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Drag-out technique using a large balloon fixed with an aspiration catheter for retrieving residual thrombus on the wall of the superior sagittal sinus: illustrative case

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BACKGROUND The authors report a patient with sagittal sinus thrombosis that was resistant to reported endovascular treatments but successfully recanalized by dragging out the thrombus using a large balloon fixed with an aspiration catheter.

OBSERVATIONS A 57-year-old man presented with the persistent headache and a simple partial seizure. Diagnostic study with computed tomography and angiography demonstrated the superior sagittal sinus (SSS) thrombosis. Due to the neurological worsening even after systemic heparinization, the patient underwent mechanical thrombectomy. Despite six passes of stent retrievers and a large-bore aspiration catheter, functional recanalization was not achieved. Therefore, the so-called dental floss technique was attempted using a large compliant balloon catheter (Transform 7 × 7 mm). However, the balloon catheter just wobbled along the lesion without recanalization. To restrict the movement of the balloon catheter, the distal shaft of the balloon catheter was fixed with the aspiration catheter, and both the balloon and the aspiration catheter were slowly pulled to drag the thrombus out, resulting in recanalization of cortical veins as well as the SSS.

LESSONS Dragging the thrombus using a large balloon fixed with an aspiration catheter was a useful technique to retrieve sticky thrombus in the patients with the sinus thrombosis.

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KEYWORDS cerebral venous sinus thrombosis; cortical venous circulation; large balloon catheter

The standard therapy for cerebral venous sinus thrombosis (CVST) is anticoagulation with heparin, being the sole treatment with evidence from randomized, controlled trials.[1,2] However, since anticoagulation basically prevents progressive thrombus formation where the drug can reach, venous sinus occlusion with large thrombus is less likely to be recanalized. Endovascular treatments, such as mechanical thrombectomy,[3] aspiration thrombectomy,[4] and combined procedures with a balloon and aspiration catheter[5,6] are alternatives in cases refractory to anticoagulation treatment. However, in contrast to arterial embolic stroke, the inflammation-driven thrombus on the wall of the venous sinus is often resistant to such endovascular treatments. The case of a patient with CVST with extensive thrombus burden who was treated successfully with mechanical thrombectomy followed by dragging residual thrombus on the wall of the superior sagittal sinus using a large balloon and a large-bore aspiration catheter is described.

Illustrative Case

A 57-year-old man with no relevant past medical history was transferred to our hospital for persistent headache for 2 days and a simple partial seizure. Initial computed tomography (CT) of the brain

ABBREVIATIONS CT = computed tomography; CVST = cerebral venous sinus thrombosis; MRI = magnetic resonance imaging; SS = sigmoid sinus; SSS = superior sagittal sinus; TS = transverse sinus.

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demonstrated subarachnoid hemorrhage in the left central sulcus (Fig. 1A) and a high-density area in the superior sagittal sinus (SSS) measuring 7.32 × 7.99 mm (Fig. 1B and C). Magnetic resonance imaging (MRI) showed a high-intensity area in the left primary motor and sensory cortex on T2-weighted images (Fig. 1D). Magnetic resonance venography showed occlusion of the SSS, right transverse sinus (TS), and sigmoid sinus (SS), suggesting cerebral venous sinus thrombosis (Fig. 1E). Laboratory data showed no abnormalities in coagulation, but elevations of his white blood cell count (15,720 cells/μl) and C-reactive protein (2.10 mg/dl). Due to the neurological worsening evolving with repeated systemic seizure even after systemic heparinization for 6 hours, the medical management was less likely to be effective. Therefore, the patient underwent endovascular treatment. A 4F sheath was placed in the right common femoral artery, and a 4F diagnostic catheter was placed in the right internal carotid artery. Right carotid injection demonstrated a contrast defect in the SSS, right TS, and SS (Fig. 2A and B). A 6F FUBUKI Neurovascular Dilator Guiding Kit (Asahi Intecc Co., Ltd.) was placed in the right common femoral vein and advanced into the right internal jugular vein. An EMBOVAC aspiration catheter (Neuravi/Cerenovous), a TrevoTrak21

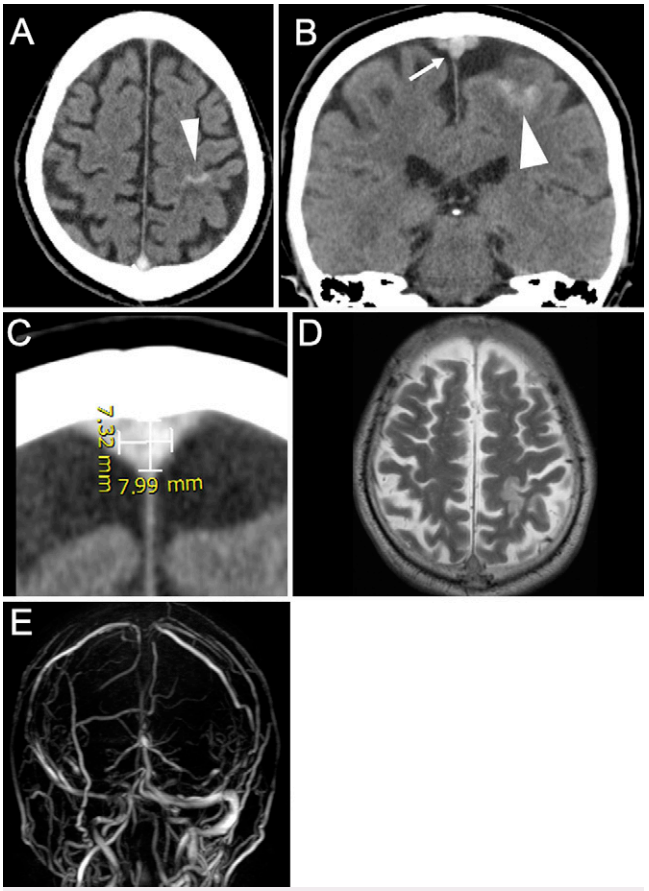

FIG. 1. Admission axial (**A**) and coronal (**B**) CT images showing subarachnoid hemorrhage (SAH) in the left central sulcus (*arrowheads*) and a high-density area in the SSS (*arrow*), measuring 7.32 × 7.99 mm^2 (**C**). Admission T2-weighted MRI demonstrating a high-intensity area in the left primary motor and sensory cortex (**D**). Magnetic resonance venography, lateral view, demonstrating occlusion of the SSS, right TS, and SS (**E**).

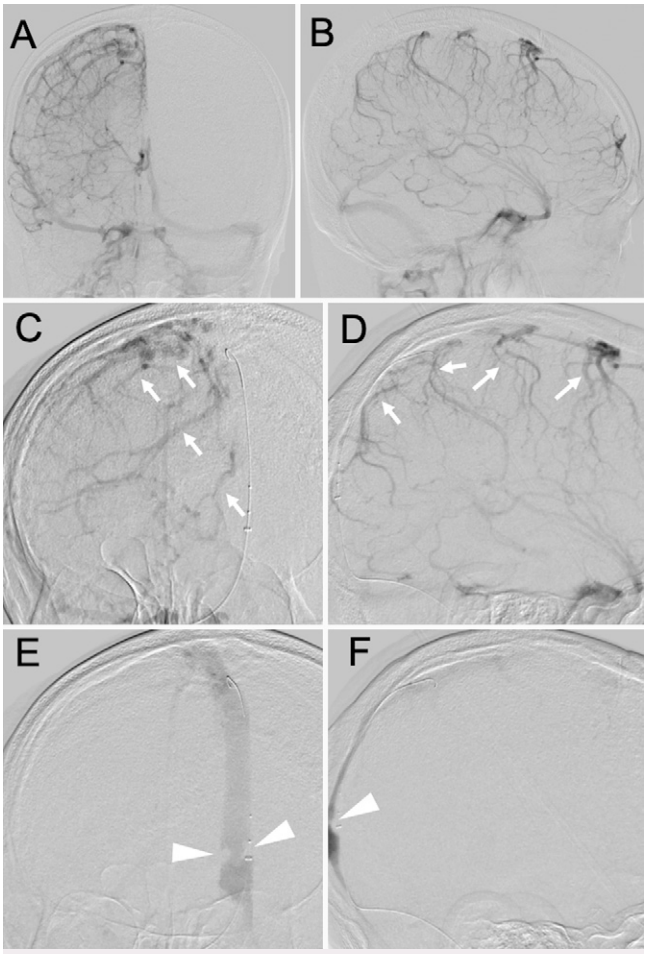

FIG. 2. Right carotid injection before endovascular treatment showing occlusion of the SSS, right TS, and SS in the venous phase, anteroposterior (**A**) and lateral (**B**) views. Right carotid injection after the sixth pass of the stent and the aspiration catheter, demonstrating stagnant venous flow in the right cortical vein in the middle venous phase (*arrows*), anteroposterior (**C**) and lateral (**D**) views, and showing contrast pooling in the SSS with the defect of contrast in the posterior SSS in the late venous phase (*arrowheads*), anteroposterior (**E**) and lateral (**F**) views.

microcatheter (Stryker Neurovascular), and a CHIKAI 18 micro-guidewire (Asahi Intecc Co., Ltd.) were advanced through the guiding sheath as a triaxial system to reach the anterior SSS. After confirming the anterior edge of the thrombus by microangiography, the stent retriever was deployed in the distal part of the thrombus and retrieved into the EMBOVAC aspiration catheter under continuous aspiration with a 60-ml VacLok syringe (Merit Medical Systems). After a total of six passes of the stent retrievers (three passes of Trevo NXT 6 × 37 mm (Stryker Neurovascular) and three passes of a Solitaire 6 × 40 mm (Medtronic), the SSS was partially recanalized, with stagnant flow in the parietal cortical vein (Fig. 2C and D) and the posterior SSS (Fig. 2E and F). During the mechanical thrombectomy procedures, most thrombus was retrieved after the first and second passes, and the flow in the cortical veins and SSS did not improve after the third to sixth passes. Therefore, we speculated that the inflammation-driven sticky thrombus on the wall of the SSS could not be easily captured or extracted by the stents smaller

than the inner diameter of the SSS. Thus, a large compliant balloon catheter, Transform 7 × 7 mm (Stryker Neurovascular) was advanced through the aspiration catheter over the CHIKAI black/14 (Asahi Intecc) and inflated to the diameter of the SSS at 7.6 mm with 0.4 ml of 50% contrast and saline solution. Thereafter, the balloon catheter was moved back and forth along the posterior SSS with continuous aspiration, which is the so-called dental floss technique.[7] However, the balloon glided along the lesion by being pushed away from the contrast pooling, and thus contrast pooling in the SSS remained evident even after the procedure (Fig. 3A). Based on these findings, it was thought that the shaft of the balloon catheter was too flexible to drag the thrombus out. Then, to restrict the movement of the shaft of the balloon catheter, an EMBOVAC aspiration catheter was advanced until it reached the proximal marker of the balloon, and the inflated balloon catheter and the aspiration catheter were fixed and slowly pulled from the anterior SSS toward the posterior SSS with continuous aspiration. During this maneuver, the balloon dislodged the contrast pooling like a dragnet without sliding on the lesion (Fig. 3B). After two sets of this maneuver, successful recanalization was achieved (Fig. 3C and D). The large amount of thrombus retrieved after the procedure is shown in Fig. 3E. A recanalization procedure along the right TS-SS was not attempted since the venous drainage system of the posterior fossa was not impaired on the venous phase of the left vertebral artery. The step-by-step procedure can be seen in Video 1. Systemic heparinization was continued for 2 days after the thrombectomy, and the patient was then switched to a direct oral anticoagulant. The patient recovered from severe headache on postoperative day 2. He was discharged home 7 days after the endovascular treatment with a modified Rankin scale score of 0. Follow-up magnetic resonance venography obtained 3 months after surgery showed good patency of the SSS (Fig. 3F), and the patient has been free of neurological symptoms for 6 months after the thrombectomy.

VIDEO 1. Clip showing the step-by-step procedure using a combination of stent retrievers and a large-bore aspiration catheter followed by dragging out residual thrombus on the wall of the SSS. Click here to view.

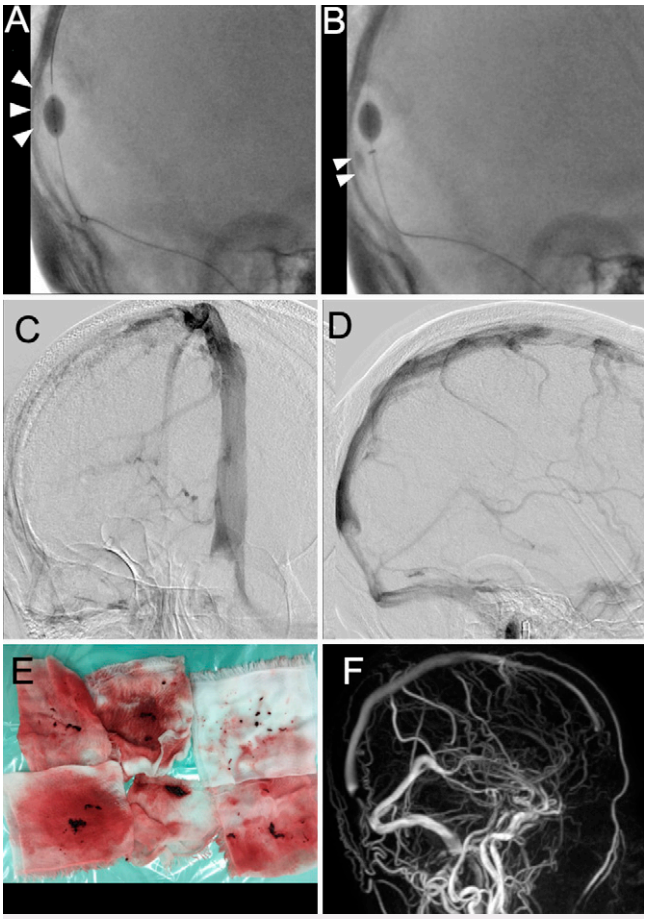

FIG. 3. Lateral unsubtracted angiogram demonstrating localization of the balloon to the pooled contrast. The balloon is pushed away from the contrast (*arrowheads*) when the balloon catheter is retrieved into the aspiration catheter (**A**). However, the balloon traces the route of the posterior wall of the SSS and drags the contrast proximally when the shaft of the balloon is stabilized with the aspiration catheter (*arrowheads*, **B**). Right carotid injection demonstrating successful recanalization of the SSS without stagnant flow of cortical veins, anteroposterior (**C**) and lateral (**D**) views. A large amount of the thrombus is obtained after the whole procedure (**E**). Magnetic resonance venography, lateral view, obtained 3 months after the procedure, showing the patent SSS (**F**).

Discussion

Observations

Based on the international study of CVST, approximately one-fifth of patients with CVST have morbidity or mortality due to congestion of the cortical or deep venous system.[8,9] In such cases, endovascular treatment could be suggested as a salvage treatment. In the present case, the SSS involving the entries of cortical veins was entirely occluded, resulting in venous circulation being significantly impaired. Therefore, the patient underwent endovascular treatment in conjunction with systemic anticoagulation.

Current techniques of endovascular treatment for CVST include direct catheter thrombolysis, mechanical thrombectomy, and a combination of both. In the present case, the patient underwent mechanical thrombectomy because direct catheter thrombolysis seemed to have little benefit to recanalize the SSS occluded with large thrombus burden with a higher risk of hemorrhagic complications, as described previously.[10–12] Various methods of mechanical thrombectomy have been reported, such as a stent retriever[3] or a large-bore aspiration catheter,[4] or a combination of the two devices.[5] Balloon angioplasty with or without stenting has also been attempted.[13,14] However, given the lack of evidence, the recommended method of mechanical thrombectomy for treatment of CVST remains unclear. Moreover, a recent randomized, controlled study showed that endovascular treatment with medical care did not improve angiographic and functional outcomes of patients with CVST compared to medical care alone.[8]

However, there might be several reasons why endovascular treatments did not appear to be superior to medical treatment. First, based on an anatomical study, the mean vertical and horizontal diameters at the level of the coronal suture were reported to be 5.3 ± 1.8 mm and 6.7 ± 1.6 mm.[15] Second, the pathophysiology of the CVST should be considered. The presence of an

inflammatory reaction on the wall of the venous sinus must affect thrombus characteristics, resulting in adherent thrombus in the sinus wall.[16] The maximum diameter of the stent retriever used for acute ischemic stroke is 6 mm. Moreover, even current large-bore aspiration catheters with distal inner and outer diameters of 1.80 and 2.06 to 2.17 mm designed for intracranial thrombectomy are much smaller compared to the diameter of the SSS.[17,18] Therefore, this device-sinus size mismatch might have led to just hollowing out the thrombus, leaving adherent thrombus on the sinus wall, resulting in incomplete recanalization. In fact, most of the thrombus was retrieved in the first and second passes, but only small fragments of thrombus were retrieved from the third to fifth passes in the present case. Moreover, despite partial restoration of flow in the SSS, cortical venous flow would remain impaired by residual thrombus on the sinus wall into which cortical veins drain.

To retrieve residual thrombus on the sinus wall, the devices should contact the sinus wall to extract the thrombus. In the present case, a relatively large balloon catheter, Transform SC 7 $\times$ 7 mm and a large-bore aspiration catheter were used as a coaxial system. Then, the venous sinus floss technique was performed by moving the inflated large balloon catheter back and forth as a separator to extract the thrombus with continuous aspiration.[6] However, since the balloon just slid down and was pushed away from the lesion due to the flexibility of the shaft of the balloon catheter, this attempt could not dislodge the contrast pooling, indicating that the thrombus was sticking on the sinus wall. Therefore, the aspiration catheter was advanced to cover the distal shaft of the balloon catheter to increase stiffness and to maintain the radial force toward the wall of the SSS, and the balloon and the aspiration catheter were slowly pulled to drag out the thrombus on the sinus wall, resulting in successful recanalization of the cortical veins and the SSS. Although a compliant balloon was used, a noncompliant balloon might also be used to drag out the thrombus in the sinus. However, if a long balloon catheter is used, the proximal part of the balloon should be advanced beyond the distal edge to the thrombus; otherwise, the balloon inflation might cause secondary migration of thrombus into cortical veins. Therefore, a relatively large and short balloon catheter is likely useful for the present purpose.

We should note the risk of pulmonary embolism using our technique, as well as any other combined techniques. Since the efficacy of the present technique should continue to be investigated and compared with that of existing techniques, further experience is needed.

Lessons

Inflammation-driven thrombus in the venous sinus is often resistant to endovascular treatment. Dragging the residual thrombus using a large balloon fixed with an aspiration catheter was effective option for achieving functional recanalization following unsuccessful mechanical thrombectomy for sinus thrombosis.

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18. React Catheter [package insert]. Japan, Medtronic; 2020.

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: Akamatsu, Kashimura, Ogasawara. Acquisition of data: Akamatsu, Kojima, Yoshida, Miyoshi, Kashimura. Drafting the article: Akamatsu, Kojima, Kashimura. Critically revising the article: Akamatsu, Kashimura, Ogasawara. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Akamatsu. Study supervision: Ogasawara.

Supplemental Information

Video

Video 1. https://vimeo.com/692260772.

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