Usefulness of Tumor Blood Flow Imaging by Intraoperative Indocyanine Green Videoangiography in Hemangioblastoma Surgery

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Key words
- Hemangioblastoma
- Indocyanine green videoangiography
- Transit feeder
- Tumor blood flow imaging

Abbreviations and Acronyms
AVM: Arteriovenous malformation
ICG: Indocyanine green
MR: Magnetic resonance
PICA: Posterior inferior cerebellar artery

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OBJECTIVE: **Hemangioblastomas remain a surgical challenge because of their arteriovenous malformation–like character. Recently, indocyanine green (ICG) videoangiography has been applied to neurosurgical vascular surgery. The aim of this study was to evaluate the usefulness of tumor blood flow imaging by intraoperative ICG videoangiography in surgery for hemangioblastomas.**

METHODS: **Twenty intraoperative ICG videoangiography procedures were performed in 12 patients with hemangioblastomas. Seven lesions were located in the cerebellum, two lesions were in the medulla oblongata, and three lesions were in the spinal cord.**

RESULTS: **Ten procedures were performed before or during dissection, and 10 procedures were performed after tumor resection. ICG videoangiography could provide dynamic images of blood flow in the tumor and its related vessels under surgical view. Interpretation of these dynamic images of tumor blood flow was useful for discrimination of transit feeders (feeders en passage) and also for estimation of unexposed feeders covered with brain parenchyma. Postresection ICG videoangiography could confirm complete tumor resection and normalized blood flow in surrounding vessels.**

CONCLUSIONS: **In surgery for hemangioblastomas, careful interpretation of dynamic ICG images can provide useful information on transit feeders and unexposed hidden vessels that cannot be directly visualized by ICG.**

INTRODUCTION

Hemangioblastomas are highly vascular tumors that occur predominantly in the cerebellum and spinal cord and comprise 1.5%–2.5% of intracranial and 3%–4% of spinal tumors (1, 6, 11, 16). They mainly present as sporadic events, but 20%–30% of cases are associated with von Hippel-Lindau disease. Hemangioblastomas are histologically benign tumors, and complete resection results in a favorable outcome. However, this tumor remains a surgical challenge because of its arteriovenous malformation (AVM)–like character (1, 11, 16). In hemangioblastoma surgery, it is important to distinguish between transit feeders (which have branches supplying the tumor) and adjacent nonfeeding arteries.

Indocyanine green (ICG) videoangiography has been recently applied to the neurosurgical field (2, 5, 10, 12, 13, 15). Previous reports have shown that intraoperative ICG videoangiography was useful in extracranial–intracranial bypass surgery and in the treatment of cerebral aneurysms (10, 13, 15). Here, we report the usefulness of tumor blood flow imaging by intraoperative ICG videoangiography in surgery for hemangioblastomas. ICG videoangiography can provide useful information on transit feeders (feeders en passage) and unexposed hidden vessels by careful interpretation of dynamic images of tumor blood flow.

CLINICAL MATERIALS AND METHODS

Patient Population

Twenty ICG videoangiography procedures were performed in 12 patients with hemangioblastomas. The patient characteristics are summarized in Table 1. The mean age at the time of surgery was 47.3 years (range 15–82 years). Seven lesions were located in the cerebellum. Five of these 7 cerebellar lesions were cystic and 2 lesions were solid. Two lesions were located in the medulla oblongata, and 3 lesions were in the spinal cord.

ICG Videoangiography

We used an OPMI Pentero surgical microscope (Carl Zeiss, Co., Oberkochen, Germany) integrated with ICG videoangiography. In each procedure, ICG (8–12.5 mg) was injected into a peripheral vein as a bolus. Arterial, capillary, and venous angiographic images could be observed on the video screen in real time (12, 13). Images were recorded and reviewed immediately for analysis. Recorded movies were analyzed by FLOW800 software (Carl Zeiss, Co.).

RESULTS

One to three ICG videoangiography procedures were performed in each operation. The timing of ICG videoangiography is summarized in Table 1. Among 20 ICG videoangiograms, 10 procedures were performed before or during dissection, and 10

Table 1. Summary of All Cases

Patient Number	Age (Years)/ Sex	Location	Type	Number of ICG Videoangiography: Before Tumor Removal	Number of ICG Videoangiography: After Tumor Removal	Information Obtained from ICG Videoangiography
1	65/F	Cerebellum	Solid	1	1	3), 4), 5)
2	82/M	Cerebellum	Solid	2	1	1), 4), 5)
3	71/F	Cerebellum	Cystic	1	1	1), 4), 5)
4	28/F	Cerebellum	Cystic	0	1	4), 5)
5	37/M	Cerebellum	Cystic	0	1	4), 5)
6	32/M	Cerebellum	Cystic	0	1	4), 5)
7	37/F	Cerebellum	Cystic	1	0	1), 2)
8	48/M	Medulla	Solid	1	1	1), 4), 5)
9	15/F	Medulla	Cystic	1	1	1), 2), 4), 5)
10	68/F	Spinal cord (Th9)	Solid	1	1	1), 3), 4), 5)
11	54/M	Spinal cord (L1)	Solid	2	0	1)
12	30/M	Spinal cord (L2-3)	Solid	0	1	4), 5)

Information obtained from ICG videoangiography are as follows: 1) identification of feeders and drainers; 2) discrimination between transit feeders and adjacent non-feeding arteries; 3) estimation of unexposed feeders; 4) verification of complete resection; 5) verification of normalized blood flow in surrounding vessels.
ICG, indocyanine green; M, male; F, female.

procedures were performed after removal of the tumor.

In pre-resection studies, the feeding arteries were visualized in six of seven cases (86%) by ICG. The tumor was visualized in all eight cases (100%), and the drainers were visualized in seven of nine cases (78%). ICG videoangiography was available only for vessels visible in the surgical field, because ICG videoangiography could not visualize vessels that were covered with parenchyma. However, ICG videoangiography could provide dynamic images of blood flow in the tumor and its related vessels under surgical view. Interpretation of these tumor blood flow images was extremely useful for discrimination between transit feeders and adjacent non-feeding arteries, and also for estimation of unexposed hidden feeders. Transit feeders were filled with ICG in the early phase, and adjacent nonfeeding arteries were visualized by ICG in the late phase. Postresection ICG videoangiography could show that complete resection had been achieved in all 10 cases (100%). Moreover, normalized blood flow in surrounding vessels could also be confirmed by ICG videoangiography after removal of the tumor in all cases.

ILLUSTRATIVE CASES

Case 1 (Patient 7)

A 37-year-old woman with known von Hippel-Lindau disease presented with ataxia. Magnetic resonance (MR) imaging revealed a cystic lesion with a homogeneously enhancing mural nodule in the cerebellar hemisphere (Figure 1A). She underwent surgery to remove the tumor. In the surgery, we could easily detect the mural nodule and the main feeding artery. However, it was difficult to distinguish between transit feeding arteries and adjacent nonfeeding arteries. Therefore, ICG videoangiography was performed and the recorded movie was analyzed by FLOW800 software. At first, the main feeding artery was filled with ICG (Figure 1B,C, *open arrowhead* [1]). After 4 seconds, the draining vein (*open arrow* [2]) and the vessel indicated by *arrow* (3) were visualized (Figure 1D). After 7 seconds, the vessel indicated by *arrowhead* (4) was filled with ICG (Figure 1E). The mural nodule was visualized underneath the thin cyst wall by ICG (Figure 1E). The intensity diagram analyzed by FLOW800 clearly showed the variation of blood flow in these vessels (Figure 1F). These findings indicated that the artery indicated by *arrow* (3) was a transit feeder (which had branches supplying the tumor) and that the artery indicated by *arrowhead* (4) was an adjacent nonfeeding artery. According to these findings, we carefully dissected the tumor and could coagulate all feeders. Then, we could remove the tumor completely.

Case 2 (Patient 9)

A 15-year-old girl presented with headache and nausea, and MR imaging revealed a cystic lesion with a homogeneously enhancing mural nodule in the medulla oblongata (Figure 2A). A cerebral angiogram showed a highly vascularized tumor fed by the posterior inferior cerebellar artery (PICA) (Figure 2B). She underwent surgery to remove the tumor with the preoperative diagnosis of hemangioblastoma. In the surgery, we carefully checked complex vasculatures around the highly vascular tumor, and we could detect the main feeding artery from the PICA. After clipping this main feeding artery, ICG videoangiography disclosed that the flow of the tumor was reduced (Figure 2C-F). The draining vein and the artery coursing along the upper part of the tumor were filled with ICG about 3 seconds after the PICA was visualized (Figure 2E). In contrast, the artery coursing along the lower part of the tumor was filled with ICG about 10 seconds after the PICA was visualized (Figure 2F). These findings indicated that the artery coursing along the upper part of the tumor was a transit feeding artery (which had branches supplying the tumor) and that the artery coursing along the lower part of the tumor was an adjacent nonfeeding artery. According to this interpretation, we carefully dissected the upper side of the tumor, and we could detect and coagulate residual feeding arteries. After that, we could remove the tumor completely. Finally, ICG videoangiography showed complete tumor resection and normalized blood flow in surrounding vessels (Figure 2G, H).

Case 3 (Patient 1)

A 65-year-old woman presented with dizziness, and MR imaging revealed