheter (Technocrat). However, Onyx could not reach the isolated sinus because the microcatheter tip was far from the shunting point due to the tortuous occipital artery. Although the cortical venous reflux remained, percutaneous endovascular embolization was suspended due to the extensive radiation dose on that day. We planned a second session of percutaneous endovascular therapy.

The following day, his consciousness level acutely declined to Glasgow Coma Scale E3M6V4 with a headache. Brain CT showed expansion of the intracerebral hematoma (hematoma volume 41 ml) and subdural hematoma with midline shift, indicating rebleeding (Fig. 2A). Emergent hematoma removal and rebleeding prevention were required. However, a craniotomy adjacent to the TSS has a risk of excessive bleeding because many feeding arteries are gathering. Therefore, we planned to perform single-session hematoma removal and a transcortical venous approach for coil embolization of an isolated TSS-DAVF in a hybrid operating room.

After general anesthesia was induced, a 6-French sheath was inserted into the right femoral artery. The patient was placed in the left park bench position, and the head was fixed with a carbon headframe. A 6-French ENVOY guiding catheter (Johnson and Johnson) was placed in the right external carotid artery for intraoperative cerebral angiography. We performed a temporoparietal craniotomy, which included intracerebral hematoma, vein of Labbé,

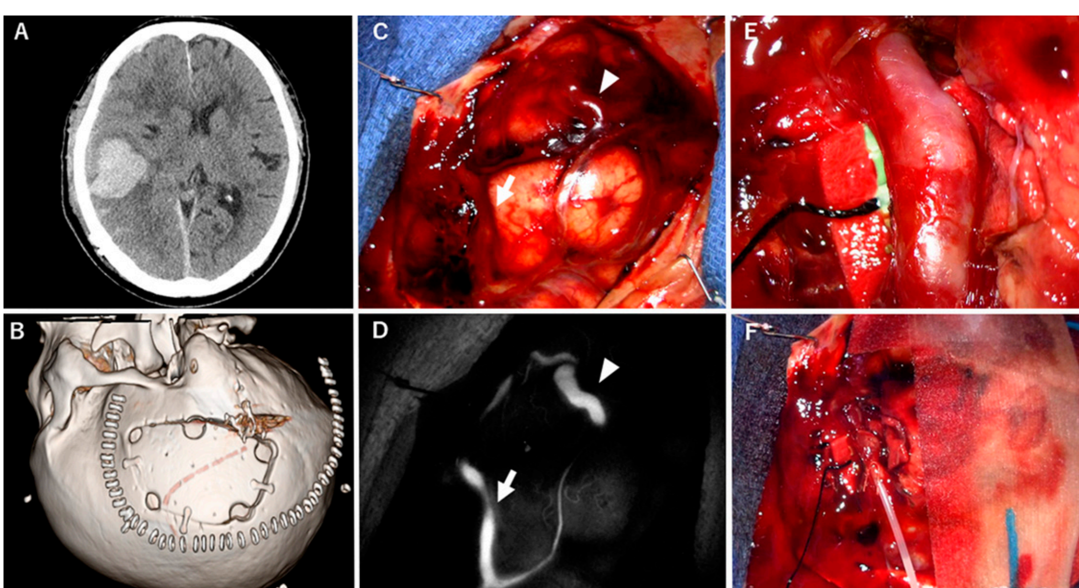

FIG. 2. Preoperative brain CT (**A**) showing hematoma enlargement with midline shift. Postoperative CT (**B**) showing temporoparietal craniotomy with U-shaped skin incision. Intraoperative photograph (**C**) and intra-arterial superselective indocyanine green video angiography (**D**) show the arterialized vein of Labbé (*arrow*) and posterior parietal vein (*arrowhead*) as seen on cerebral angiogram. The arterialized vein of Labbé was isolated for direct puncture (**E**). An 18-gauge needle was placed into the vein of Labbé, and 5-0 silken thread was tied (**F**).

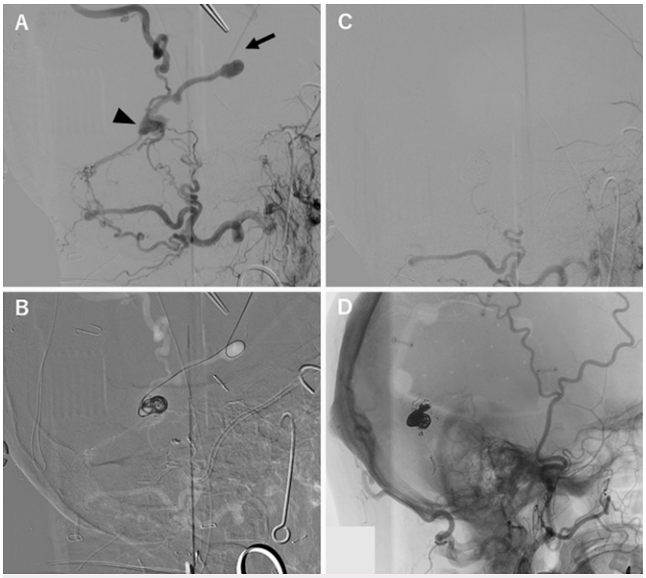

FIG. 3. A: Intraoperative external carotid angiography (ECAG) showing right TSS-DAVF with cortical venous reflux. *Arrow* indicates the puncture point of the vein of Labbé. *Arrowhead* points to the shunt pouch adjacent to the transverse sinus. **B:** The microcatheter was advanced into the shunt pouch via the Labbé vein, and coil embolization was performed. **C:** Intraoperative ECAG showing disappearance of arteriovenous shunt. **D:** Plain angiogram, lateral view, showing the coils in the shunt pouch.

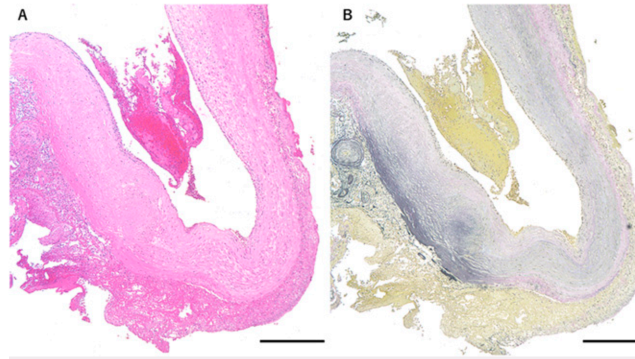

FIG. 4. The arterialized vein of Labbé with extensive hyperplasia of media on hematoxylin and eosin staining (**A**) and Elastica van Gieson staining (**B**). Bars = 500 μm.

and posterior parietal vein using the navigation system (Fig. 2B). The vein of Labbé and posterior parietal vein were dilated and red in color (Fig. 2C) with early venous filling on intra-arterial superselective indocyanine green video angiography (Fig. 2D). The vein of Labbé was microscopically isolated (Fig. 2E) and directly punctured with an 18-gauge needle (SURFLO I.V. catheter, Terumo). A 5-0 silken thread was tied around the outer sheath for fastening (Fig. 2F). A Radifocus Hemostasis valve (Terumo) was attached to the outer sheath for microcatheter insertion. Using fluoroscopic guidance of the cortical venous reflux into the vein of Labbé, an Excelsior SL-10 microcatheter (Stryker) was advanced into the shunt pouch adjacent to the transverse sinus, and coil embolization was performed (Fig. 3A and B). Shunt flow, including cortical venous reflux, completely disappeared on cerebral angiography (Fig. 3C and D). Surgical cauterization of the Labbé vein and posterior parietal vein was performed. Histological examination revealed that the vein of Labbé was arterialized and showed remarkable hyperplasia of the media (Fig. 4A and B). After confirming the disappearance of shunt flow, corticotomy and hematoma evacuation were microscopically performed. The patient's postoperative course was uneventful, and he was discharged to the rehabilitation hospital on postoperative day 21. Finally, his neurological deficit was only left quadrantic hemianopsia, and the 90-day modified Rankin scale score was 2. No recurrence was observed 3 months postoperatively on cerebral angiography.

Discussion

Observations

To our knowledge, this is the first case of single-session hematoma removal and a transcortical venous approach for coil embolization of an isolated TSS-DAVF in a hybrid operating room.

The transcortical venous approach for coil embolization of an isolated TSS-DAVF has several advantages. First, hematoma removal and shunt occlusion can be performed in the same surgical field in a single session in cases of TSS-DAVF with massive hematoma. TSS-DAVFs presenting with hemorrhage are often high-grade DAVFs with CVR.[10] Therefore, the surgical field for hematoma removal usually includes CVR for this approach. Second, there is less bleeding risk than that with direct sinus packing, selective disconnection of the CVR, skeletonization, and sinus resection under craniotomy. TSS exploration, brain retraction, and cranial base exposure are unnecessary for the transcortical venous approach.

However, the transcortical venous approach has several disadvantages. The first is that the fragile vein of the CVR might be perforated due to microcatheter navigation. Therefore, careful judgment regarding whether the vein of the CVR can be durable for microcatheter navigation is required. In our case, the vein of Labbé was observed to be arterialized and thickened enough to be durable for microcatheter navigation in the surgical field. Second, a hybrid operating room is needed for safe microcatheter navigation. Third, radiation exposure to the surgeon may be high.

With the development of endovascular devices, endovascular therapy has become the first-line therapy for most DAVFs.[3] However, non–sinus-type DAVFs located in the anterior cranial fossa and tentorium have often been treated by open surgery. A sinus-type DAVF sometimes progresses to the isolated sinus, resulting in difficulty with percutaneous transvenous access. The wire rotation technique, triple-catheter technique, and microcatheter pull-up technique have been investigated to access the occluded venous segment.[11,12] Lekkhong et al.[13] reported that the technical success rate was 82% (53 of 65 sessions) with the transvenous approach through an occluded sinus. Recently, TAE with Onyx has become an alternative treatment for cerebral DAVFs.[14] Kim et al.[15] reported that a dual-lumen balloon catheter can significantly increase the complete occlusion rate and decrease the total procedure time, Onyx injection time, and number of feeders requiring embolization. Hendriks et al.[16] reported that complete obliteration rates of TVE and TAE for an isolated sinus DAVF at the first attempt were 85.7% and 77.8%, respectively. Open surgery was successful in all cases in which percutaneous endovascular treatment failed or was thought to be dangerous. A multimodal treatment approach, including surgical intervention, is important to achieve complete occlusion of isolated sinus DAVFs. There are several surgical procedures for isolated sinus TSS-DAVFs, such as direct sinus packing, disconnection of cortical venous reflux, skeletonization, and sinus resection under craniotomy.[5–8] Although a transcranial catheter approach via a draining cortical vein has been described in cavernous sinus DAVF, there has been no report on isolated TSS-DAVF.[17–19]

A higher rate of early rebleeding (35%) has been reported in cerebral DAVFs presenting with hemorrhage.[20,21] Furthermore, subarachnoid hemorrhage or subdural hematoma with venous ectasia and direct CVR are risk factors for early rebleeding.[22] Considering the higher rate of early rebleeding, unnecessary delays in definitive treatment should be avoided in such patients. Therefore, when percutaneous endovascular treatment is unsuccessful or is thought to be dangerous, an early decision to change to surgical intervention is required.

Lessons

Single-session hematoma removal and a transcortical venous approach for coil embolization of an isolated TSS-DAVF can be considered in cases with massive hematoma. This strategy is useful, considering recent developments in hybrid operating rooms.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Yamaguchi, Kanematsu, Sogabe. Acquisition of data: Yamaguchi, Kanematsu, Shimada, N Yamamoto, Miyake, Miyamoto, Shikata, Y Yamamoto, Kuroda, Takagi. Analysis and interpretation of data: Yamaguchi, Kanematsu, Takagi. Drafting the article: Yamaguchi. Critically revising the article: Yamaguchi, Ishihara, Takagi. Approved the final version of the manuscript on behalf of all authors: Yamaguchi. Administrative/technical/material support: Y Yamamoto, Takagi. Study supervision: Kanematsu, Miyake, Ishihara.

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