Online March 19, 2024
Journal of Neuroendovascular Therapy 2024; 18: 142–148
DOI: 10.5797/jnet.tn.2023-0094

Technical Note

Dural Arteriovenous Fistula Treated with Transvenous Embolization via the Upper Limb Cutaneous Vein

Toshinari Meguro, Yuma Tada, Miki Taniguchi, Shuji Hamauchi, Toru Fukuhara, Yasuyuki Miyoshi, and Sigeki Ono

Objective: In recent years, the transradial artery approach has gained prominence and is increasingly employed in neurovascular angiography and therapy due to its safety, reduced complications, and minimal invasiveness. While various venous approaches, including the conventional transfemoral vein approach, exist for procedures such as transvenous embolization, recent reports have highlighted methods involving upper extremity cutaneous veins. However, the practicality and efficacy of these approaches remain unclear.
Case Presentations: This study presents our experience with three cases of dural arteriovenous fistulas, where transvenous embolization was performed via upper limb cutaneous veins. In all instances, the arteriovenous approach was successfully executed using a single upper extremity, leading to the successful completion of treatment.
Conclusion: This technique demonstrates significant advantages, not only in terms of its minimal invasiveness but also due to its simplicity and safety. Anticipating broader acceptance in the future, this approach offers a promising avenue for further exploration in neurovascular interventions.

Keywords transvenous embolization, upper limb cutaneous vein, dural arteriovenous fistula, single arm neurointervention

Introduction

In neuroendovascular intervention, the transradial artery approach, involving arterial access from the upper extremity, has garnered recent attention for its potential to reduce complications at the puncture site and its minimally invasive nature.[1,2] Moreover, there is a growing body of literature on the distal radial artery approach and is considered even more minimally invasive.[3] Conversely, in transvenous embolization (TVE), exemplified by dural arteriovenous fistula (dAVF), as well as in vein sampling for pituitary hormones, venous sinus pressure measurement for idiopathic intracranial hypertension, and stent placement in narrowed venous sinuses, conventional methods have traditionally involved femoral vein or direct internal jugular vein puncture.

However, in recent years, driven by the pursuit of minimally invasive treatments, there has been increasing interest in a transvenous approach that involves puncturing the cutaneous veins of the upper limbs (e.g., cubital vein, cephalic vein, basilic vein, etc.).[4] At our hospital, we have recently implemented TVE for dAVF via the cutaneous veins of the upper limb. Arteriography is also performed by puncturing the same upper limb, a technique known as single-arm arteriovenous approach,[5–9] and has been successfully applied in three cases, demonstrating its effectiveness.

Compared to the traditional puncture of the femoral vein or direct internal jugular vein, puncturing the upper limb cutaneous vein is less invasive for patients. This approach proves particularly beneficial for obese patients, minimizing complications at the puncture site, and for women of reproductive age, mitigating pelvic radiation exposure during X-ray fluoroscopy. This potential reduction in complications and radiation exposure enhances the overall usefulness of this approach. In this paper, we present

Department of Neurosurgery 2, Kawasaki Medical School, Okayama, Okayama, Japan

Received: December 11, 2023; Accepted: February 11, 2024
Corresponding author: Toshinari Meguro. Department of Neurosurgery 2, Kawasaki Medical School, 2-6-1, Nakasange, Kita-ku, Okayama, Okayama 700-8505, Japan
Email: tmeguron@hotmail.com

our experience with three cases, focusing on the utility and safety of TVE via the upper limb cutaneous vein. Our findings underscore the effective and safe application of this treatment, supported by existing literature. We believe that this method introduces a promising new option for selecting access methods in future neuroendovascular interventions.

Case Presentations

Case selection

This study encompassed three consecutive patients who underwent TVE for dAVF at our hospital between 2022 and 2023. While conventional femoral vein or direct internal jugular vein puncture was considered feasible for the targeted patients, the choice of upper limb cutaneous vein puncture as the access site was at the discretion of the surgeon.

Procedure

Transvenous embolization of dAVF was conducted under general anesthesia. Initially, we verified the suitability of the puncturable skin vein in the patient's right upper extremity. The choice of the skin vein for puncture in the patient's right upper extremity was determined by assessing its size and straightness. To facilitate this, the use of a tourniquet helped identify an appropriate cutaneous vein. We aimed for a vein that was not only sufficiently large for puncture but also straight, allowing for easier navigation of the catheter. Subsequently, a cutaneous vein was punctured, and either a 6Fr. or 4Fr. short sheath was inserted. Simultaneously, a 4Fr. sheath was positioned in the (distal) radial or brachial artery of the right upper limb. For the purpose of diagnostic arteriography, a Simmons catheter was guided through the 4 Fr. arterial sheath into the left or right common carotid artery.

In cases where a 6Fr. sheath was positioned in a cutaneous vein of the upper limb, a 6Fr. guiding catheter was used coaxially with a 4Fr. Simmons catheter, as well as the guiding catheter, was guided into the internal jugular vein with a 0.035" guide wire in front. For instances with a 4Fr. sheath, the 0.035" guide wire was directed to the right subclavian vein. Using an exchange method, the 6Fr. guiding sheath was advanced to the right subclavian vein. A 4Fr. Simmons catheter was then coaxially placed with the 0.035" guide wire, and the 6Fr. guiding sheath was guided into the internal jugular vein. Although a Simmons catheter was used as the inner catheter in all three cases, it is important to note that, in practice, the left and right internal jugular veins could be selected using only a 0.035" guide wire without forming the tip of the Simmons catheter. By advancing the guiding catheter (sheath) into the internal jugular vein, transvenous embolization was carried out.

The bleeding at the puncture site was manually stopped by applying pressure for 10–15 minutes.

Case 1

Patient: 78-year-old male. *Chief complaint*: consciousness disorder, language disorder. *Progress*: The patient collapsed at home and came to the hospital in a JCS II-10 condition. He was unresponsive to verbal commands and had difficulty speaking. Mild right hemiparesis was observed. Head CT revealed a subcortical hemorrhage in the left frontotemporal lobe. MRA/DSA confirmed a dAVF (Borden Type I, Congnard Type IIb) in the left transverse-sigmoid sinus (**Fig. 1A**), and the diagnosis was made.

Treatment: A 6Fr. long sheath was inserted into the right cubital skin vein, and a 4Fr. sheath was inserted into the right brachial artery (**Fig. 1B**). A 4Fr. Simmons catheter was guided into the left common carotid artery, and preparations were made for diagnostic imaging. A 6Fr. ASAHI FUBUKI guiding catheter (ASAHI INTECC, Aichi, Japan) was advanced from the 6Fr. venous sheath with a 4Fr. Simmons catheter/0.035" Radiofocus Guidewire M (Terumo, Tokyo, Japan) coaxially placed, and it was easily guided into the left internal jugular vein (**Fig. 1C**). An Excelsior 1018 microcatheter (Stryker, Kalamazoo, MI, USA) was used to embolize detachable coils up to the sigmoid sinus, and the artery vein (AV) shunt completely disappeared (**Fig. 1D**). The guiding catheter did not move during the treatment and remained stable. The surgical time was 3 hours and 45 minutes.

Postoperative course: Consciousness disorder and right paresis improved. The patient was discharged home alone with only mild aphasia.

Case 2

Patient: 74-year-old female.
Chief complaint: right orbital pain and diplopia.
Progress: The patient noticed right orbital pain and diplopia and was referred to our hospital after a nearby ophthalmology clinic pointed out right abducens nerve palsy. CCF was suspected by MRI, and DSA was performed. She was diagnosed with a right cavernous sinus dAVF (**Fig. 2A**) and underwent TVE.

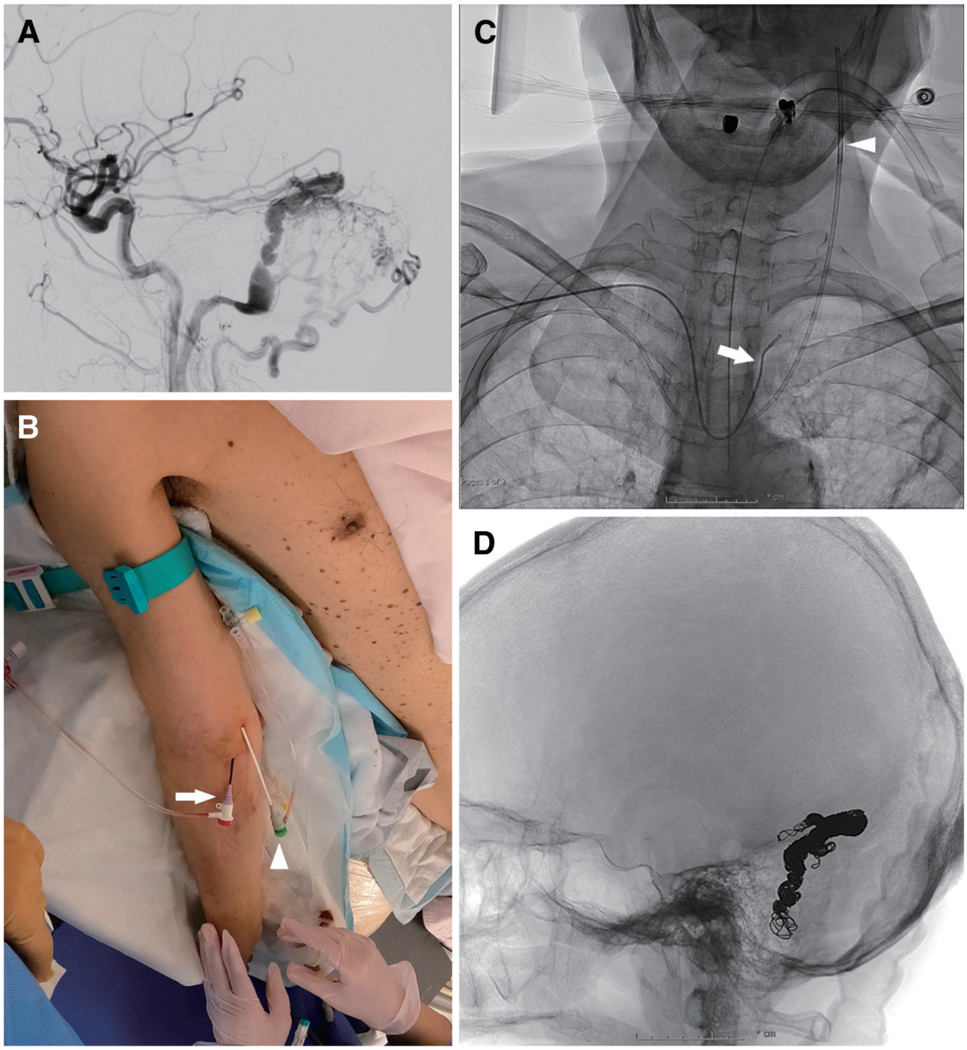

Fig. 1 Case 1. (**A**) Left common carotid angiography showing a dural arteriovenous fistula in the left transverse-sigmoid sinus. (**B**) Right brachial artery access using a 4Fr. sheath (arrow) and cubital venous access using a 6Fr. sheath (arrowhead). (**C**) 4Fr. Simmons catheter (arrow) within the left common carotid artery for angiographic runs and a 6Fr. guiding catheter (arrowhead) within the left internal jugular vein. (**D**) The shunt segment of the transverse-sigmoid sinus is completely embolized with coils.

Treatment: A 4Fr. sheath was inserted into the right distal radial artery, a 4Fr. Simmons catheter was advanced into the right common carotid artery, and diagnostic imaging was prepared. A 4Fr. sheath was inserted into the cephalic vein of the right forearm, a Radiofocus guide wire was advanced into the right subclavian vein, and a 6Fr. ASAHI FUBUKI guiding sheath (ASAHI INTECC) was advanced using an exchange method (**Fig. 2B**). When the 4Fr. Simmons catheter was placed coaxially with the 0.035” Radifocus guidewire in front, the guidewire easily advanced to the right internal jugular vein, and the guiding sheath was able to be stably guided to the right internal jugular vein (**Fig. 2C**). A double microcatheters (Excelsior1018 and Phenom17; Medtronic, Minneapolis, MN, USA) was advanced into the right cavernous sinus, and the right cavernous sinus was sinus packed with detachable coils, and the AV shunt completely disappeared (**Fig. 2D**). The guiding sheath remained stable without movement during treatment. The surgical time was 4 hours and 50 minutes.

Postoperative course: After TVE, orbital pain disappeared, but right abducens nerve palsy remained.

Case 3

Patient: 78-year-old male.
Chief complaint: Convulsions, impaired consciousness.
Progress: The patient developed a seizure and was rushed to our hospital. At the time of admission, the seizures had

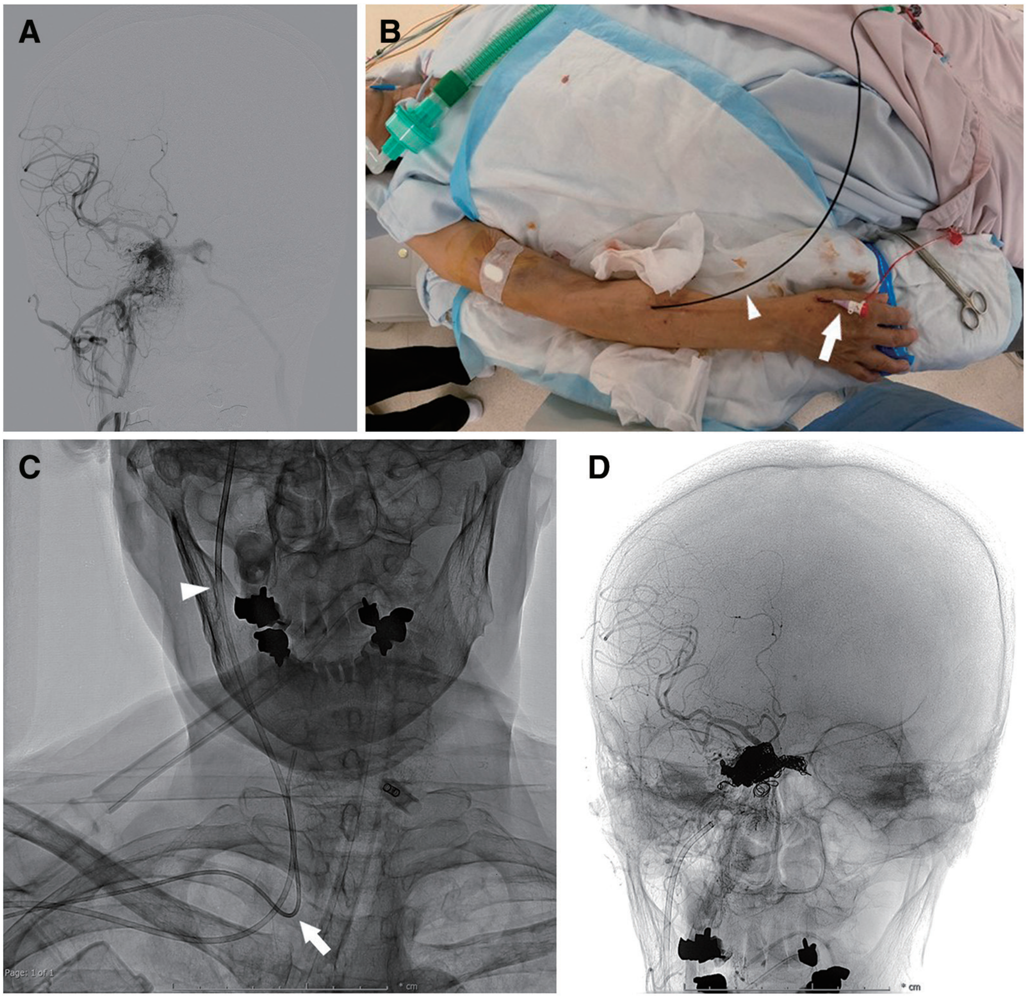

Fig. 2 Case 2. (**A**) Right common carotid angiography showing a dural arteriovenous fistula in the right cavernous sinus. (**B**) Right distal radial artery access using a 4Fr. sheath (arrow) and cephalic venous access using a 6Fr. guiding sheath (arrowhead). (**C**) 4Fr. Simmons catheter (arrow) within the right common carotid artery for angiographic runs and a 6Fr. guiding catheter (arrowhead) within the right internal jugular vein. (**D**) The shunt segment of the cavernous sinus is completely embolized with coils.

stopped, and the patient was in a JCS II-20 state of consciousness. Brain MRI revealed multiple microbleeds in the left temporo-occipital lobe. MRA showed dilatation and abnormal blood vessels in the left occipital artery, and DSA showed a dAVF (Borden Type II, Cognard Type IIa+b) in the left transverse-sigmoid sinus (**Fig. 3A**), and based on this diagnosis, TVE was conducted.

Treatment: A 4Fr. sheath was inserted into the right radial artery. A 4Fr. Simmons catheter was advanced into the left common carotid artery in preparation for diagnostic imaging. A 4Fr. sheath was inserted into the right cubital vein. The Radifocus Guidewire was advanced into the subclavian vein and a 6Fr. ASAHI FUBUKI guiding sheath was advanced using the replacement method (**Fig. 3B**). When the 4Fr. Simmons catheter was placed coaxially and the 0.035” Radifocus guidewire was advanced, the guidewire easily advanced into the left internal jugular vein, and the guiding sheath could be stably guided into the left internal jugular vein (**Fig. 3C**). However, the microcatheter could not be guided to the lesion from the left internal jugular vein. The guiding sheath was returned to the right subclavian vein, advanced to the right internal jugular vein with the 0.035” Radifocus guidewire in front, and the guiding sheath was placed in the right internal jugular vein (**Fig. 3D**). A 4.2Fr. ASAHI FUBUKI intermediate catheter (ASAHI INTECC) was advanced to the left transverse sinus beyond the midline, and a Headway DUO microcatheter (MicroVention, Aliso Viejo, CA, USA) was guided to the lesion and detachable coil embolization was performed (**Fig. 3E**), resulting in complete disappearance of the AV

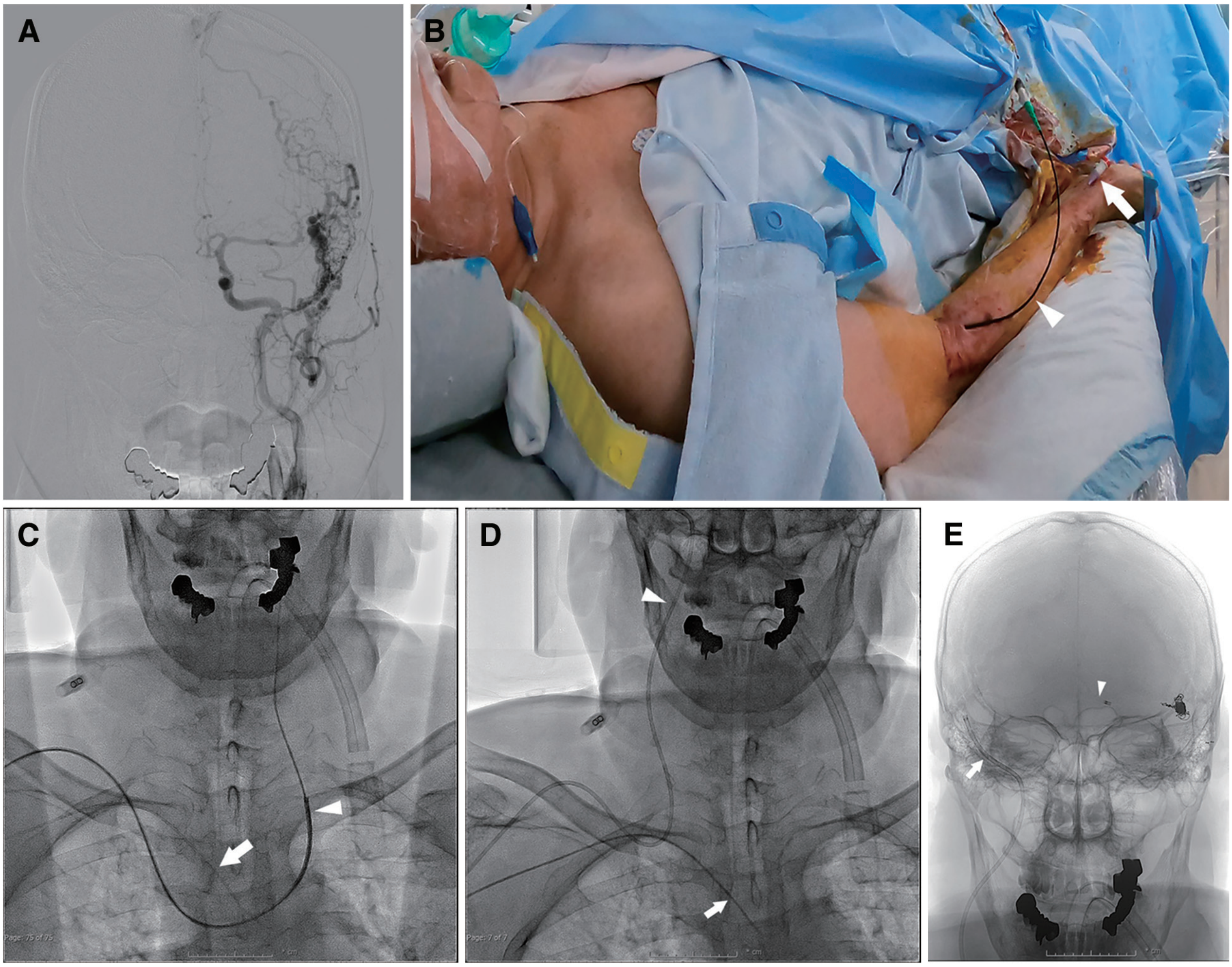

Fig. 3 Case 3. (**A**) Left common carotid angiography showing a dural arteriovenous fistula in the left transverse-sigmoid sinus. (**B**) Right radial artery access using a 4Fr. sheath (arrow) and cubital venous access using a 6Fr. guiding sheath (arrowhead). (**C**) Catheterization of the 6Fr. guiding sheath (arrowhead) to the left internal jugular vein with Simons catheter/guidewire and a 4Fr. Simmons catheter (arrow) within the left common carotid artery for angiographic runs. (**D**) 4Fr. Simmons catheter (arrow) within the right common carotid artery and a 6Fr. guiding sheath (arrowhead) within the right internal jugular vein. (**E**). 6Fr. guiding sheath (arrow) and 4.2Fr. intermediate catheter (arrowhead) within the left transverse sinus over the confluence. The shunt segment of the left transverse-sigmoid sinus is completely embolized with coils.

shunt. The guide wire was guided into the left and right internal jugular veins, and the guiding sheath remained stable without movement during the treatment. The surgical time was 4 hours and 20 minutes.

Postoperative course: Postoperatively, the patient was discharged home on his own with mild aphasia.

Discussion

One of the advantages of cerebrovascular and endovascular treatment is that it is a minimally invasive treatment, and the treatment approaches are progressing year-on-year. In the past, femoral artery puncture was common as an access route to cerebral arteries, but recently radial artery puncture has been attracting attention from the viewpoint of minimal invasiveness and avoidance of complications.[1,2] This is because the use of radial artery puncture may particularly reduce the risk of puncture site trouble and bleeding complications. Furthermore, from the viewpoint of catheter access, the radial artery approach may be easier to guide the catheter to the lesion site due to the patient's unique blood vessel shape. This is progressing towards reducing the burden on patients by shortening treatment time and reducing complications.

In recent years, as arterial approaches have become less invasive, venous approaches in neuroendovascular treatment using skin vein puncture in the upper extremity have been attracting attention.[4] The reason for this is that TVE is generally performed by femoral vein puncture or direct puncture of the internal jugular vein, but the following complications have been reported, although rare. These include accidental arterial puncture, arrhythmia, right atrial rupture, thromboembolism, arteriovenous fistula, and puncture site infection. Catheter access from the upper extremity does not require fluoroscopy of the pelvic area, so it is considered to be highly useful for women of reproductive age. In addition, since the upper limb skin veins cover a wide range of areas, including the upper arm, elbow, and forearm, it is possible to search for and select the thickest and easiest to puncture veins closest to the trunk of the body. We believe that it is possible to guide a guiding catheter to any part of the upper extremity as long as there is a certain diameter of the blood vessel, but if it cannot be found, it may be one kind of idea to search for it using echography and consider puncturing it using echo guidance. After treatment, the punctured vein is usually compressed manually to stop the bleeding. Compression of the upper extremity veins is easier than compression after femoral vein puncture or direct puncture of the internal jugular vein, so serious complications are thought to be less likely to occur.

Regarding guiding the catheter to the internal jugular vein, it has been reported that the catheter can basically be guided from the upper limb skin vein to the left and right internal jugular veins without any problems.[4–9] In our cases, by first advancing the guide wire into the left and right internal jugular veins and following it with the guiding catheter, we were able to easily guide it to the left and right internal jugular veins in a short time. Although we have only experienced 3 cases so far, we believe that this method often allows the guiding catheter to be advanced to the left and right internal jugular veins. The right internal jugular vein may have an acute branch angle with the right subclavian vein, and in this case it may not be possible to advance the guide wire directly into the right internal jugular vein. In this case, it is necessary to form the tip of the coaxial Simmons catheter in the superior vena cava, pull the catheter back into the internal jugular vein, and advance the guide wire. Memon et al.[7] described in detail a method for forming the Simmons shape in the superior vena cava, and the authors think that this is important knowledge to know.

There is a report summarizing 147 cases from 13 institutions regarding the venous approach for endovascular treatment of the brain from the upper extremity skin vein.[4] According to this, in 5 of 147 cases (3.4%), treatment could not be completed with the upper extremity cutaneous vein approach, so the patients were changed to the transfemoral vein approach. The reasons for the change in 5 cases were that an appropriate vein could not be found in the upper extremity, failure to puncture the cephalic vein, incorrect puncture of the brachial artery, kinking/occlusion of the catheter, and inability to access the left internal jugular vein due to chronic occlusion of the right brachiocephalic vein. There were two minor complications (1.4%), including a case of accidental puncture of the brachial artery and a case of thrombophlebitis that required antibiotics and anticoagulant therapy; however, in this case, the IV line was used as a puncture access.

Based on this report, cases deemed inappropriate for a venous approach from the upper extremity include situations where a suitable vein for sheath insertion cannot be found or cases where the vein is occluded or too curved to guide the guiding catheter. Even if the catheter is successfully guided, the intervention cannot be completed if the vein becomes too tortuous, leading to catheter kinking or occlusion. However, we believe that predicting in advance whether an approach from the upper limb is appropriate remains challenging.

In the three cases of TVE for dAVF that we performed, no instability, such as falling out during treatment, was observed after the guiding catheter was placed in the internal jugular vein. In the report by Abecassis et al.,[4] once the catheter was guided to the target internal jugular vein, there were no problems, such as instability of the guiding catheter that prevented the completion of the treatment. We believe direct puncture of the internal jugular vein to guide the guiding catheter is the most stable method, and we believe its stability is comparable to the femoral vein approach.

In this study, we performed embolization using a venous approach from the cutaneous vein of the right upper limb and performed image diagnosis using an arterial approach in the same upper limb. This attempt to approach the artery and vein simultaneously using only one upper limb has already been reported as a common procedure in cardiac intervention,[10] and several cases have been reported in neuroendovascular treatment in recent years.[5–9] These reports also suggest that a unified approach from the upper extremity may make the treatment less invasive, reduce the risk of complications at the puncture site, and improve the safety of the treatment. This was considered one of the main options for future approaches to neurointervention.

Conclusion

We experienced a case in which the TVE of a dAVF was performed by puncturing a cutaneous vein in the upper extremity. At the same time, arterial diagnostic imaging was performed from the ipsilateral upper limb, resulting in a single upper limb treatment approach.

A stable guiding catheter could be easily placed in the internal jugular vein using an approach from the upper limb cutaneous vein, and the treatment could be completed. The approach from the upper extremity cutaneous vein is less invasive than femoral vein/internal jugular vein puncture, and we believe that it will be used more often in the transvenous approach of neurointervention in the future.

Disclosure Statement

The authors declare that they have no conflicts of interest.

References

1) Hanaoka Y, Koyama J-I, Yamazaki D, et al. Transradial approach as the primary vascular access with a 6-Fr Simmons Guiding Sheath for anterior circulation interventions: a single-center case series of 130 consecutive patients. *World Neurosurg* 2020; 138: e597–e606.
2) Joshi KC, Beer-Furlan A, Crowley RW, et al. Transradial approach for neurointerventions: a systematic review of the literature. *J Neurointerv Surg* 2020; 12: 886–892.
3) Hoffman H, Jalal MS, Masoud HE, et al. Distal transradial access for diagnostic cerebral angiography and neurointervention: systematic review and meta-analysis. *AJNR Am J Neuroradiol* 2021; 42: 888–895.
4) Abecassis IJ, Saini V, Phillips TJ, et al. Upper extremity transvenous access for neuroendovascular procedures: an international multicenter case series. *J Neurointerv Surg* 2021; 13: 357–362.
5) Ramos AD, Sundararajan S, Santillan A, et al. Single arm access venous sinus stenting (SAVeS) technique: technical note. *Interv Neuroradiol* 2020; 26: 501–505.
6) Galvan Fernandez J, Martínez-Galdámez M, Schüller Arteaga M, et al. Arm-only access for combined transarterial and transvenous neurointerventional procedures. *J Neurointerv Surg* 2021; 13: 39–41.
7) Memon MZ, Nisar T, Gupta G, et al. Single arm access for combined transarterial and transvenous neurointerventional procedures. *World Neurosurg* 2021; 150: 121–126.
8) Babici D, Johansen PM, Carranza O, et al. Combined transradial and upper extremity transvenous accesses in the treatment of carotid-cavernous fistulae: two case reports and a literature review. *Cureus* 2022; 14: e24094.
9) Tan WN, Rajadurai A, Balakrishnan D. Endovascular treatment of cavernous sinus dural arteriovenous fistula via radial artery and median cubital vein. *Neurointervention* 2021; 16: 194–198.
10) Lo TS, Buch AN, Hall IR, et al. Percutaneous left and right heart catheterization in fully anticoagulated patients utilizing the radial artery and forearm vein: a two-center experience. *J Interv Cardiol* 2006; 19: 258–263.