The Usefulness of Subcutaneous Infiltration of Epinephrine-Containing Lidocaine for Curative Transarterial Embolization of Dural Arteriovenous Fistula

A Technical Note

SHIGERU YAMAUCHI¹, AKIMASA NISHIO¹, YOSHINOBU TAKAHASHI¹, YUTAKA MITSUHASHI², YUZO TERAOKA², TAICHIRO KAWAKAMI², KENJI OHATA²

¹ Department of Neurosurgery, Hokuto Social Medical Corporation Hokuto Hospital, Obihiro, Hokkaido, Japan

² Department of Neurosurgery, Osaka City University Graduate School of Medicine, Osaka, Japan

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Summary

Recently, transarterial embolization (TAE) with liquid embolic materials has been recognized as one of the curative therapeutic options for non-sinus type dural arteriovenous fistula (d-AVF). To prevent glue fragmentation and incomplete obliteration, flow reduction of transosseous high-flow feeders is one of the key points of this therapy. However, flow reduction of transosseous feeders is sometimes difficult with previously reported techniques such as particle embolization, manual compression, or proximal balloon occlusion. This report introduces a new technique to reduce the flow of transosseous feeders using epinephrine-containing lidocaine, and describes a case of intracranial d-AVF successfully treated with this technique. The usefulness and efficacy of the technique are discussed.

According to the Cognard classification, it is classified into five subtypes based on venous drainage patterns correlated with clinical manifestations of d-AVF¹. Generally, high-grade (Cognard types 3, 4 or 5) intracranial d-AVF show aggressive manifestations and sometimes are not amenable to treatment by transvenous embolization (TVE). Recent reports have demonstrated the efficacy of transarterial embolization (TAE) with liquid embolic materials as curative therapeutic options²⁻¹⁵, with some authors describing the importance of flow reduction of other competing high-flow feeders prior to injection of the liquid embolic material^{2-5,12,14}. However, previously reported flow-control techniques have some limitations and are sometimes unsuccessful, leading to incomplete flow reduction. Here we propose a novel technique to reduce competing flow of transosseous feeders for the treatment of d-AVF.

Introduction

Dural arteriovenous fistula (d-AVF) is the condition where a pathological arteriovenous shunt is formed in the dura mater and may cause venous congestion, high intracranial pressure, or sometimes intracranial hemorrhage.

Case Presentation

A 73-year-old man complaining of right hemianesthesia was referred to our outpatient clinic. Magnetic resonance imaging (MRI) showed a small subcortical hematoma in the

Figure 1 Diagnostic right (A) and left (B) common carotid angiography showing a falcine sinus dural arteriovenous fistula mainly fed by bilateral superficial temporal arteries and middle meningeal arteries in which some antegrade sinus drainage to the superior sagittal sinus remained. Almost all shunt blood flow refluxed to the left parietal cortical veins. C) Right common carotid angiography obtained two months after the first embolization revealing recanalization of the shunt.

Figure 2 Angiography during the second embolization. A) Synchronized injection from the guiding catheter and microcatheter (black arrowhead), which had been placed in the distal right middle meningeal artery. B) Injection from the guiding catheter before infiltration of epinephrine-containing lidocaine, showing marked transosseous blood supply from the right superficial temporal artery (STA) (black arrow). C) Injection from the guiding catheter after infiltration of epinephrine-containing lidocaine, showing marked vasoconstriction of the transosseous blood supply from the right STA (black arrow). D) Blank road map during injection of n-butyl cyanoacrylate, showing penetration of the glue to the venous side (black arrowhead) and some glue refluxed to the transosseous feeders (black arrow). E) Final angiography, revealing complete obliteration of the shunt.

left parietal lobe. Diagnostic angiography revealed a d-AVF located in the falx cerebri, mainly fed by bilateral superficial temporal arteries (STAs) and middle meningeal

(MMAs). Although some antegrade sinus drainage to the superior sagittal sinus remained, almost all shunt blood flow refluxed to the left parietal cortical veins (Figure 1A,B). TVE was

considered overly hazardous due to the limitations of the access route. We therefore planned curative TAE using n-butyl cyanoacrylate (NBCA).

Two weeks after onset, TAE was performed under general anesthesia. A 6-Fr guiding catheter was inserted into the left external carotid artery via a transfemoral approach with some difficulty due to a tortuous aortic arch. Initially, a microcatheter was navigated to the left STA, which was obliterated with polyvinyl alcohol (PVA) particles. The microcatheter was then repositioned to the left MMA as close to the shunt point as possible. At this point, 20% NBCA was slowly injected under manual compression of the contralateral STA. The glue penetrated the shunt, but could not form an adequate glue cast due to the flow from other competing feeders. The shunt was thus unable to be completely obliterated.

Two months later, follow-up angiography demonstrated recanalization of the d-AVF, with the arteriovenous (AV) shunt mainly fed by the right STA and MMA, and reflux only to the left parietal cortical veins in a retrograde pattern (Figure 1C). We then performed a second TAE. This time, a 6-Fr guiding catheter was inserted into the right external carotid artery using a transbrachial approach. The microcatheter was navigated to the right MMA as close to the shunt point as possible. Synchronized contrast medium injection from the guiding catheter and microcatheter revealed transosseous feeders joining the MMA distal to the microcatheter tip (Figure 2A). Prior to the injection of NBCA, 20 ml of 1% epinephrine-containing lidocaine was infiltrated to the subcutaneous tissue around the STA penetrating the skull. After this infiltration, marked vasoconstriction of the transosseous feeders occurred (Figure 2B,C). Under this condition, 20% NBCA was injected from the microcatheter and then the glue penetrated the shunt to form an adequate glue cast, and also refluxed to the STA (Figure 2D). Complete obliteration was thus achieved (Figure 2E).

Discussion

In the past decade, many reports have described the feasibility of transarterial embolization (TAE) with liquid embolic materials as a curative treatment for high-grade d-AVFs²⁻¹⁵. Those reports used NBCA or ethylene vinyl al-

cohol (Onyx; ev3 Neurovascular, Irvine, CA, USA) as liquid embolic material. Nelson et al. reported excellent results of TAE for d-AVF with diluted NBCA and the wedged microcatheter technique in 2003. That report described a technique to obtain complete obliteration of high-grade d-AVFs with transarterial glue embolization, in which glue penetration to the venous side is essential, so 20-25% diluted NBCA was recommended. That report also emphasized the need for flow reduction in competing high-flow feeders prior to NBCA injection². Other reports using NBCA have likewise described the need for flow reduction to minimize the risk of glue fragmentation and incomplete obliteration³⁻⁵. Basically our procedure follows this theory.

Furthermore, several reports on TAE with Onyx have recently been published⁶⁻¹⁵. According to these reports, Onyx has the potential to backfill multiple feeding arteries from a single arterial injection, and always behaves like a column, and fragmentation rarely occurs^{6,8-10,15}. Although these reports suggest that the need for flow reduction is smaller in embolization with Onyx than with NBCA, flow reduction itself can theoretically enhance the advantageous properties of Onyx. Indeed, some reports have described the need for flow reduction in TAE with Onyx^{11,12,14}. In this case, we could not use Onyx due to regulation of national insurance, and did not use Onyx because some reports described the risk of chronic recanalization^{16,17}.

In general, d-AVFs possess multiple feeders. Among these, transosseous feeders like the STA or occipital artery are usually high-flow and tortuous. When we conduct curative TAE from the other dural feeder, reducing the flow from transosseous feeders prior to injection of the liquid embolic material appears worthwhile. In such situations, PVA particle embolization^{2,4,12}, proximal manual compression, or proximal balloon occlusion^{3,14} are commonly applied. However, these methods have some limitations. For example, super-selective PVA embolization can embolize distal collateral vessels from a proximal catheter position and effectively reduce the blood in flow. So we used that procedure for tortuous STA in a first session even though it is sometimes technically difficult or complex due to the tortuosity of proximal vessels. PVA may permanently occlude not only the AV shunt but also normal cutaneous blood supply, so maladaptation can occur when open surgery is applied, especially when bilateral

STA are embolized¹⁸. In this case, we did not perform additional embolization in first session because adequate flow reduction was already obtained and if we performed further glue embolization via the right MMA under flow control of the right STA with PVA embolization, we were concerned about ischemic complications of the skin. Furthermore, in high-flow AVF, PVA can migrate to the venous side and cause pulmonary embolism¹⁹. Proximal compression and proximal balloon occlusion are very easy, but sometimes insufficient due to the plentiful collateral blood flow of the scalp.

Epinephrine is a non-selective agonist of all adrenergic receptors, which causes contraction of the smooth muscle lining most arterioles leading to vasoconstriction²⁰. Traditionally, subcutaneous infiltration of epinephrine-containing lidocaine was used in craniotomy to reduce blood flow in the scalp and minimize intraoperative blood loss. Although some reports have described the side-effects of subcutaneous infiltration of epinephrine-containing lidocaine, such as unstable blood pressure and arrhythmia, the technique is basically safe and routinely used in craniotomy²¹⁻²³. We have applied this method in curative TAE for high-grade d-AVF

to reduce the blood flow from transosseous competing feeders. In the present case, this method was successful and we were able to achieve complete obliteration of the AV shunt. Our method is theoretically more effective than proximal manual compression or balloon occlusion. In contrast to selective PVA embolization, our method is easier and more economical, and can temporarily reduce scalp blood flow, so wound maladaptation would rarely occur when open surgery is applied. From these points of view, our method has some theoretical advantages and may be useful in TAE for high-grade d-AVF.

As our experience is only one case, potential pitfalls of our technique might exist. Under the situation in which a transosseous feeder and dural feeder supply the same shunt and draining vein, as far as an adequate glue cast occludes the proximal portion of the draining vein, this embolization might be durable. But if the transosseous feeder and dural feeder each supply a different shunt and draining vein, our technique might lead to misdiagnosis of a complete occlusion. Careful preoperative diagnosis of angio architecture might be essential for our technique.

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Shigeru Yamauchi, MD
 Department of Neurosurgery, Hokuto Hospital
 7-5 Inada, Obihiro, Hokkaido 080-0033, Japan
 Tel.: 81-155-48-8000
 Fax: 81-155-49-2121
 E-mail: ymailadd@silver.ocn.ne.jp