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Case Report

Efficacy of intra-arterial indocyanine green angiography for the microsurgical treatment of dural arteriovenous fistula: A case report

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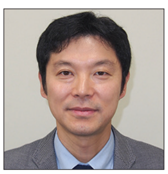

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ABSTRACT

Background: In this study, we report a case of dural arteriovenous fistula (dAVF) that was successfully treated using intra-arterial indocyanine green (IA-ICG) videoangiography during open surgery. Moreover, the findings of IA-ICG videoangiography were compared with those of intraoperative digital subtraction angiography (DSA).

Case Description: A 72-year-old male patient with a history of hypertension, hyperlipidemia, and thrombocytosis presented with generalized seizure. DSA revealed Cognard Type III dAVF in the superior wall of the left transverse sinus, which was fed by a single artery (the left occipital artery [OA]) and drained into a single vein (the left temporal cortical vein), without drainage into a venous sinus. Since transarterial embolization was considered challenging due to the tortuosity of the left OA, surgical interruption of the shunt was performed by craniotomy. After excising the feeding artery, we were unable to observed dAVF on intraoperative DSA. However, IA-ICG videoangiography revealed the remaining shunt, which was fed by the collateral route from the feeding artery. The shunting point and draining vein were then surgically resected to eliminate the shunt. The shunt was not observed during the second IA-ICG videoangiography conducted after resection.

Conclusion: ICG videoangiography is a better method compared with DSA in terms of visualizing fine vascular lesions. In contrast to the typical intravenous administration, selective IA-ICG can be repeatedly injected at a minimal dose. IA-ICG is a useful intraoperative tool that can be used to evaluate the elimination of the dAVF.

Keywords: Digital subtraction angiography, Dural arteriovenous fistula, Indocyanine green, Intra-arterial injection

INTRODUCTION

Dural arteriovenous fistulas (dAVFs) are defined as abnormal connections between arterial feeders and a dural venous sinus or leptomeningeal vein. The cortical venous reflux of intracranial dAVFs can cause intracranial hemorrhage or neurological deficit due to venous hypertension.[3] With the development of the endovascular device, endovascular treatment is considered to be the first-line of treatment for intracranial dAVFs at present. When an endovascular access procedure is not appropriate, surgical treatment is recommended.[7] Digital subtraction angiography (DSA) is the gold-standard technique for intraoperative evaluation during open surgery. In addition to DSA, indocyanine green (ICG) videoangiography was also recently found to be a safe and effective alternative for visualizing normal vascular structures or abnormal vascular lesions.[13] This method aids surgeons to examine fine vascular structures without interrupting surgical procedure as it can be performed in real-time under a microscope. ICG can be administered using intravenous (IV) and intra-arterial (IA) injections.[6,12] Herein, we report a case of intracranial dAVF that was successfully treated using IA-ICG videoangiography during open surgery.

CASE REPORT

A 72-year-old male patient who had a history of hypertension, hyperlipidemia, and thrombocytosis presented with generalized seizure. T2-wighted magnetic resonance imaging (MRI) at admission revealed focal edema in the left posterior temporal lobe [Figure 1a]. Susceptibility-weighted imaging revealed the presence of microbleed within the edematous area in the brain [Figure 1b]. The seizure was controlled by the oral administration of levetiracetam (1000 mg/day). DSA revealed dAVF in the superior wall of the left transverse sinus, which was fed by a single artery (the left occipital artery [OA]) and drained into a single vein (the left temporal cortical vein), without drainage into the left transverse sinus [Figures 1c-e]. Left internal carotid artery angiography revealed segmental stenosis of the left transverse sinus, which was adjacent to the shunting point [Figure 1f]. This finding indicated the presence of thrombosis in the left transverse sinus, which can be a cause for the development of Cognard Type III dAVF. Since endovascular access to the shunting point was difficult due to the tortuosity of the feeding artery, surgical interruption of the intradural draining vein was performed in the hybrid operating room.

After the induction of general anesthesia, a 4-F catheter was placed in the left common carotid artery (CCA) through the right radial artery. Then, the patient was placed in prone position. Left CCA angiography that was performed before craniotomy revealed the presence of dAVF [Figure 2a]. Left temporo-occipital craniotomy was then performed, and the left OA was excised during craniotomy. The shunt was not observed during the second DSA conducted after craniotomy [Figure 2b]. However, after dural opening, the draining vein was discovered as a red vein, indicating the presence of the remaining shunt [Figure 3a]. Abnormal arterial vessels were accumulated in the dura adjacent to the shunting point. IA-ICG videoangiography was performed using the same catheter used in DSA using the microscope with integrated ICG technology (ZEISS KINEVO 900, Carl Zeiss CO., Oberkochen, Germany). ICG videoangiography after craniotomy revealed early venous filling of the draining vein, which clearly indicated the remaining shunt [Figure 3b]. We resected the shunting point along with the sinus wall and arterialized draining vein [Figure 3c]. The shunt was not observed during IA-ICG videoangiography conducted after resection [Figure 3d].

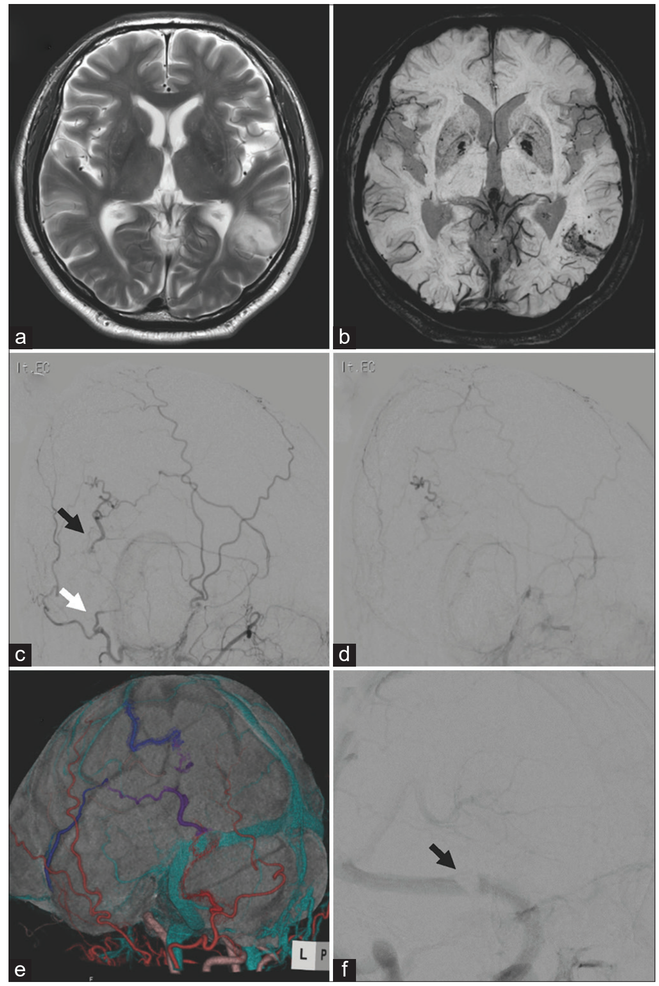

Figure 1: (a) T2-weighted magnetic resonance imaging (MRI) showing focal edema in the left temporal lobe. (b) Susceptibility-weighted imaging revealing microbleed in the same area. (c) Preoperative left external carotid artery angiography showing Borden Type III dural arteriovenous fistula (dAVF) in the left transverse sinus. White arrow indicates the feeding artery and black arrow indicates a shunting point. (d) Early venous phase of angiography demonstrating cortical venous reflux without the transverse sinus. (e) Fusion image of three-dimensional computed tomography angiography and MRI showing the detailed structure of the dAVF, consisting the occipital artery (red), cortical vein reflux (purple), and draining vein (blue). (f) Preoperative left internal carotid artery angiography showing sinus thrombosis in the left transverse sinus adjacent to the shunting point (f, black arrow).

Postoperative T2-weighted MRI revealed rapid improvement of the edema [Figure 4a] and magnetic resonance angiography showed the elimination of the shunt [Figure 4b].

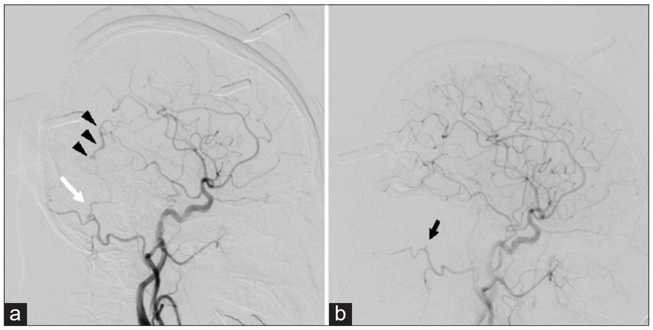

Figure 2: (a) Intraoperative left common carotid artery angiography performed before craniotomy showing the occipital artery (OA) (white arrow) and cortical venous reflux (black arrowheads). (b) Angiography conducted after craniotomy revealing the disappearance of the shunt and interrupted OA (black arrow).

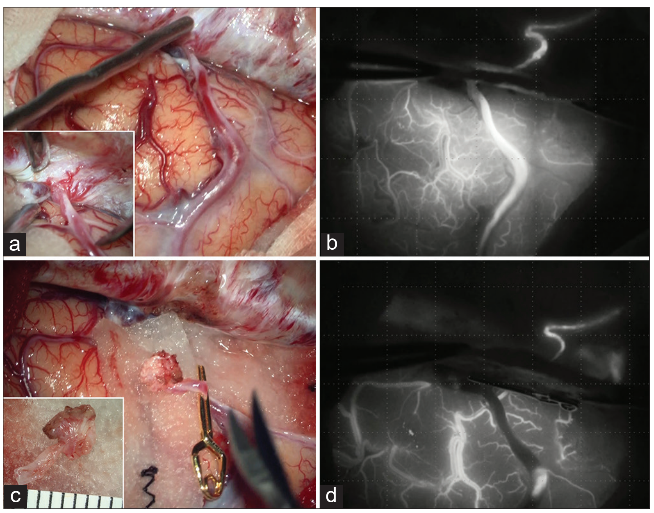

Figure 3: (a) Intraoperative microscopic view showing the red draining vein and accumulation of the dural arteries around the shunting point. (b) Indocyanine green (ICG) videoangiography revealing the remaining shunt. (c) Clip application to the origin of the draining vein. (d) ICG videoangiography showing the disappearance of the venous reflux.

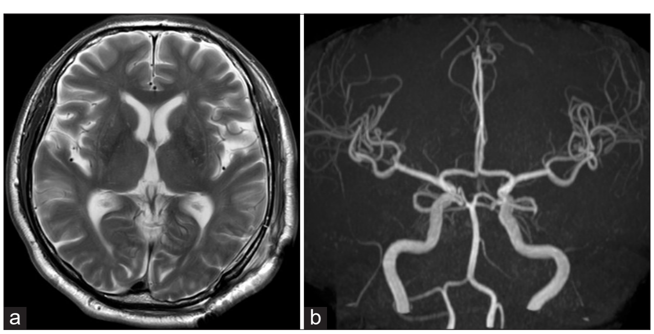

Figure 4: (a) Postoperative T2-weighted magnetic resonance imaging showing rapid improvement of the edema. (b) Magnetic resonance angiography revealing the elimination of the shunt.

The postoperative course was uneventful, and the patient was discharged without any neurological deficits.

DISCUSSION

Transvenous embolization (TVE) is considered more effective compared with transarterial embolization (TAE) in the endovascular treatment of dAVF.[14] A Japanese survey on the treatment of dAVF revealed that the complete cure rate of TVE is 86%, whereas that of TAE is only 47%.[10] Recently, TAE has become more effective with the use of Onyx.[9] When anatomic features prevent endovascular access, or when embolization fails to obliterate the lesion, surgical treatment is indicated.[7] In our study, endovascular access was difficult using either the transvenous or transarterial approach. In a study by Kakarla *et al.*, open surgery was performed in 53 patients with high-risk intracranial dAVFs, and 92% of the patients had good or excellent outcomes.[7]

Intraoperative imaging is important in evaluating the effect of treatment during cerebrovascular microsurgery.[2,5,11,13,15] Intraoperative DSA is still considered to be the gold-standard method because it provides a dynamic view of the whole arterial and venous systems. Lopez *et al.* have evaluated 191 patients with intracranial aneurysm, arteriovenous malformation (AVM), and dAVF using intraoperative DSA.[11] They reported that 23% of the patients had relevant findings, such as residual lesion, parent artery or branch vessel occlusions, and vasospasm.[11] Recently, intraoperative ICG videoangiography has been reported to be a less invasive alternative for visualizing fine vascular structures.[13] ICG videoangiography can provide real-time information on arterial and venous flow, including that in thin perforating arteries of >0.5 mm in diameter.[13] Cardiologists introduced ICG angiography for cardiac flow studies in the 1960s.[4] ICG videoangiography through IV bolus injection is commonly performed by dissolving 12.5–25 mg of ICG in saline at a maximum dose of 5 mg/kg/day.[8] IV-ICG angiography must be conducted 10–20 min before the dissipation of ICG fluorescence, making repeat studies time-consuming.[8]

In this study, we performed IA-ICG angiography through selective catheterization to the left CCA. Some reports have suggested that IA-ICG angiography uses a minimum dose of ICG; thus, it has a short washout period and facilitates repeat examinations.[6,12] In our case, only a dose of 0.06 mg was used per injection in one examination. Horie *et al.* have reported about two cases of spinal dAVF with multiple drainers that were successfully treated with repeat IA-ICG angiography.[6] Osanai *et al.* have evaluated 22 patients with intradural arteriovenous lesions or spinal dAVF and also defined the efficacy of intraoperative ICG injection.[12]

Only a few reports have compared ICG and DSA intraoperatively. Hardesty *et al.* have retrospectively compared DSA alone and ICG videoangiography combined with DSA.[5] Results have shown that the rate of clip repositioning and perioperative stroke did not differ between the groups who underwent the procedures. However, the cost of intraoperative DSA was significantly higher compared with that of ICG videoangiography.[5] Thus, they considered intraoperative ICG videoangiography as a safe, effective, and cost-effective alternative to routine intraoperative DSA.[5] One of the disadvantages of ICG videoangiography is that it can only show superficial structures within the surgical field.[1] Bilbao *et al*. reported that intraoperative DSA detected two additional small residual AVMs that were missed on ICG videoangiography, both of which were located deeply in the surgical field.[1] Considering the characteristics of both methods, they must be used complementarily. In the present case, ICG videoangiography was more sensitive because of the superficial location of the lesion with slow venous drainage, which can be clearly demonstrated by ICG videoangiography under operative microscope.

No study has compared IA-ICG and DSA in a single case of intracranial lesion. In our case, IA-ICG videoangiography revealed the remaining shunt, which was not observed on intraoperative DSA. Thus, IA-ICG angiography is a useful intraoperative imaging tool for dAVF surgery because one can clearly visualize fine vascular structures with it, and it can be performed repeatedly. However, its application is limited to superficial structures.

CONCLUSION

Herein, we report a case of dAVF that was successfully treated using IA-ICG videoangiography during open surgery. IA-ICG videoangiography showed the presence of residual shunt, which could not be detected on intraoperative DSA. Thus, the procedure is a useful intraoperative tool as it assists in clearly visualizing fine vascular structures and can be conducted repeatedly, thereby providing real-time information during intracranial vascular surgery.

Declaration of patient consent

Patients consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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