ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.surgicalneurologyint.com

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Neurovascular

Editor
Kazuhiro Hongo, MD
Shinshu University, Matsumoto, Japan

SNI
Open Access

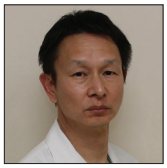
Case Report

Ultrasound localization of embolic material to guide resection of brain AVM: Report of two cases

Shigeomi Yokoya[1], Hidesato Takezawa[2], Yukihiro Hidaka[2], Gaku Fujiwara[1], Hideki Oka[1]

Departments of [1]Neurosurgery, [2]Neurology, Saiseikai Shiga Hospital, Imperial Gift Foundation Inc., Ritto, Shiga, Japan.

E-mail: *Shigeomi Yokoya - yokoya@ks.kyorin-u.ac.jp; Hidesato Takezawa - takezawa.kyoto@gmail.com; Yukihiro Hidaka - yuki.hidaka0426@gmail.com; Gaku Fujiwara - gakufujiwara@hotmail.com; Hideki Oka - hidekiokajp@yahoo.co.jp



***Corresponding author:**
Shigeomi Yokoya,
Department of Neurosurgery,
Saiseikai Shiga Hospital,
Imperial Gift Foundation Inc.,
Ritto, Shiga, Japan.

yokoya@ks.kyorin-u.ac.jp

Received : 18 March 2023
Accepted : 08 April 2023
Published : 21 April 2023

DOI
10.25259/SNI_242_2023

Quick Response Code:

ABSTRACT

Background: The Spetzler–Martin Grade (SMG) is widely used to evaluate the risk of resection of cerebral arteriovenous malformation (AVM), and direct surgery is strongly recommended for low SMG lesions. Micro-AVMs are defined as AVMs with a nidus <1 cm in diameter, and sometimes, the challenge is identifying the exact lesion site during AVM resection, although identification of the site is very important in the procedure. Here, we present two cases in which the sites of micro-AVM were marked using presurgical embolization and easily confirmed by intraoperative ultrasonography (IUS) and discuss the benefits of IUS in combination with presurgical embolization for low-grade micro-AVM.

Case Description: (Patient 1) A 30-year-old man was brought to our hospital and diagnosed with a micro-AVM, which was classified as SMG II AVM. He underwent evacuation of the intracerebral hematoma and subsequently underwent AVM resection. However, the lesion was not identified because it was not exposed in the cerebral cortex although we searched for the lesion. Therefore, endovascular embolization was performed before subsequent surgical resection. During AVM resection following embolization with Onyx, the IUS clearly demonstrated the Onyx-embolized lesion, and it was resected uneventfully. (Patient 2) A 46-year-old man with a ruptured SMG II AVM underwent AVM resection using a microsurgical technique with IUS after embolization for AVM preoperatively. IUS clearly showed abnormal vessels embolized with Onyx and indicated the correct location of the nidus, although the lesion was not observed directly from the brain surface. After identifying some embolized AVM constructions, we excised the entire AVM with ease and safety.

Conclusion: The combined use of presurgical embolization, which focuses on marking the lesions and IUS, may contribute to improving surgical outcomes of low SMG micro-AVMs, which are not exposed on the brain surface.

Keywords: Intraoperative ultrasonography (IUS), Microarteriovenous malformation (AVM), Onyx, Presurgical embolization

INTRODUCTION

The Spetzler–Martin Grade (SMG) is widely used to evaluate the risk of arteriovenous malformation (AVM) resection,[13] and direct surgery is strongly recommended for low (I and II) SMG lesions according to the American Heart Association guidelines.[6,9] Micro-AVMs are defined as AVMs with a nidus <1 cm in diameter[16] and the challenge is identifying the micro-AVMs exact site when performing AVM resection.[2] In clinical practice, grasping these locations during surgery may be difficult even if we utilize currently available surgical support instruments such as a neuronavigation system or indocyanine green video angiography (ICG-VA). Although

the use of intraoperative neuronavigation is effective in locating the nidus,[2] brain shift due to the removal of a hematoma or outflow of cerebrospinal fluid reduces the reliability of neuronavigation. Furthermore, ICG-VA is useful when angioarchitecture is present on the brain surface and the subcortical components of AVMs are not visualized.[1,8,10,17] These problems sometimes lead to difficulties in intraoperative confirmation of the exact site of the micro-AVM.

Herein, we present two cases in which low-SMG micro-AVMs were marked by presurgical embolization using an ethylene-vinyl alcohol co-polymer (Onyx), and intraoperative ultrasonography (IUS) from the brain surface identified the exact locations of subcortical AVM.

CASE DESCRIPTION

Patient 1

A 30-year-old man with unremarkable medical history was brought to our hospital with a sudden onset of the left hemiparesis and headache. On admission, he was in a restless state and experienced several episodes of vomiting. Although he demonstrated alert consciousness, hemiplegia and hemihypesthesia were observed on his left side. Computed tomography (CT) revealed subcortical hemorrhage in the right frontoparietal cerebrum [Figure 1a]. Digital subtraction angiography (DSA) showed a micro-AVM fed by the central artery of the middle cerebral artery (MCA), which was classified as an SMG II AVM [Figure 1b]. We evacuated the intracerebral hematoma not aggressively but modestly with remain the hematoma located around the nidus or the ruptured site so as not to rebleed from the untreated nidus and subsequently performed AVM resection. Since the AVM was not exposed in the cerebral cortex, we dissected the neighborhood cerebral sulci blindly to find the lesion, but with failure [Figure 1c]. Therefore, we embolized the AVM as a presurgical procedure [Figure 1d] and attempted AVM resection again. During direct surgery, the IUS demonstrated an Onyx-embolized AVM [Figure 1e]. Using this ultrasonographic finding as a marker for the site, we dissected the sulcus slightly above the lesion and directly confirmed

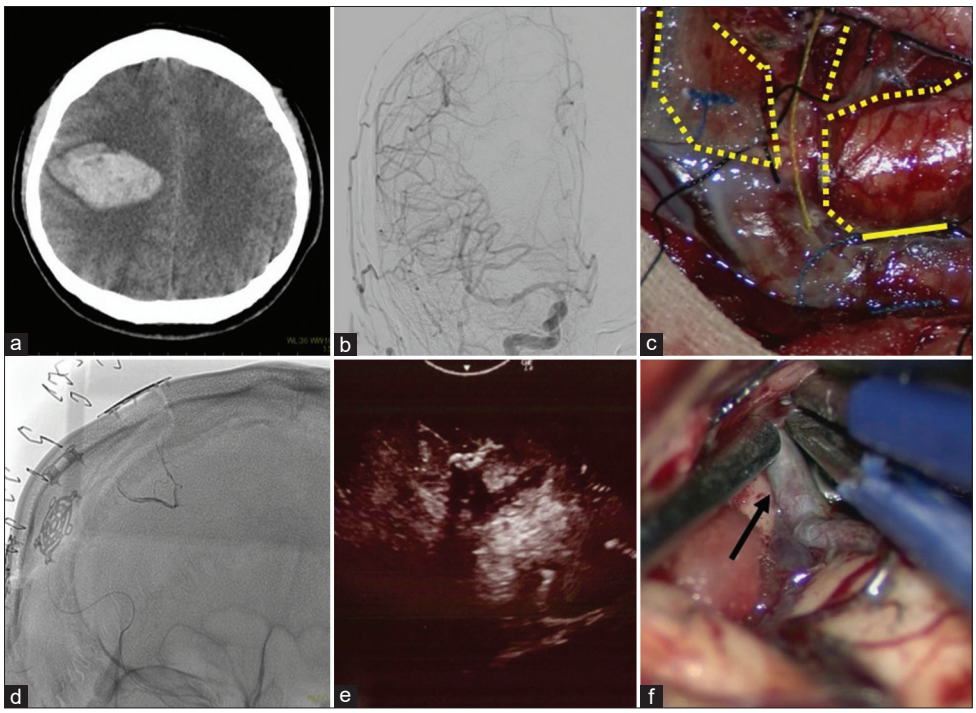


Figure 1: (a) Computed tomography scan on admission showing subcortical hematoma in the left frontal region. (b) Pre-embolization digital subtraction angiography (DSA) anteroposterior images showing a microarteriovenous malformation (AVM) fed by the central artery of the middle cerebral artery. (c) Intraoperative photograph showing that the AVM is not exposed in the cerebral cortex. We dissected the cerebral sulci to find the lesion (dotted line) but with failure. The solid line indicates the sulcus located just above the lesion according to intraoperative ultrasonography (IUS) at the second resection surgery. (d) DSA, during endovascular embolization showing that the lesion is embolized with Onyx. (e) IUS showing that the embolized compartment of the AVM presents as a highly echogenic lesion with acoustic shadow formation. (f) Intraoperative photograph after dissecting the sulcus just above the lesion, showing that an embolized vessel is confirmed (arrow).

the vessels embolized with Onyx [Figure 1f]. We followed the embolized vessel, identified the entire AVM structure, and excised it completely. After these procedures, his left hemiplegia improved considerably, and he was able to walk on his own and was transferred to a rehabilitation hospital.

Patient 2

A 46-year-old man presented felt listless in his right fingers and noticed facial paresis. On admission, he demonstrated motor aphasia without conscious disturbance or hemiparesis. A CT scan showed a left subcortical hemorrhage [Figure 2a]. DSA revealed a micro-AVM fed by the central artery of the MCA [Figure 2b]. The patient was diagnosed with ruptured SMG II AVM, and the lesion located in the eloquent area was not exposed to the brain surface. We embolized part of the lesion with Onyx preoperatively [Figure 2c], and subsequently, we excised the AVM using microsurgical technique with IUS. IUS revealed abnormal vessels that were clearly embolized with Onyx [Figure 2d] and indicated the correct location of the nidus. We dissected the sulcus, in which the nidus was present [Figure 2e] and confirmed the presence of an embolized feeder in the sulcus [Figure 2f]. By identifying some of the embolized vessels, we could easily trace the entire AVM construction, and finally, we excised the AVM completely. His aphasia and facial palsy worsened transiently after the direct surgery, but these symptoms improved promptly and were alleviated compared to those before the operation.

DISCUSSION

We present two cases of low SMG micro-AVMs marked using presurgical Onyx embolization, and IUS was useful for detecting the lesions, which could not be observed from the brain surface, correctly with ease. From our cases, the following two important points are implied. First, aggressive presurgical embolization without curative intent for low-SMG micro-AVM treatment may improve the outcomes of surgical intervention. Previously, it was reported that the main purposes of preoperative embolization are (1) to reduce the blood flow of the nidus and minimize bleeding that can occur during microsurgical removal;[9,15] (2) to control the feeder that flows into the nidus from the eloquent area or control the feeder that may be challenging to confirm directly

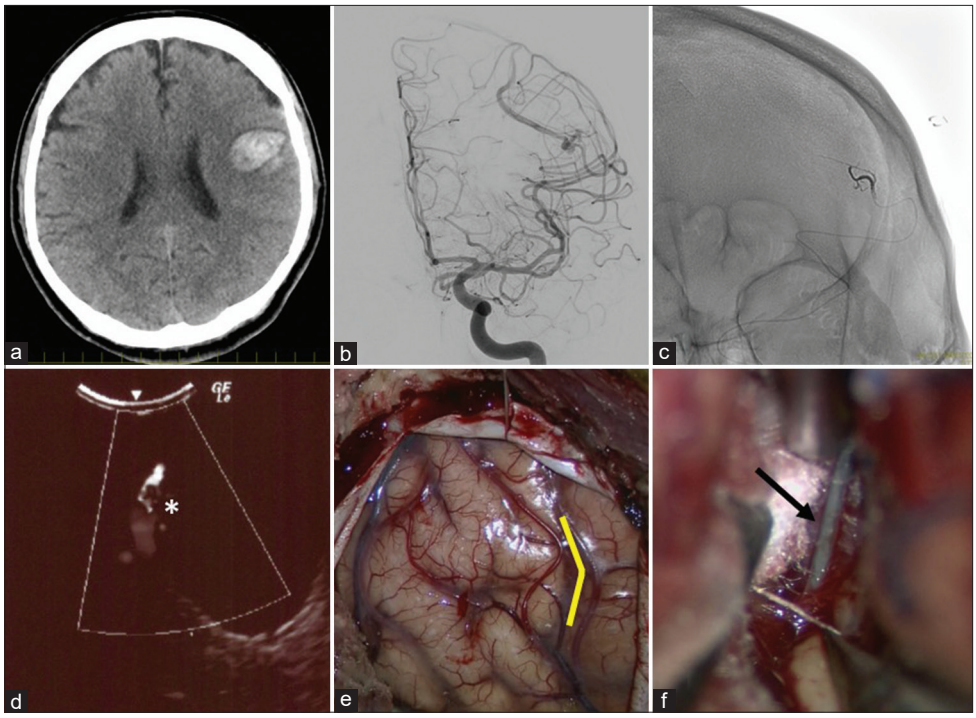


Figure 2: (a) Computed tomography scan on admission demonstrating a subcortical hematoma in the left frontal region. (b) Pre-embolization digital subtraction angiography (DSA), anteroposterior images showing a microarteriovenous malformation (AVM) fed by the central artery of the middle cerebral artery. (c) DSA, during endovascular embolization, showing that part of the lesion was embolized presurgically with Onyx. (d) Intraoperative ultrasonography (IUS) showing abnormal vessels embolized with Onyx as well as intracerebral hematoma (*). (e) Intraoperative photograph showing that the AVM is not exposed in the cerebral cortex. The solid lines indicate the sulcus located just above the lesion according to the IUS. (f) Intraoperative photograph after dissecting the sulcus just above the lesion, showing that an embolized vessel is confirmed (arrow).

in AVM resection when it flows from the back of the nidus; (3) to embolize flow-rerated aneurysms with a high risk of bleeding or embolize on-feeder aneurysms that occur in close proximity to the nidus; and (4) to prevent postoperative hemodynamic complications by suppressing dramatic changes in blood flow to the surrounding brain associated with excision with staged presurgical feeder embolization.

From our two cases, we realized that presurgical Onyx is highly effective as a marker for AVM sites by the embolizing substance in addition to the common purpose of embolizing the feeder and/or obstructing the nidus, although embolization for micro-AVM entails extra risks. The endovascular embolization of micro-AVM has reported a slightly high risk associated with the procedure.[3,12] In addition, marking with an embolic material reduces the risk of damage to surrounding normal brain structures unrelated to lesions by reducing our unnecessary search actions during direct surgery. Therefore, preoperative marking may improve the safety of surgical interventions. The effectiveness of lesion marking using presurgical embolization has been reported in pediatric cases.[7,11]

Second, IUS may improve the outcome of AVM surgery as one of the intraoperative support devices when used in combination with presurgical embolization. An intraoperative ultrasonic device, especially color-flow Doppler, has been reported to be useful for intraoperative assessment of AVM surgery.[4,5,14] In addition, our cases revealed that AVM can be detected even after presurgical embolization. This is because Onyx, which is the first choice embolic material for AVM embolization, contains microtantalum powder as a component to ensure visibility under fluoroscopy. This tantalum powder can be clearly detected using IUS and is a guide for direct surgery.

In conclusion, although presurgical embolization for micro-AVM may have a slightly high risk of complications associated with the procedure, presurgical embolization, which does not necessarily aim at complete obstruction of the nidus but marks the lesion site, is considered to be an effective method that can reduce complications in AVM excision and improve the overall safety of micro-AVM treatment.

CONCLUSION

The combined use of presurgical embolization, which clarifies the purpose of marking lesions, and IUS may contribute to safe surgical interventions.

Ethical approval

The publication of this case report was approved by the Ethics Committee of Saiseikai Shiga Hospital (Permission number: 526).

Declaration of patient consent

The Institutional Review Board (IRB) permission obtained for the study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Aboukaïs R, Vinchon M, Quidet M, Bourgeois P, Leclerc X, Lejeune JP. Reappearance of arteriovenous malformations after complete resection of ruptured arteriovenous malformations: True recurrence or false-negative early postoperative imaging result? J Neurosurg 2017;126:1088-93.
2. Alén JF, Lagares A, Paredes I, Campollo J, Navia P, Ramos A, *et al*. Cerebral microarteriovenous malformations: A series of 28 cases. J Neurosurg 2013;119:594-602.
3. Andreou A, Ioannidis I, Lalloo S, Nickolaos N, Byrne JV. Endovascular treatment of intracranial microarteriovenous malformations. J Neurosurg 2008;109:1091-7.
4. Black KL, Rubin JM, Chandler WF, McGillicuddy JE. Intraoperative color-flow Doppler imaging of AVM's and aneurysms. J Neurosurg 1988;68:635-9.
5. Chandler WF, Knake JE, McGillicuddy JE, Lillehei KO, Silver TM. Intraoperative use of real-time ultrasonography in neurosurgery. J Neurosurg 1982;57:157-63.
6. Derdeyn CP, Zipfel GJ, Albuquerque FC, Cooke DL, Feldmann E, Sheehan JP, *et al*. Management of brain arteriovenous malformations: A scientific statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2017;48:e200-24.
7. Ito Y, Tsuruta W, Muroi A, Takigawa T, Marushima A, Nakai Y, *et al*. Multimodal therapy for pediatric arteriovenous malformation: Effectiveness of preoperative embolization. Nerv Syst Child 2017;42:371-9.
8. Killory BD, Nakaji P, Gonzales LF, Ponce FA, Wait SD, Spetzler RF. Prospective evaluation of surgical microscope-integrated intraoperative near-infrared indocyanine green angiography during cerebral arteriovenous malformation surgery. Neurosurgery 2009;65(3):456-62; discussion 462.
9. Ogilvy CS, Stieg PE, Awad I, Brown RD Jr., Kondziolka D, Rosenwasser R, *et al*. AHA Scientific Statement: Recommendations for the management of intracranial arteriovenous malformations: A statement for healthcare professionals from a special writing group of the Stroke Council, American Stroke Association. Stroke 2001;32:1458-71.
10. Oya S, Nejo T, Fujisawa N, Tsuchiya T, Indo M, Nakamura T, *et al*. Usefulness of repetitive intraoperative indocyanine green-based videoangiography to confirm complete obliteration of micro-arteriovenous malformations. Surg Neurol Int 2015;6:85.
11. Oya S, Shojima M, Matsui T. Effectiveness of preoperative

superselective embolization to mark the shunt vessels prior to micro-AVM obliteration: A case report. Nerv Syst Child 2020;45:110-5.
12. Perrini P, Scollato A, Cellerini M, Mangiafico S, Ammannati F, Mennonna P, *et al*. Results of surgical and endovascular treatment of intracranial micro-arteriovenous malformations with emphasis on superselective angiography. Acta Neurochir (Wien) 2004;146:755-66.
13. Spetzler RF, Martin NA. A proposed grading system for arteriovenous malformations. J Neurosurg 1986;65:476-83.
14. Tekula F, Pritz MB, Kopecky K, Willing SJ. Usefulness of color Doppler ultrasound in the management of a spinal arteriovenous fistula. Surg Neurol 2001;56:304-7.
15. Viñuela F, Dion JE, Duckwiler G, Martin NA, Lylyk P, Fox A, *et al*. Combined endovascular embolization and surgery in the management of cerebral arteriovenous malformations: Experience with 101 cases. J Neurosurg 1991;75:856-64.
16. Yaşagil MG. Microneurosurgery. Volume IIIA. AVM of the Brain, History, Embryology, Pathological Considerations, Hemodynamics, Diagnostic Studies, Microsurgical Anatomy. New York: Thieme; 1987.
17. Zaidi HA, Abla AA, Nakaji P, Chowdhry SA, Albuquerque FC, Spetzler RF. Indocyanine green angiography in the surgical management of cerebral arteriovenous malformations: Lessons learned in 130 consecutive cases. Neurosurgery 2014;10 Suppl 2:246-251; discussion 251.

How to cite this article: Yokoya S, Takezawa H, Hidaka Y, Fujiwara G, Oka H. Ultrasound localization of embolic material to guide resection of brain AVM: Report of two cases. Surg Neurol Int 2023;14:146.