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CASE REPORT

Visualization of vascular structure of spinal hemangioblastoma using intraoperative indocyanine green videoangiography and temporary feeder occlusion

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Abstract
Background and purpose To more safely resect pathological lesions during spinal vascular lesion surgery, it is most important to understand local abnormal hemodynamics in detail. New devices or techniques that make out intraoperative local hemodynamics have been awaited. To introduce a resourceful method, we present a case of spinal hemangioblastoma for which temporary arterial occlusion during near-infrared intraoperative indocyanine green (ICG) videoangiography gives useful assessment of the main and minor feeders easily.
Methods A 36-year-old female suffered progressive paresthesia of both lower extremities for 12 months and gait disturbance for 2 weeks. A neurological examination revealed T10 myelopathy. Magnetic resonance imaging (MRI) of the thoracic spine showed an intramedullary tumor at the T8 level and severe spinal cord edema with a flow void in the extended dorsal spinal veins. Spinal angiography showed a hemangioblastoma at the T8 level, with two main feeders and minor feeders.
Results She underwent total resection of the tumor by a posterior approach. During the intraoperative ICG videoangiography, temporary arterial occlusion of the two main feeders and FLOW®800 analysis enabled clear understanding of the vasculature, especially of the two minor feeders. At the 9-month follow-up, her neurological manifestation was partially resolved, and post-operative MRI showed total removal of the tumor and disappearance of the spinal cord edema.
Conclusions Temporary clipping of the main feeders during intraoperative ICG videoangiography is very useful for easily determining the minor feeding arteries, and helpful for maintaining normal perfusion of the spinal cord in spinal hemangioblastoma surgery. Furthermore, the FLOW 800 analysis, especially the false color-coded variation, increased our understanding of the hemodynamics.

Keywords FLOW®800 · Hemangioblastoma · Indocyanine green videoangiography · Spinal lesion · Temporary arterial occlusion · Intraoperative assessment

Introduction

Intraoperative near-infrared indocyanine green (ICG) fluorescence videoangiography has been recently applied to various neurosurgical practices. Previous reports demonstrated the usefulness of the application mainly for cranial surgeries, including cerebral aneurysm clippings, bypass surgeries, and arteriovenous malformation resections [1, 2]. Recently, a few case series on spinal vascular lesions reported the use of intraoperative ICG videoangiography [3–5]. Particularly in the surgery of spinal hemangioblastoma, several reports describe the usefulness of ICG videoangiography [6–8]. However, these reports emphasized its usefulness only for evaluations of feeding arteries and draining veins at the beginning, and for residual lesions at the end of the surgery. Moreover, FLOW®800 (Carl Zeiss, Oberkochen, Germany) was recently introduced as a software tool for instant color-coded visualization and analysis of the temporal distribution dynamics of the fluorescent ICG dye [9]. We describe an interesting surgery for a case of spinal hemangioblastoma, in which we conducted a simple trial using

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temporary arterial occlusion during intraoperative ICG videoangiography. This application enabled an easy and clear understanding of the local abnormal hemodynamics, especially of the minor feeders.

Case report

A 36-year-old female with progressive sensory disturbance of both lower extremities for 12 months and gait disturbance for 2 weeks was referred to our institution. Neurological findings showed paresthesia and hyperesthesia below T10 and motor weakness (manual muscle test showed 3/5) in the right lower extremity without urinary or bowel dysfunction. Magnetic resonance imaging (MRI) of the thoracic spine revealed severe spinal cord edema and an intramedullary mass located in the right posterior funiculus at T8, with a flow void of the extended dorsal spinal veins (Fig. 1). Brain and total spine MRI revealed no other abnormal lesions. Spinal angiograms showed a hemangioblastoma at T8, with 2 main feeders from the bilateral T9 radicular arteries and minor feeders from the right T5 and T6 radicular arteries (Fig. 2). Her symptoms gradually deteriorated, and surgical resection was planned.

The intramedullary tumor was resected under somatosensory evoked potential (SEP) and motor evoked potential (MEP) monitoring with the use of intraoperative ICG videoangiography. At the dural opening, microscopic and ICG videoangiography revealed two main feeders from the bilateral caudal side (Fig. 3a). After temporary clips were applied to these two main feeders, another ICG videoangiography clearly showed two minor feeders running along the surface of the spinal cord from the cranial side, which were likely normal structures. Analysis using FLOW®800 software showed obvious differences in the minor feeders between the initial and second examinations (Fig. 3b, c). There were no remarkable waveform changes in SEPs or MEPs during the temporary arterial occlusions. The tumor was carefully resected en bloc after cutting off the major and minor feeders at the tumor surface. Follow-up ICG videoangiography documented the absence of residual tumor fluorescence and the maintenance of normal perfusion from minor feeders (Fig. 3d). There were no changes in amplitude waveform of the SEPs during the surgery. On the other hand, a 70 % reduction in the amplitude of the MEPs was observed during resection of the tumor, which finally recovered to 50 %.

A post-operative neurological examination revealed a new deep sensory disturbance in the right lower extremity, and rehabilitation was started. Post-operative MRI showed total removal of the tumor and dramatic disappearance of the spinal cord edema (Fig. 4). At the 9-month follow-up, her motor weakness and deep sensory disturbance in the right lower extremity were partially resolved (manual muscle test showed 4/5), but hyperesthesia at T10 was refractory.

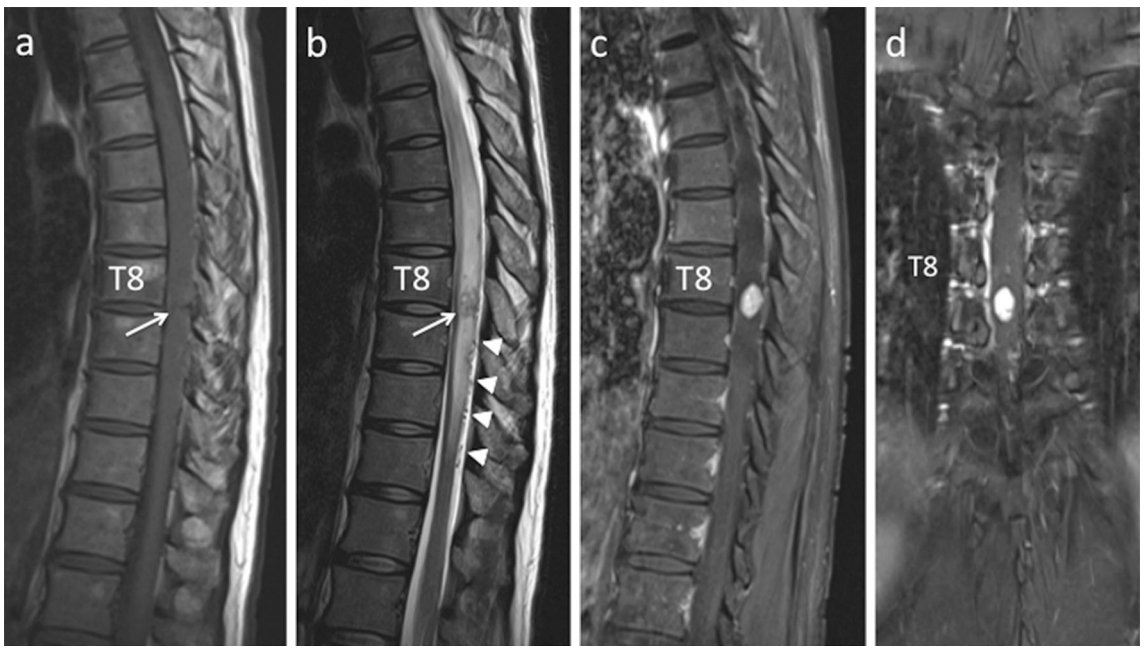

Fig. 1 Preoperative magnetic resonance images of the thoracic spine. **a**, **b** Sagittal T1- (**a**) and T2- (**b**) weighted images show an intramedullary mass lesion at T8 level (*arrows*) and spinal cord edema with a flow void of the extended dorsal spinal veins (*arrowheads*). Sagittal (**c**) and coronal (**d**) gadolinium-enhanced T1-weighted images show a homogeneously enhanced intramedullary mass lesion at the same level

Fig. 2 Digital subtraction angiograms of the *right* T9 (**a**), *left* T9 (**b**), *right* T6 (**c**), and *right* T5 (**d**) intercostal arteries. Radiculomedullary arteries are visualized as main feeding arteries from the bilateral caudal side (**a**, **b**), and minor feeding arteries from the cranial side are suspected by a pale tumor stain (**c**, **d**)

Discussion

Spinal hemangioblastomas comprise approximately 5 % of all spinal cord tumors [10]. Spinal hemangioblastomas are benign but highly vascular intramedullary tumors, and can be cured by surgical resection. Therefore, it is necessary to extirpate the tumor completely without any damage to the normal structure of the spine cord [11]. Advancements in microsurgical techniques for spinal tumors in recent years make such tumor removal safer. En bloc resection via careful microsurgical dissection of the tumor margin from its pial attachments is advocated [12].

To differentiate the vessels supplying a tumor from those supplying the normal spinal cord, Clark et al. [13] reported the effectiveness of temporary arterial occlusion of the feeding arteries under intraoperative spinal cord monitoring. They recommended this approach, particularly if the vessels being clipped could be safely determined as tumorous and if no changes in evoked potentials were observed. However, the approach met with a degree of suspicion because the report lacked a true positive case. Moreover, Spetzler et al. [12] raised the question of whether ICG angiography can help to differentiate between vascular structures. Our present case report answers this question: ICG videoangiography with temporary main feeder occlusions during spinal hemangioblastoma surgery provides additional useful information about the detailed vasculature, especially about minor feeding arteries.

Benedetto et al. [14] described their experience with the application of ICG videoangiography and FLOW®800 analysis during a spinal hemangioblastoma surgery. After coagulating and cutting the main feeder, it was observed that another feeder remained in the shadowed area of the

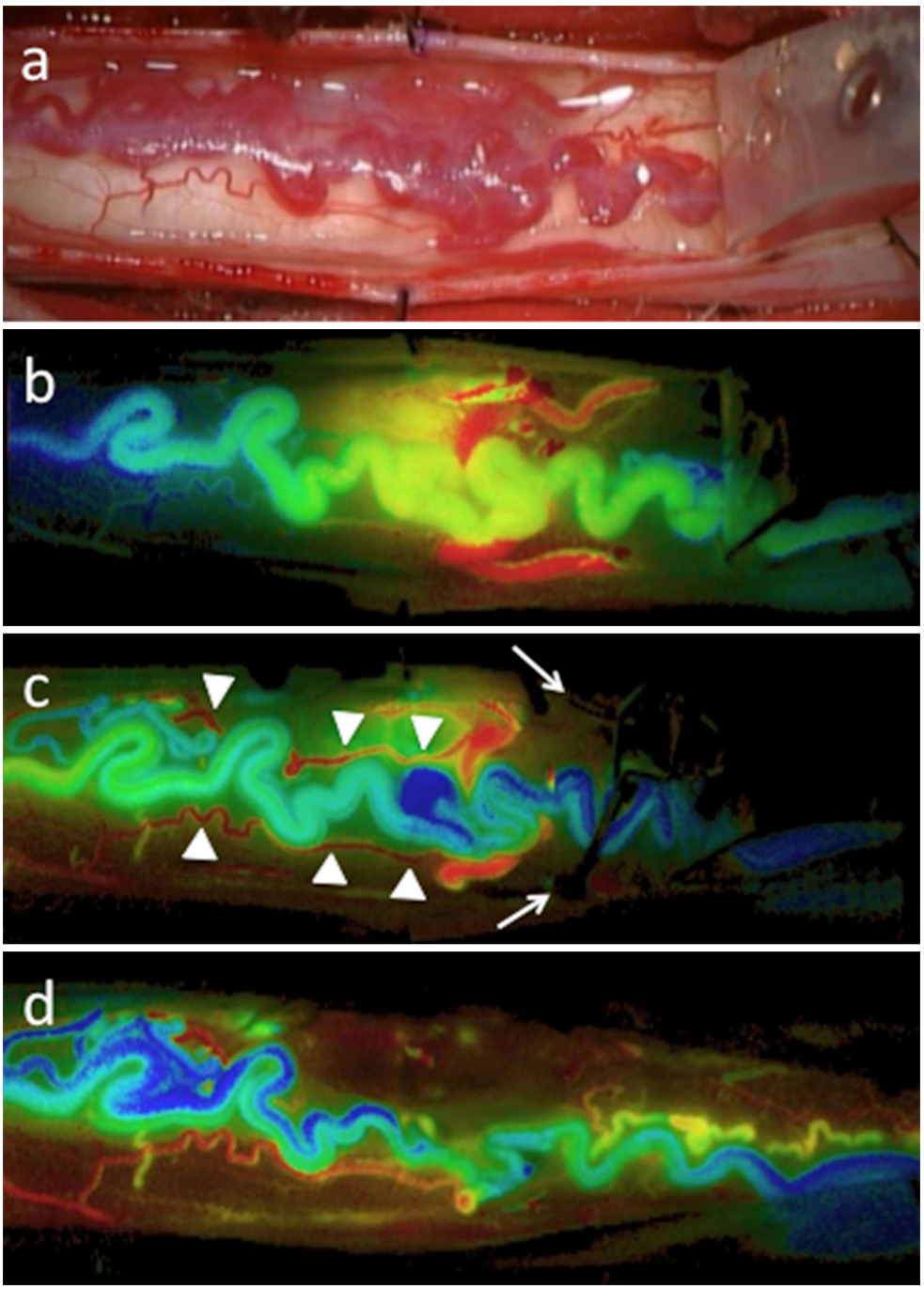

Fig. 3 Intraoperative microscopic photograph (**a**) and indocyanine green videoangiographies using FLOW®800 analysis with false color-coding (**b**–**d**). **a**, **b** Microscopic view and ICG videoangiography reveal two main feeders from the bilateral caudal side. **c** After temporary clips are applied to the two main feeders (*arrows*), 2 minor feeders running along the surface of the spinal cord from the cranial side clearly emerge (*arrowheads*). **d** ICG videoangiography after removal of the tumor shows absence of residual tumor fluorescence and normal perfusion from minor feeders maintained

main feeder. On the other hand, the usefulness of FLOW®800 in the presented case is basically different from the past report, that the FLOW®800 analysis revealed occult vascular channels that were generally difficult to visualize directly. More specifically, reduced shunt flow from the main feeders induced by the temporary occlusion afforded clear visualization of other channels from minor feeders, which were likely normal structures. The size of the tumor in our case was relatively small; however, ICG videoangiography with temporary arterial occlusion will probably be even more useful with larger tumors that have more complicated vasculatures.

Fig. 4 Magnetic resonance images 3 months after surgery. Sagittal T2-weighted images (**a**, **b**) of the thoracic spine show disappearance of the spinal cord edema with a flow void, and the mass lesion

It is thought that perhaps the placement of temporary clips may add risk and obstruct the operative field [12]. We used low volume, profile clips (MH clip; Bear Medic Corp., Tokyo, Japan) for temporary occlusion of the main feeders. It is the same clip we usually use during cerebrovascular bypass surgery in daily practice, and it is more suitable for use in narrow spaces, such as spinal cord surgery. If it is placed in an appropriate fashion, it does not become an obstruction at all.

Conflict of interest The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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