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Utility of manual venous compression during transvenous Onyx injection for a scalp arteriovenous fistula: illustrative case

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BACKGROUND When performing transvenous liquid embolization for scalp arteriovenous fistulas, multiple networks of venous drainage could limit effective retrograde penetration of embolic agents into feeding arteries, resulting in incomplete obliteration. A salvage technique to achieve effective Onyx penetration with manual venous compression during transvenous embolization is demonstrated.

OBSERVATIONS A 43-year-old man presented with a progressively enlarging mass on his left temporal scalp that was first noticed approximately 20 years earlier. External carotid artery injection showed two scalp arteriovenous fistulas (AVFs). The patient received endovascular embolization. After successful transarterial obliteration of one AVF, transvenous Onyx embolization was performed for another AVF located in the subcutaneous layer. To avoid unnecessary Onyx migration into multiple venous networks, several coils were put in a venous pouch as a scaffold for the Onyx, and feeding arteries were temporarily occluded. Despite these adjunctive techniques, the Onyx migrated into multiple veins and even toward the orbit without complete fistula obliteration. Thereafter, Onyx was injected under manual compression of venous outlets from the pouch, resulting in complete obliteration.

LESSONS Manual compression of venous outlets can be used as a salvage procedure during transvenous Onyx embolization for a scalp AVF. A surgeon's radiation exposure can be reduced by step-by-step adjunctive procedures.

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KEYWORDS manual compression; scalp arteriovenous fistula; transvenous Onyx embolization

A scalp arteriovenous fistula (AVF) with a direct fistula between arteries and draining veins in subcutaneous tissues of the scalp is rare.[1,2] Because of the long and subcutaneous course of the superficial temporal artery (STA), scalp AVFs can occur following head trauma.[3–5] These lesions usually develop as a subcutaneous pulsatile swelling that can cause cosmetic, social, and psychological problems.[6] Treatments of scalp AVFs include resection, endovascular embolization, and resection following embolization.[7–10] In the current era, endovascular therapy has been performed as an upfront treatment or adjunct to surgical excision through transarterial access, transvenous access, or directly punctured access.[8–11] When attempting transarterial embolization for scalp AVFs fed by STAs, possible complications such as scalp necrosis and alopecia are a concern.[9] However, if accessible, transvenous embolization is preferable because retrograde embolization with liquid embolic agents carries a high chance of obliterating a fistulous pouch and a low risk of occluding feeding arteries supplying normal subcutaneous tissue. Although direct puncture is feasible in some cases with a single fistula and a relatively large venous pouch, it may be challenging to detect puncture sites that would be amenable to embolization in cases of diffuse and/or multiple fistulas.

Although transvenous liquid embolization has often been performed, the robust venous network in scalp tissue sometimes requires a large amount of liquid embolic agent to achieve complete obliteration, which may cause cosmetic problems. To avoid these

ABBREVIATIONS ADTA = anterior deep temporal artery; AVF = arteriovenous fistulas; ECA = external carotid artery; EJV = external jugular vein; MRA = magnetic resonance angiography; STA = superficial temporal artery.

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issues, multiple techniques have been reported to converge the liquid embolic agent in the fistulous pouch, including cookie cutter technique[12,13] and armored concrete technique.[14,15]

The case of a patient with a scalp AVF is presented here, along with a discussion of the efficacy of an adjunctive technique for converging Onyx in the fistulous pouch with manual venous compression during transvenous Onyx embolization.

Illustrative Case

A 43-year-old man with a history of head trauma 30 or more years earlier was referred from a local clinic for evaluation of tinnitus and a pulsatile mass on his left temporal scalp. The scalp mass was first noticed 20 years earlier and had progressively enlarged and become painful (Fig. 1A). Magnetic resonance angiography (MRA) demonstrated serpiginous vascular structures in the left temporal region (Fig. 1B), and axial source images showed the posterior lesion located in the subcutaneous layer and the anterior lesion buried in temporal muscle (Fig. 1C and D). Physical examination showed a pulsatile and soft tender mass in the temporal region anterosuperior to the patient's left ear (Fig. 1A). A diagnostic angiogram identified a saccular aneurysm at the left internal maxillary artery that measured approximately 15×12 mm^2 and two scalp AVFs anterosuperior to the ear (Fig. 2A). The arterial supply was by a highly tortuous STA and an anterior deep temporal artery (ADTA). The posterior AVF drained into a serpiginous superficial temporal vein, whereas the anterior AVF drained into a serpiginous deep temporal vein. Then, draining flow from both the superficial and deep temporal veins joined together into the external jugular vein (EJV), which had further reflux into the internal jugular vein (Fig. 2B and C). For embolization of the maxillary artery aneurysm and detailed analysis of the angioarchitecture of the AVF, a 6-Fr sheath was placed in the right femoral artery and a 6-Fr FUBUKI guiding catheter (Asahi Intech Co., Ltd.) was navigated into the left external carotid artery (ECA) via

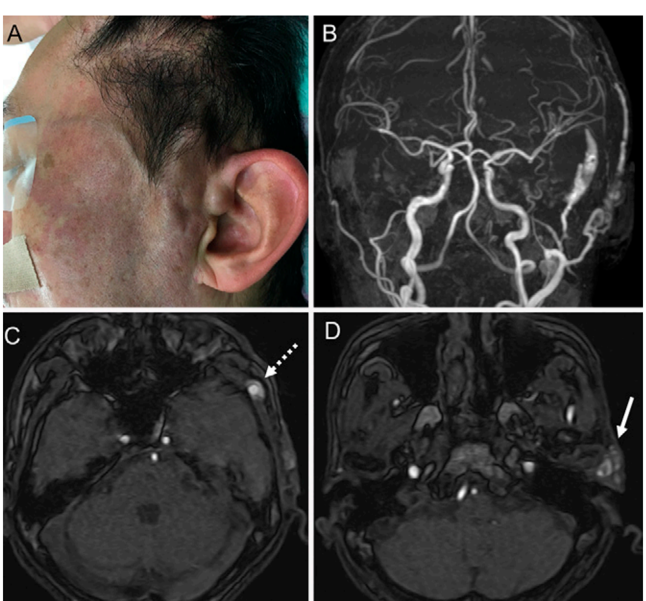

FIG. 1. A: A preoperative picture of the scalp lesion showing a pulsatile mass with reddish pigmentation. **B:** MRA demonstrating the angioarchitecture of the AVF fed by the ECA. **C and D:** Axial source images of MRA showing a hyperintense mass in the left temporal muscle (*dotted arrow*) and subcutaneous layer (*solid arrow*).

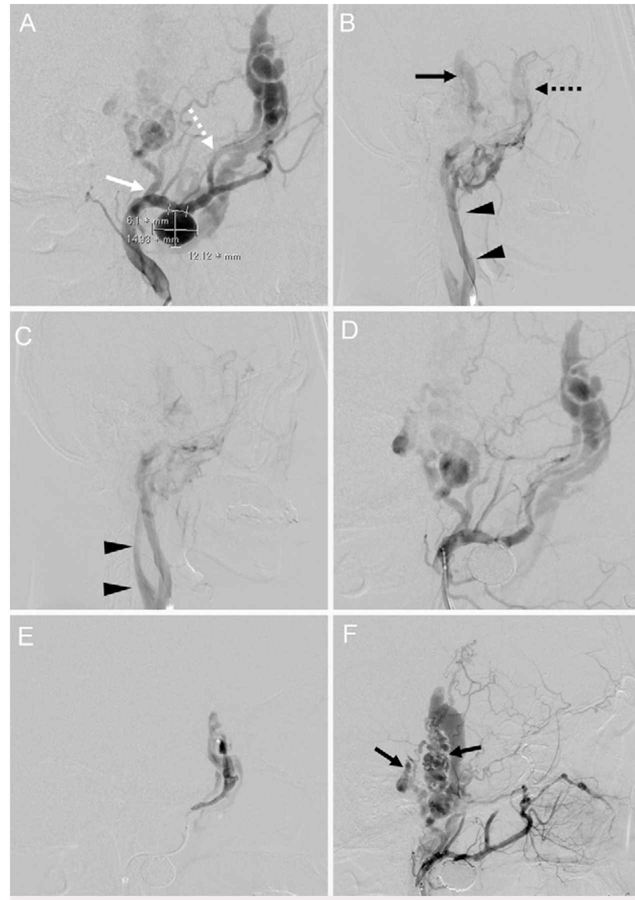

FIG. 2. A: Left ECA injection (lateral view) showing scalp AVFs and an internal maxillary artery aneurysm. The anterior AVF is fed by the ADTA (*white dotted arrow*). The posterior AVF is fed by the STA (*white solid arrow*). **B:** Early venous phase of the ECA injection demonstrating that a serpiginous deep temporal vein (*black dotted arrow*) and a superficial temporal vein (*black arrow*) join together in the EJV (*black arrowheads*). **C:** Note that retrograde flow into the internal jugular vein is observed in the late venous phase (*black arrowheads*). **D:** Left ECA injection following coil embolization of the internal maxillary artery aneurysm. **E:** Selective injection from the Scepter C balloon placed in the ADTA showing the anterior scalp AVF. **F:** Left ECA injection following Onyx embolization for the anterior scalp AVF showing complete obliteration of the fistula. Note that the residual scalp AVF is fed by multiple small branches of the tortuous STA (*black arrows*).

the right femoral artery. After coil embolization of the internal maxillary artery aneurysm (Fig. 2D), superselective injection from the ADTA was performed from an inflated Scepter C balloon (4×7, MicroVention, Terumo; Fig. 2E). Transarterial Onyx (Medtronic) embolization was performed using the pressure cooker technique,[16] resulting in complete fistula obliteration. ECA injection immediately after obliteration of the AVF fed by the ADTA demonstrated the other AVF fed by the highly tortuous STA and draining into a large venous pouch in the superficial temporal vein (Fig. 2F). After several unsuccessful attempts at distal microcatheter navigation into the STA, transarterial embolization of the fistula was attempted. Because transvenous access from the left EJV seemed more straightforward, it was decided to perform transvenous Onyx embolization for the residual AVF.

To avoid pulmonary embolism of the Onyx, an 8-Fr, 85-cm Flowgate balloon guiding catheter (Stryker Neurovascular) was navigated into the left EJV. An SL-10 microcatheter (Boston Scientific) and a 1.5-Fr Marathon microcatheter (Medtronic) were placed in the venous pouch. To avoid unnecessary diffusion of the Onyx cast, three i-ED ∞ ExtraSoft coils (Kaneka Medics) were deployed in the pouch as a scaffold for the Onyx cast (known as the armored concrete technique).[15] Before Onyx embolization, the left ECA was temporarily occluded with a Scepter C balloon to decrease the flow from the STA, which could compete with the Onyx injected from the venous pouch, and the balloon guiding catheter was inflated in the EJV to avoid pulmonary embolism of the Onyx (Fig. 3A). With these adjunctive techniques, Onyx 18 was continuously injected from the Marathon catheter. However, despite these techniques, the Onyx cast was diffused through the multiple subcutaneous venous networks and migrated closer to the orbit through the superficial temporal vein without obliterating the AVF (Fig. 3B). Therefore, the surgeon manually compressed the venous outlets from the pouch while wearing radioprotective gloves to restrict Onyx diffusion (Fig. 3C). With this technique, successful retrograde penetration of the Onyx into a feeding artery was achieved (Fig. 3D). Finally, the area was embolized with 2.02 mL of Onyx, resulting in complete obliteration of the AVF (Fig. 3E). The patient's postoperative course was uneventful, without cosmetic complications affecting the skin (Fig. 3F). The patient has been free from symptoms for 2 years after the intervention. The step-by-step procedure is shown in Video 1.

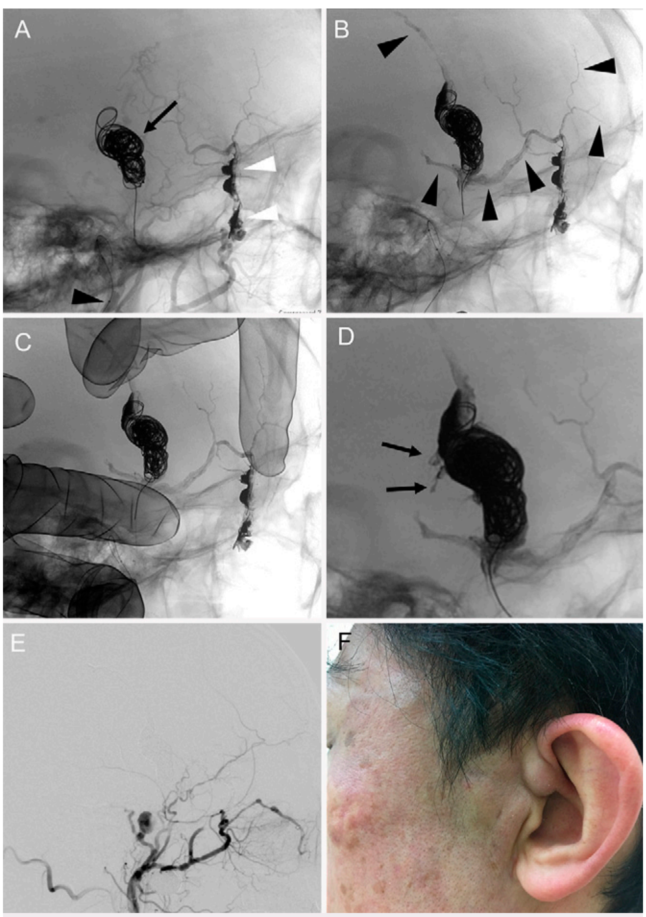

FIG. 3. A: Nonsubtracted image, lateral view, obtained before Onyx embolization for the posterior scalp AVF, demonstrating coils deployed in the pouch (*black arrow*), the inflated balloon in the STA (*black arrowhead*), and the Onyx cast in the ADTA (*white arrowheads*). **B:** The Onyx cast migrated into a venous network in the superficial temporal vein (*black arrowheads*). **C:** The nonsubtracted image showing a manual compression maneuver. Note that venous outlets are manually compressed by the surgeon wearing radioprotective gloves. **D:** Nonsubtracted image after the embolization showing the Onyx cast penetrating into feeding arteries (*black arrows*). **E:** Postoperative left ECA injection showing complete obliteration of the fistula. **F:** A photograph obtained 1 year after the embolization, showing no cosmetic problems.

VIDEO 1. Clip showing the step-by-step procedure of venous outlet compression technique during transvenous Onyx embolization. Click here to view.

Discussion

Observations

In the current endovascular era, endovascular treatment is increasingly used for scalp AVFs. However, complete obliteration of scalp AVFs is challenging even with different endovascular approaches, including transarterial, transvenous, and direct puncture embolization.[17–19] Although transarterial embolization has been reported as a simple and safe method over the past few decades,[9,20] tortuous feeding arteries impede distal catheterization, resulting in incomplete occlusion of the AVFs. Furthermore, despite distal catheterization, reflux of the liquid embolic agent into scalp arteries can cause skin ischemia and hair loss. Therefore, transarterial liquid embolization has been performed in limited cases that permit deep cannulation into proper feeders.[21] In the present case, because one of the AVFs was fed by a relatively straight ADTA that did not perfuse into the scalp but into the temporal muscle, successful obliteration of the fistula was achieved with Onyx embolization using the pressure cooker technique.[16]

Direct puncture embolization with a liquid embolic agent is also an effective technique for preoperative embolization of scalp AVFs.[17,22,23] When performing direct puncture embolization, the injection needle or catheter should ideally be placed in a dilated venous pouch next to the fistula for complete fistula obliteration. However, accurate placement of the needle tip in the target is difficult, especially when the pouch cannot be separated from the other vascular structures.[24] In the present case, because of close localization of the feeding arteries and the venous pouch, the direct puncture technique was not attempted.

Transvenous liquid embolization is a feasible alternative leading to retrograde occlusion of a fistulous pouch and even feeding arteries, with preserved arteries supplying normal scalp. However, because liquid embolic agents can easily migrate into low-resistance, dilated draining veins during liquid injection, Onyx migration into a nontarget drainage system, such as orbital, intracranial, and pulmonary veins, is a major issue. Various adjunctive techniques of transvenous liquid embolization have been reported to prevent unintended venous occlusion. Dalyai et al. reported combined use of a liquid embolic agent with temporary balloon occlusion of the external jugular vein to prevent pulmonary embolism.[2] Wei et al. demonstrated armored concrete technique using a combination of coils and Onyx to avoid diffusion of the Onyx from a fistulous pouch.[15] Furthermore, other groups reported the use of cookie-cutter or other implements that encircle the lesion to trap the embolic agent within the fistula when performing direct puncture technique.[12,24] In the present case, the Onyx migrated toward the orbital veins even under both of the above techniques and flow control of the feeding artery. Therefore, venous outlets from the fistula were manually compressed to prevent further reflux into the distal venous circulation during Onyx injection, resulting in successful obliteration of the fistula.

Transvenous embolization with the present strategy for scalp AVFs has several advantages. First, manual compression can be applied for any scalp structure, although consistent pressure over the heterogeneous scalp structure may not be effectively achieved using existing implements. Second, although circumferential implements would lead to inadvertent damage of the catheters encircled in the implements, that complication can be easily avoided by the manual compression technique. Third, although both the manual compression technique and the cookie cutter technique carry the risk of radiation exposure to the surgeon's arm, the risk can be reduced by limited use of the present compression technique when a combination of arterial flow control, balloon protection of the external jugular vein, and coil framework has failed.

Lessons

Manual compression of venous outlets was an effective salvage procedure during transvenous Onyx embolization for a scalp AVF. A step-by-step endovascular procedure should also be considered to reduce the surgeon's radiation exposure.

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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: Akamatsu, Kojima. Acquisition of data: Akamatsu, Kojima, Fujimoto, Oikawa, Kashimura. Analysis and interpretation of data: Akamatsu, Kojima, Oikawa, Kubo. Drafting the article: Akamatsu, Kojima, Kubo. Critically revising the article: Akamatsu, Kojima, Kubo, Ogasawara. Reviewed submitted version of manuscript: Akamatsu, Kubo. Approved the final version of the manuscript on behalf of all authors: Akamatsu. Administrative/technical/material support: Kojima. Study supervision: Ogasawara.

Supplemental Information

Video

Video 1. https://vimeo.com/752135938.

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