Intraoperative Use of Indocyanine Green Fluorescence Videography for Resection of a Spinal Cord Hemangioblastoma

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BACKGROUND AND IMPORTANCE: Indocyanine green (ICG) fluorescence videography has been recently applied to the neurosurgical field, mostly in the management of cerebral aneurysms, but has had limited description in the subspecialty of spine or oncological neurosurgery. We describe a novel application of this previously defined surgical tool to assist in the resection of a residual spinal cord hemangioblastoma.

CLINICAL PRESENTATION: Our patient is a 49-year-old woman with a residual symptomatic cervical hemangioblastoma that was previously embolized and resected at another institution. After initial symptomatic improvement, she returned with progressive symptoms, increasing radiographic spinal cord edema, and a residual lesion at the level of C1. We resected the remaining tumor with the adjuvant use of ICG fluorescence videography. Intraoperative injection of ICG clearly identified a component of the tumor underlying adhesive, opaque arachnoid that was not visualized by direct microscopy. Immediate postresection ICG videography suggested a complete resection was achieved which was later corroborated by postoperative magnetic resonance imaging.

CONCLUSION: The adjuvant use of ICG videography is a useful surgical tool that permits greater visualization of the complete extent of the lesion, particularly in managing recurrent or residual lesions obscured by adhesions.

KEY WORDS: Cervical, Hemangioblastoma, Indocyanine green, Spine

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Indocyanine green (ICG) fluorescence videography has been well-reported in its use for ophthalmological surgery.[1-4] It recently has been applied to follow retinal capillary hemangioblastomas after treatment,[4] and its use in neurosurgery has been broadened to include intraoperative assessment of vasculature after cerebral aneurysm clipping.[5-7] However, its application in neurosurgical oncological care is still being defined.[8,9] We adapted the use of ICG videography to assist in the resection of a residual spinal cord hemangioblastoma.

CASE PRESENTATION

Our patient is a healthy 49-year-old woman who initially presented with paresthesias in her hands and feet as well as mild nuchal rigidity. She was seen at another institution and found to have an intramedullary cervical hemangioblastoma at the C1 to 2 level. She underwent embolization of a vertebral artery feeding branch followed by C1 and 2 laminectomies and subtotal resection of the hemangioblastoma. She improved after the initial surgery, but approximately 6 months later she noted progressive worsening of her presenting symptoms.

She was referred to our institution concerning numbness and paresthesias throughout her lower extremities, her entire right arm, left hand, and perineal region. She had full strength in all her motor groups, but had brisk reflexes throughout with upgoing plantar reflexes. Serial imaging revealed increased spinal cord edema compared with her initial postoperative imaging as well as a small 5 × 11 mm enhancing intramedullary lesion at C1 (Figure 1).

Given her progressive symptoms and radiographic edema (Figure 2), she opted to undergo repeat surgery for resection of the residual lesion. She underwent reexploration of the wound and resection of the residual hemangioblastoma with neuromonitoring. After opening the dura mater, a small, clearly identifiable lesion was apparent on the dorsum of the spinal cord

ABBREVIATIONS: ICG, indocyanine green

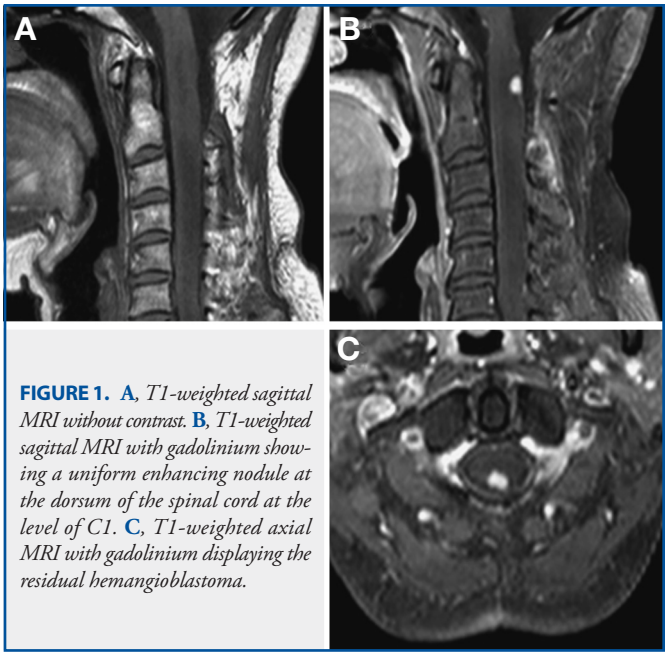


FIGURE 1. **A**, *T1-weighted sagittal MRI without contrast.* **B**, *T1-weighted sagittal MRI with gadolinium showing a uniform enhancing nodule at the dorsum of the spinal cord at the level of C1.* **C**, *T1-weighted axial MRI with gadolinium displaying the residual hemangioblastoma.*

(Figure 3A). However after injection of 50 mg [diluted in 8 mL of sterile saline] of ICG, the remaining hemangioblastoma and component of tumor underneath adhesive scar tissue became more apparent (Figure 3B). The Leica M525 OH 4 microscope fitted the FL800 system and near infrared camera (filtering 835 nm light) were used to excite and visualize the injected ICG. The tumor was carefully resected using microsurgical technique under maximal magnification. Ultimately, the residual tumor was resected en bloc (Figure 3C) and a follow-up ICG injection did not reveal any residual tumor fluorescence (Figure 3D). Immediate and 6-month follow-up MRI imaging did not reveal any residual tumor enhancement and showed significantly decreased edema within the cord (Figure 4).

The patient recovered with mild worsening of numbness in her lower extremities extending to a T10 level. However, she had started to improve by her discharge. At 8 weeks of follow-up, the presenting symptoms in her upper extremities were completely resolved and numbness in her lower extremities was significantly improving, but not completely resolved.

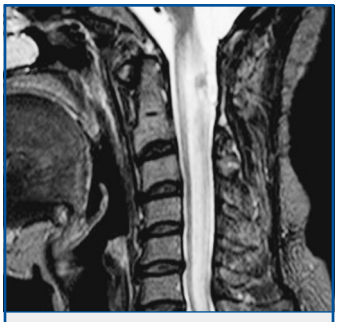


FIGURE 2. *Short tau inversion recovery sagittal MRI image of the cervical spine highlighting the amount of cord edema.*

DISCUSSION

Spinal cord hemangioblastomas are a rare entity, but there is little dispute that surgical management should aim to achieve a complete resection.[10,11] The goal of complete resection is often, but not always achieved using microsurgical techniques. Whereas Roonprapunt et al[10] reported a complete excision in their series of 19 patients, Shin et al[11] reported a complete excision in 18 of 20 patients. They listed excessive blood loss, severe adhesions, and ill-defined margins as reasons limiting a complete resection. Furthermore, all patients with residual tumor had recurrence.[11]

In our case, the initial surgery was performed at another institution and operative reports suggest that a complete excision was attempted, but residual tumor was observed by postoperative imaging. Certainly, the most likely opportunity to achieve a complete excision is during the initial surgery and perhaps ICG videography would be useful to identify the surrounding vasculature of the lesion and facilitate the complete en bloc excision. Although not previously described in the spine, ICG videography has been described to facilitate complete resection of a forearm arteriovenous hemangioma.[12] However, we found the adjuvant use of ICG videography helpful to achieve a complete resection of the residual tumor.

Even with gross total resections, Shin et al[11] reported 3 patients who developed recurrent lesions that required further surgical intervention that can be complicated by adhesions and postoperative scarring. More importantly, we found that ICG helped delineate the extent of the lesion, particularly when the surgical planes are obstructed by adhesive scar tissue. This may facilitate intraoperative planning and resection of the lesion while minimizing trauma to remaining areas of the spinal cord. Furthermore, by defining the extent of the lesion with use of ICG, we may minimize the risk of entering the lesion inadvertently and contributing to massive blood loss or an incomplete resection.[13] Unfortunately, the image visual-

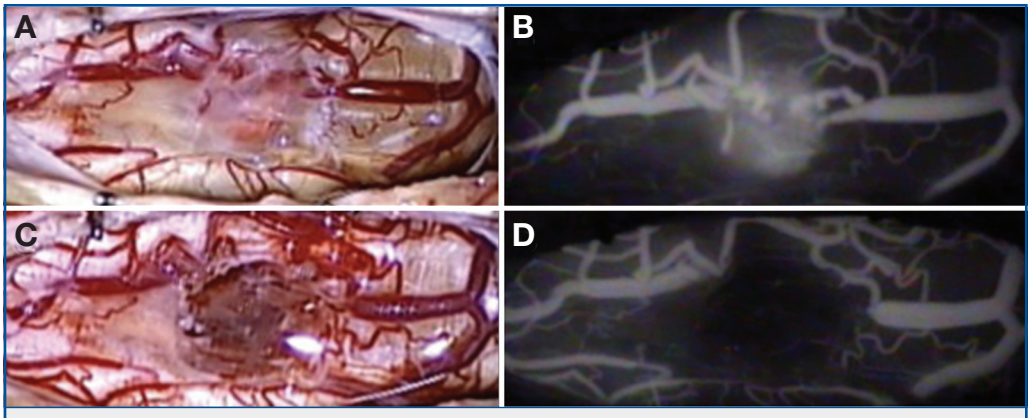


FIGURE 3. **A**, *intraoperative image showing the residual hemangioblastoma and surrounding venous drainage.* **B**, *intraoperative image using ICG videography prior to excision of the tumor. A larger area of enhancement is visible underneath scar tissue using ICG.* **C**, *postexcision image under the light microscope.* **D**, *postexcision ICG videography revealing the absence of the previously enhancing lesion. ICG, indocyanine green.*

ized using ICG videography does not simulate the three-dimensional perspective of standard light microscopy and therefore does not convey additional information regarding the depth of the lesion.

Although the use of preoperative embolization is debatable in the management of these lesions, most authors have supported the use of angiography to visualize the relevant vasculature preoperatively.[10,14] ICG may obviate this need, depending on the size and depth of the lesion, but further technical assessment would be required as comparison. The image visualized with ICG videography was thought to represent the vasculature within the lesion and not breakdown of the blood-brain barrier into edematous neural tissue. Previous authors have demonstrated uptake into gliomas and adjacent neural tissue in animal models at much higher doses, whereas our dosing more closely correlates with visualization seen in vascular pathology.[5-9]



FIGURE 4. *Postoperative T1-weighted sagittal MRI with gadolinium at 6 months suggesting a complete resection.*

To our knowledge ICG videography has not yet had much applicability to the spine. As novel applications, ICG has been reported in attempts to visualize granulation tissue postoperatively in a rat model,[15] and to selectively target nucleus pulposus excision using percutaneous laser microdiscectomy in a rat.[16] However, this is the first clinical application of ICG videography to a spinal cord lesion. Further studies are required to determine which lesions may have greater benefit from the adjuvant use of ICG and the applicability of this technology to resect intramedullary spinal cord tumors.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

Hwang et al report the use of ICG dye to enhance visualization of a residual spinal hemangioblastoma in a patient who had undergone a prior subtotal resection. They credit the ability to visualize the entire extent of the residual tumor to their use of the indocyanine. They indicate that the vascular blush led to the detection of additional tumor under postoperative adhesions. The authors assert that this report represents the first use of this dye for the resection of a spinal cord lesion. However, ICG has been used for years in attempts to delineate the borders of gliomas.[1]

We strongly support the use of indocyanine dye in vascular cases. This dye helps visualize perforating arteries a millimeter in diameter or smaller and the architecture of arteriovenous malformations. It also helps confirm clip occlusion of aneurysms. Of note, we use it frequently in spinal dural arteriovenous fistulas and arteriovenous malformations. The use of indocyanine dye for highly vascular lesions represents a logical extension of a strategy that has become routine.

Whether ICG dye incrementally improves yield, accuracy, or, most importantly, morbidity, is debated. Hemangioblastomas are readily identifiable and resectable, even during repeat surgery for residual tumor.[2]

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Hwang et al have presented a technique whereby the intraoperative injection of indocyanine green (ICG) clearly identified a component of the intramedullary tumor that was not visualized via direct microscopic visualization at the time of surgery. Although the technique has not been validated, its use in selected circumstances should be considered. It most certainly helped in the case presented here. For this, the authors are to be congratulated.

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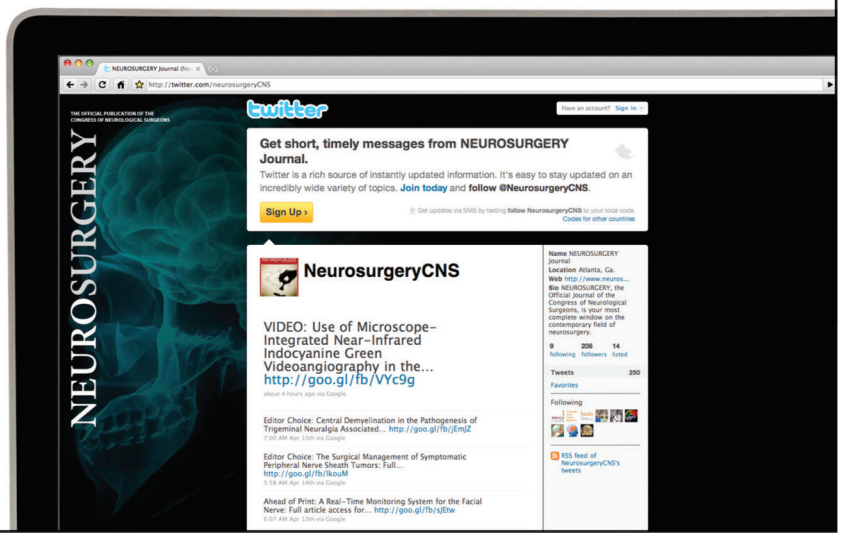
Hwang et al present a case report describing the novel use of ICG fluorescence videography in the resection of a residual spinal cord hemangioblastoma. Utilizing this technology, the authors confirmed an en bloc resection of the tumor. This is an intriguing application of a previously described surgical technique whose primary use has been with ophthalmological surgery.

The primary role of this technology appears to be limited to determining the extent of tumor resection. It is not clear what is specifically defined by the ICG image, ie, how much of the image represents breakdown of the blood-brain barrier within normal surrounding neural tissue. This, in conjunction with the 2-dimensional constraints of the image, prohibits the use of the technology to guide the resection of the tumor. In this respect, its utility may be considered similar to that of intraoperative MRI.

Despite demonstrating the feasibility of incorporating this technology, the true clinical utility cannot be determined from a single case report. As the authors appropriately acknowledge, further study is required to determine the potential impact that this technique will have on the resection of intramedullary spinal cord neoplasms.

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