Detection of a residual nidus by surgical microscope-integrated intraoperative near-infrared indocyanine green videoangiography in a child with a cerebral arteriovenous malformation

Case report

YASUSHI TAKAGI, M.D., PH.D.,¹ KEN-ICHIRO KIKUTA, M.D., PH.D.,¹ KAZUHIKO NOZAKI, M.D., PH.D.,¹ KEIKO SAWAMURA, B.E.,² AND NOBUO HASHIMOTO, M.D., PH.D.¹

¹Department of Neurosurgery, Kyoto University Graduate School of Medicine, Kyoto; and ²Carl Zeiss Meditec Co. Ltd., Tokyo, Japan

With the use of indocyanine green (ICG) as a novel fluorescent dye, and its integration into a compact system that takes advantage of modern video technology, fluorescence angiography has recently reemerged as a viable option. In this report, the authors show the efficacy of ICG videoangiography in the case of a child with a cerebral arteriovenous malformation (AVM). In this case, the ICG videoangiography shows residual nidus of diffuse-type AVM. This is a safe and simple method that can be used to assess the microcirculation of the brain. The ICG videoangiography is helpful in resecting residual cerebral AVM, especially in cases of diffuse-type AVM. (DOI: 10.3171/PED-07/11/416)

KEY WORDS • cerebral arteriovenous malformation • intraoperative near-infrared indocyanine green videoangiography • pediatric neurosurgery • residual nidus

Abbreviations used in this paper: ACA = anterior cerebral artery; AVM = arteriovenous malformation; ICG = indocyanine green; NIR = near infrared.

Administration approved the use of ICG for cardiocirculatory measurements, liver function tests, and ophthalmic angiography.

In this report, we show the efficacy of ICG videoangiography in the case of a child with a cerebral AVM. In this case, this method shows residual nidus of diffuse-type AVM. The ICG videoangiography is a safe and simple method that can be used to assess the microcirculation of the brain.

Case Report

History and Examination. This 2-year-old girl presented with sudden-onset hemiparesis due to an intracerebral hemorrhage. A cerebral angiogram disclosed a Spetzler–Martin Grade III AVM in the left frontoparietal lobe (Fig. 1a and b). The diameter of the nidus was 4 cm; it was fed by the ACA and middle cerebral artery, and drained into the ascending cortical veins and the internal cerebral vein.

First Operation. The patient underwent evacuation of the intracerebral hematoma through a craniotomy. She was then transferred to our hospital. Preoperatively the feeding vessels from the ACAs were embolized by endovascular surgery. A frontoparietal craniotomy was performed, and the nidus was removed. Intraoperative cerebral angiography could not detect a residual nidus. Nine days after the opera-
tion, a cerebral angiogram indicated residual nidus fed by the ACA, with early venous drainage (Fig. 1c and d). During these procedures, the right femoral artery was occluded. Thus, we decided not to use intraoperative digital subtraction angiography. She then underwent an additional operation with the aid of ICG videoangiography and neuronavigation (Fig. 2).

Indocyanine Green Videoangiography. The operative field was illuminated by a light source with a wavelength covering part of the ICG absorption band (range 700–850 nm, value of maximum absorption 805 nm). Indocyanine green dye was injected into a peripheral vein as a bolus (the standard 25 mg dose dissolved in 5 ml of water). After the dye solution arrived in the vessels of the NIR light-illuminated field of interest, ICG fluorescence was induced. The fluorescence (range 780–950 nm, value of maximum absorption 835 nm) was recorded by a nonintensified video camera. An optical filter blocked both ambient and excitation light so that only ICG-induced fluorescence was collected. Thus, arterial, capillary, and venous angiograms could be observed on the video screen in real time. Images can be recorded on tape or compact disk and later reviewed for analysis.

Microscope Integration of ICG Videoangiography. The Carl Zeiss Co. (Oberkochen, Germany) integrated the microscope with ICG videoangiography technology. The system was designed to integrate NIR imaging into the surgical microscope and to obtain high-resolution and high-contrast NIR images. The details of this technical integration are described elsewhere. The setup allowed high-resolution NIR images based on ICG fluorescence to be visualized without eliminating visible light during the investigation.

Second Operation. After this, the interhemispheric fissure was opened. The feeding vessels from the ACA were visualized and the location of the nidus was confirmed by neuronavigation (Vector Vision, BrainLAB Co., Fig. 2a, e, and f). A nidus with early venous drainage in this area was found by ICG videoangiography (Figs. 2b and 3a–d). After temporary clipping of the feeding artery, the residual nidus was completely removed (Fig. 2c). Total removal of the nidus was confirmed on ICG videoangiography (Fig. 2d).

Discussion

Here, we describe the detection of residual nidus by ICG angiography in a child with a cerebral AVM. The true incidence of residual lesions after the resection of intracranial AVMs is not well documented in the literature. Partial resection does not confer any improvement over the natural history risk of hemorrhage of AVMs, and in certain cases it may actually increase the risk of hemorrhage. Residual AVMs or residual early draining veins can be retained after resection, unrecognized at the time of operation, only to be seen on postoperative angiography. Postoperative angiography (or intraoperative angiography with high-standard image quality) is thus critical to assess for residual AVM, and can facilitate surgery. In this case, we used intraoperative angiography. However, we could not detect residual nidus. We think that this might be due to a limitation of image quality or a hidden compartment of the AVM. In our case, the residual part of the nidus was not obvious on preoperative angiography.

Given that our patient was 2 years old, the diameter of the femoral artery was narrower than that in adults. During

**Fig. 1.** Cerebral angiograms. Preoperative anteroposterior (a) and lateral (b) views. A diffuse-type Spetzler–Martin Grade III AVM can be seen in the left frontoparietal lobe. Anteroposterior (c) and lateral (d) views obtained after the first operation. The residual nidus fed by the ACA can be seen (arrows).

**Fig. 2.** Intraoperative photographs (a and c) and ICG videoangiography (b and d) obtained during the second operation. The residual nidus fed by the ACA (a) was removed (c). The ICG videoangiography disclosed that the residual nidus (b) was totally resected (d). Neuronavigation showed the location of the nidus (sagittal view, e; coronal view, f).
the first operation, we used intraoperative angiography with a 5-F sheath placed in the right femoral artery. Two weeks after this surgery, we detected occlusion of the right femoral artery on cerebral angiography. Thus, we hesitated to use intraoperative angiography. We selected ICG videoangiography and neuronavigation to determine the precise location of the residual nidus.

Recently, the ICG video technique was integrated with a surgical microscope. This advancement improved the simplicity and speed with which the procedure can be used. There is no need to move the microscope from the surgical field or to interrupt the operation. The results of ICG videoangiography were available within several minutes for all patients. Moreover, this imaging technique can easily be repeated as needed. Consequently, ICG videoangiography may be a simple tool for intraoperative quality control and documentation of surgical outcomes. Besides ICG videoangiography, 3D ultrasonography has been used for detection of cerebral AVMs. It may be necessary to compare the efficacy of ultrasonography with that of ICG videoangiography in AVM surgery in the further study.

In this case, the patient harbored a diffuse-type AVM. This type of AVM was first described in 1992 by Chin et al. It is typically large to moderate in size and wedge-shaped, often occupying an entire lobe, and consists of multiple small arterial feeding arteries and draining veins with a diffuse, “puddling” appearance of the contrast agent. Klipo et al. reported that this type of AVM is seen in 18% of patients. Because of the vascular architecture, complete extirpation of these lesions is generally more difficult than extirpation of the more typical compact, high-flow nidus. Although they account for 18% of cases, diffuse lesions are disproportionately represented in those patients whose lesions have not been obliterated (40%), those in whom there has been a residual nidus (44%), or those who have experienced a recurrence (80%). Zipfel et al. found that a diffuse nidus structure is associated with a lower neuroimaging-defined cure rate. Thus, novel technology is necessary to improve the cure rate.

In summary, we detected the extent of residual nidus by ICG videoangiography. This modality is helpful in resecting residual cerebral AVMs, especially in cases of diffuse-type AVMs.

Acknowledgment

We thank Carl Zeiss Meditec Co. Ltd., Tokyo, Japan, for letting us use the microscope-integrated ICG videoangiography technology.

References


Manuscript submitted April 11, 2007. Accepted July 13, 2007. Address correspondence to: Yasushi Takagi, M.D., Ph.D., Department of Neurosurgery, Kyoto University Graduate School of Medicine, 54 Kawahara-cho, Shogoin, Sakyo, Kyoto 606-8507, Japan. email: yetakagi@kuhp.kyoto-u.ac.jp.