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Indocyanine Green Fluorescence Endoscopy at Endonasal Transsphenoidal Surgery for an Intracavernous Sinus Dermoid Cyst: Case Report

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Abstract

The complete resection of intracavernous sinus dermoid cysts is very difficult due to tumor tissue adherence to important anatomical structures such as the internal carotid artery (ICA), cavernous sinus, and cranial nerves. As residual dermoid cyst tissue sometimes induces symptoms and repeat surgery may be required after cyst recurrence, minimal invasiveness is an important consideration when selecting the surgical approach to the lesion. We addressed a recurrent intracavernous sinus dermoid cyst by the endoscopic endonasal transsphenoidal approach assisted by neuronavigation and indocyanine green (ICG) endoscopy to confirm the ICA and patency of the cavernous sinus. The ICG endoscope detected the fluorescence signal from the ICA and cavernous sinus; its intensity changed with the passage of time. The ICG endoscope was very useful for real-time imaging, and its high spatial resolution facilitated the detection of the ICA and the patent cavernous sinus. We found it to be of great value for successful endonasal transsphenoidal surgery.

Key words: indocyanine green fluorescence endoscope, dermoid cyst, cavernous sinus, recurrence, transsphenoidal surgery

Introduction

Intracranial dermoid cysts are rare; they comprise less than 1% of all intracranial tumors.[1,2] Between 1989 and 2012, 6,967 patients were registered in the Brain Tumor Data Base of Kumamoto Prefecture. Of these, 7 (0.1%) had intracranial dermoid tumors.[3] Symptomatic dermoid cysts require surgery. Occasionally their capsule adheres to nerves and vessels; this renders their complete removal difficult. As residual cyst tissue can lead to recurrence,[4,5] repeat surgery may be required after partial or subtotal resection to avoid new neurological deficits.

Dermoid cysts in the cavernous sinus are extremely rare and craniotomy is usually applied to access these lesions.[6] However, complete removal is difficult when the tumor capsule adheres to the internal carotid artery (ICA), the wall of the cavernous sinus, and cranial nerves.[6–9] While endoscopic transnasal transsphenoidal surgery (ETSS) is a standard procedure for sellar and parasellar lesions, it has been used in few cavernous sinus dermoid cysts.[10,11]

We encountered a 17-year-old boy with a recurrent intracavernous sinus dermoid cyst. Due to the location of the tumor, the left carotid siphon was slightly extended and the pituitary gland was slightly compressed by the tumor. We chose ETSS to approach it directly and less invasively. While neuronavigation is usually used in ETSS, its spatial resolution was not sufficient in our case for the detection of the fine edge of the ICA and for the confirmation of the patency of the cavernous sinus from the sphenoid sinus. Therefore we used an indocyanine green (ICG) fluorescence endoscope in this operation. In vascular surgery, ICG endoscopes have been used to confirm the patency of vessels not visible under the surgical microscope.[12,13]

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Ours is the first demonstration of the usefulness of the ICG endoscope for identifying the ICA and for confirming patency of the cavernous sinus during ETSS.

Materials and Methods

I. Indocyanine green (ICG) fluorescence

The ICG compound (25 mg), purchased from Daiichi-Sankyo (Tokyo), was dissolved in 10 ml of sterile water and 5 ml of the solution were injected into a peripheral vein as a bolus. Flushing was with 10 ml of saline. The maximum absorption and emission wavelength of ICG in water are 780 nm and 805 nm, respectively; in plasma they are 800 nm and 825 nm.[14]

II. Endoscopes

Rigid 0^{o} and 30^{o} endoscopes (diameter 4 mm, length 18 cm; Karl Storz Endoscopy, El Segundo, California, USA) are commonly used for ETSS (Fig. 1A, upper). To detect the ICA and the patent cavernous sinus, we required a different type of endoscope. We used an ICG endoscope that featured a straight-forward telescope (0^{o}, diameter 5.8 mm, length 19 cm), IMAGE 1 H3-Z FI 3-Chip ICG FULL HD camera head, Image 1 HUBTM HD camera control unit and Karl Storz Cold Light Fountain D-LIGHT P (Karl Storz Endoscopy-America) (Fig. 1A, lower).[13] The light source can be converted from white- to near- infrared light by a foot switch. After placing the ICG endoscope in a suitable position under white light, we switched to near-infrared light to allow the fluorescence signals from the ICG to flow into the ICA and cavernous sinus for their post-injection identification.

III. Measurement of the ICG signals

We performed intraoperative video monitoring of the endoscopic images and identified changes in the fluorescent intensity signals in real-time. After operation, to confirm these changes in individual structures, we imported the recorded ICG endoscopic images in almost every second into photoshop and determined the color value of the spot of each structure.

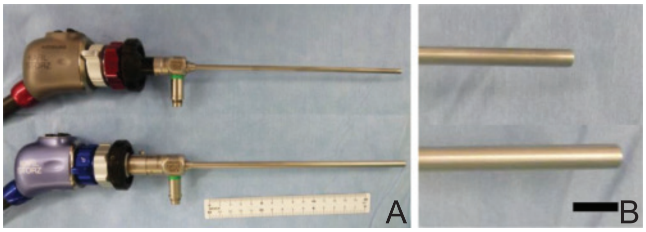

Fig. 1 HD endoscope with a camera head (A, *upper*) and ICG endoscope (A, *lower*). The ICG endoscope is 1 cm longer and 1.8 mm larger in diameter (B). Burr = 10 mm. ICG: indocyanine green.

Case Report

This 17-year-old boy was re-admitted due to magnetic resonance imaging (MRI) evidence of the near-rupture of a recurrent dermoid cyst in the left cavernous sinus. Four years earlier, he had presented with left ptosis, diplopia, and left facial pain. A computed tomography (CT) scan acquired at that time revealed a hypodense round mass lesion in the left cavernous sinus (Fig. 2A). The mass lesion was hyperintense on T_1- and heterogeneously hyperintense on T_2-weighted images; it was not contrast enhanced (Fig. 2B). Characteristically, the hyperintense area on T_1-weighted images was suppressed on fat-suppression MRI images (Fig. 2C). The preoperative diagnosis was dermoid tumor and he underwent operation by craniotomy. The lesion was resected subtotally via the pterional approach. The white sebaceous cyst content containing hairs was removed (Fig. 2D). As pathological study showed squamous epithelium and hairs the final diagnosis was dermoid cyst (Fig. 2E). Postoperative T_1-weighted MRI confirmed resection of the hyperintense mass lesion (Fig. 2F) and his symptoms disappeared soon after the operation.

Subsequent CT and MRI studies performed in the course of 4 years revealed a gradually-growing hyperintense lesion in the removal cavity that took on a dumbbell shape. Although he remained asymptomatic, he underwent repeat surgery to avoid rupture of the dermoid cyst into the subarachnoid space.

Before the second surgery, we performed CT and MRI studies to plan a safe operation. The dermoid cyst was located in the left cavernous sinus; the left carotid siphon was slightly extended by the tumor which partially faced the sphenoid sinus covered by the dura and by bone at the skull base (Fig. 2G–H). We selected ETSS for its lesser invasiveness and used a neuronavigation system (Stealth Station Pro, Medtronic, Minneapolis, Minnesota, USA) and an ICG endoscope to detect the fine edge of the ICA, the pituitary gland and the tumor mass, and to confirm patency of the cavernous sinus.

ETSS was started as in pituitary surgery through the bilateral nostrils. The dura mater around the sellar floor was exposed, and the cavernous sinus predominantly on the left side was detected with the assistance of navigation (Fig. 3A–B). To identify the fine edge of the left ICA and to confirm patency of the cavernous sinus, we injected 5 ml of ICG (25 mg dissolved in 10 ml of sterile water) into a peripheral vein after changing to the ICG endoscope system (Fig. 1A, lower). The fluorescence signals from flowing ICG in the left ICA were seen to pass through the dura and the bone that partially covered the ICA (Fig. 3B, E, I). A few seconds later, the patent cavernous sinus was identified (Fig. 3F, J, and G, K). The mucosa covering the clivus showed fluorescent signals (Fig. 3G, K). The normal pituitary gland became gradually visible more than 30 seconds after ICA detection (Fig. 3H, L).

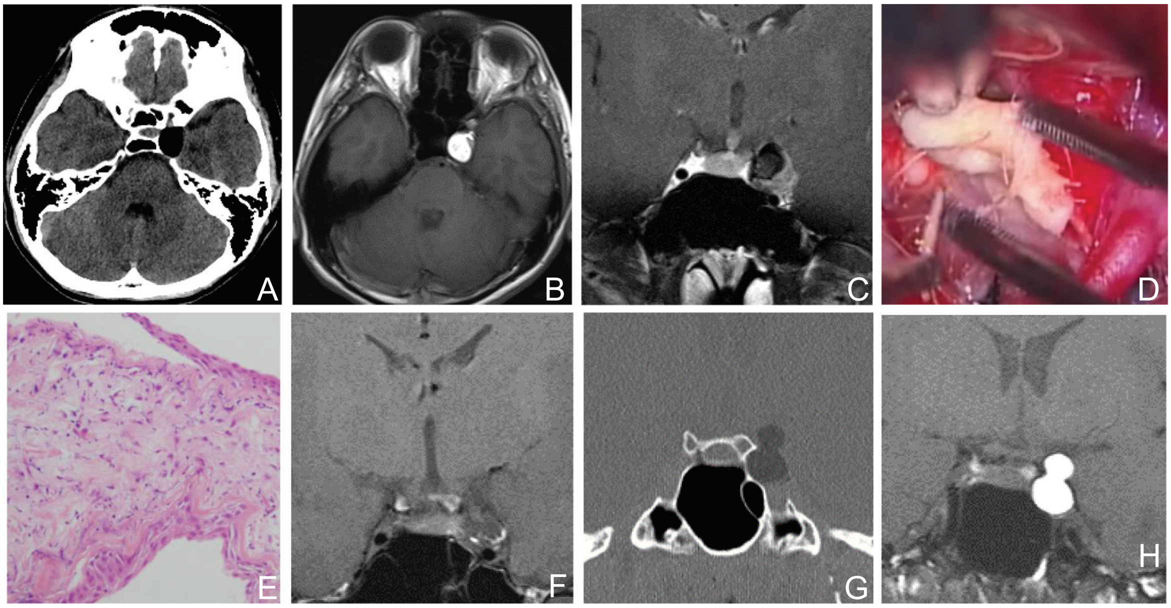

Fig. 2 Computed tomography (CT) scans (A) and magnetic resonance images (MRIs) before the first operation showing an intracavernous sinus dermoid tumor. T_1-weighted axial (B) and fat suppression coronal image with Gd-enhancement (C). Intraoperative photograph demonstrating the white sebaceous contents containing hairs (pterional approach) (D). Photomicrograph of a hematoxylin-eosin-stained section (E). T_1-weighted coronal image after the first operation showing no residual mass (F). Coronal CT image and T_1-weighted coronal image (H) showing the recurrent dermoid cyst 4 years after the first operation.

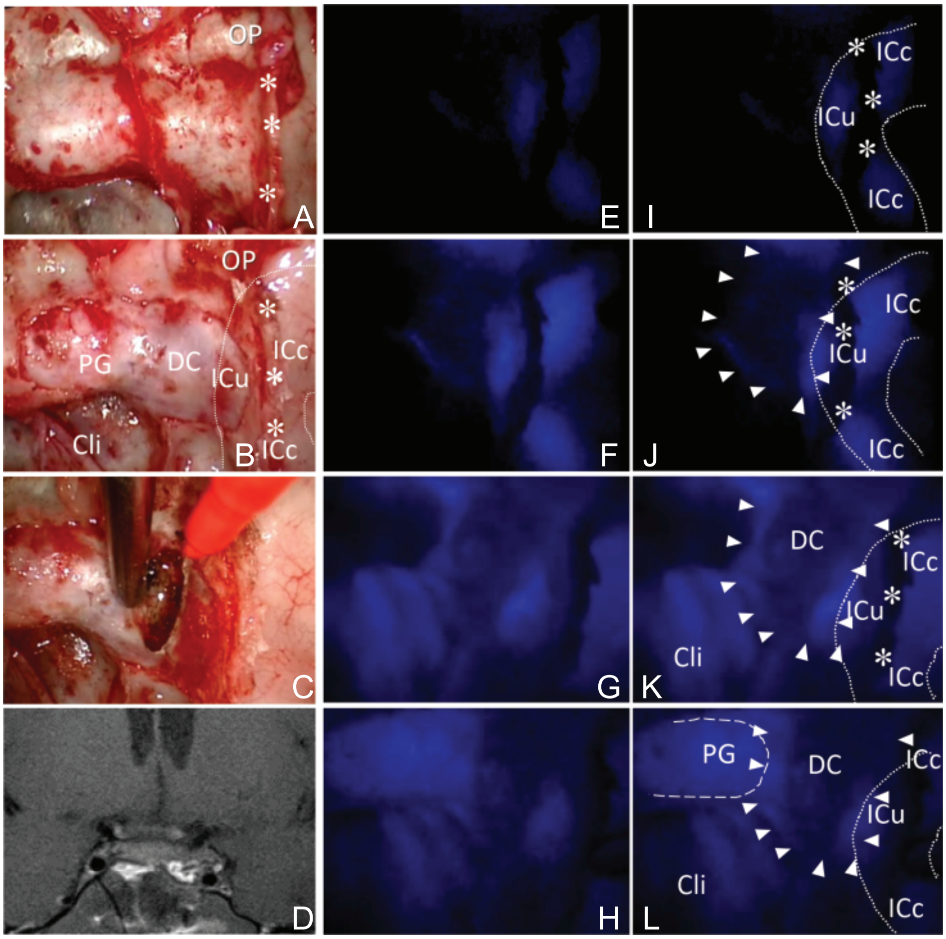

Fig. 3 Intraoperative photographs showing the endoscopic view of the sphenoid sinus before (A) and after partial removal of bone of the sellar floor (B). Intraoperative photographs just after cutting the dura. Outflow of the dermoid cyst content (C). T_1-weighted coronal image after the second operation by ETSS revealing no residual tumor mass (D). Fluorescence signals were detected by the ICG endoscope. The signal intensity changed with the passage of time (original: E–H, traced: I–L). The ICA, traced by a *dotted line* (B, I–L), and then the cavernous sinus (*arrowheads*) were detected (F–G, J–L). The signal from the mucosa in the clival region was upregulated (G, K) and finally the pituitary gland was identified (H, L). *Arrowheads*: cavernous sinus, *asterisks*: residual septum in the sphenoid sinus, *broken line*: pituitary gland, Cli: clivus, DC: dermoid cyst, *dotted line*: internal carotid artery, ETSS: endoscopic transnasal transsphenoidal surgery, IC: internal carotid artery bone-covered (ICc) and bone-uncovered (ICu), ICA: internal carotid artery, ICG: indocyanine green, OP: optic prominence, PG: pituitary gland.

The low fluorescent signal from the dermoid cyst in the cavernous sinus was slightly increased through the dura (Fig. 3H, L).

We next cut the dura, taking care to protect the ICA and the patent cavernous sinus, and evacuated the cystic fluid whose consistency was like that of motor oil (Fig. 3C). There was slight bleeding from the re-opened cavernous sinus due to decompression of a part of the cavernous sinus. Soon thereafter cerebrospinal fluid (CSF) started to leak through the window of the dural incision because the wall of the dermoid cyst in the subarachnoid space was breached. The base of the brain surface was detected endoscopically from the window in the dura. To prevent CSF leakage, after sealing the dural incision with fat and a pedicle mucosal flap, we sprayed the area with fibrin glue. Finally, a sinus balloon (Fuji Systems Co., Tokyo) was inflated to compress the operation site.

Postoperative MRI scans showed no dermoid tumor in the cavity, and the patient was discharged 10 days after the operation without CSF leakage or any neurological deficits (Fig. 3D).

Changes in the ICG fluorescent signals

After operation, pictures of second-by-second intraoperative video recordings were exported to photoshop and the color values of the saved images were measured. Figure 4 shows the changes in the fluorescent signals. The time of first detection of ICG in the ICA was designated 0 second. The ICG signals in the ICA were sharply increased and they peaked at 5 seconds. Their intensity in the cavernous sinus rose to the same level at 10 seconds. The ICG signal peak was lower in the dermoid cyst than the ICA and the cavernous sinus. The signal intensity at the pituitary rose very slowly. At 30 seconds, the signals from the pituitary started to be higher compared to that of ICA and the cavernous sinus.

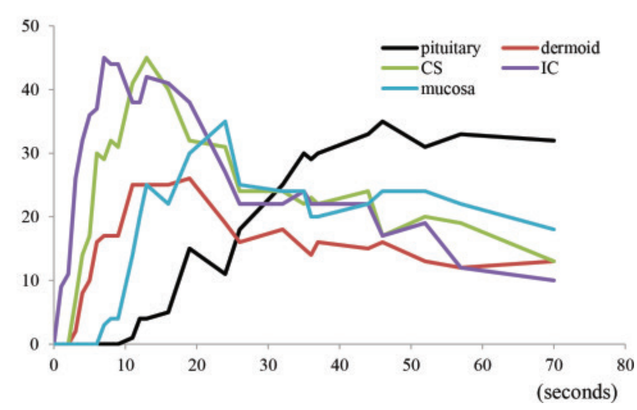

Fig. 4 Changes in the fluorescent signals. The time of first detection of ICG in the ICA was designated 0 second. CS: cavernous sinus, ICA: internal carotid artery, ICG: indocyanine green, Mucosa: mucosa in the clival region.

Discussion

The rupture of dermoid cysts in the CSF space has been reported.[5,9,15] To prevent meningitis elicited by dermoid cyst rupture, repeat operations may be needed in tumors that adhere to important structures such as the brain, vessels, and nerves. Therefore, less invasive procedures must be selected for such patients.

The blood flow is intraoperatively monitored by angiography and Doppler sonography to avoid complications in vascular surgery.[16,17] Microscope-integrated ICG video angiography has been used to confirm the blood flow in real-time[18–21] and not only microscope-integrated but also endoscope-integrated ICG video angiography has been used in vascular surgery to confirm the patency of vessels not visible under the operative microscope.[12,13]

The fluorescence signals of 5-aminolevulinic acid (5-ALA) have been used for the photodynamic diagnosis of brain tumors.[22] 5-ALA-assisted tumor resection had a direct beneficial effect on the overall survival of patients with primary malignant gliomas.[22–24] Neuroendoscopic surgeries and/or assists are important for minimal invasiveness. The endoscopic identification and biopsy of an intraventricular malignant glioma and a deep-seated primary malignant brain tumor have been reported.[25,26] In patients with pituitary adenomas who underwent ETSS, the fluorescence signals of 5-ALA and ICG have helped to identify the tumors.[27,28]

Neuroendoscopic images are two-dimensional and they can be disorienting. However, characteristic anatomical structures and color distinctions facilitate the understanding of the exact anatomical orientation. In endoscopic skull base surgery, anatomical landmarks are sometimes buried in bone and tumors. Instrumentation is available to detect the ICA and cavernous sinus in ETSS. Neuronavigation systems provide good orientation and Doppler sonography shows the flow in arteries in real-time, however their spatial resolution can be insufficient for some types of operation and the detection of real-time venous flow is difficult.

We used an ICG endoscope in a patient with a recurrent intracavernous sinus dermoid cyst. It helped to detect the fine edge of the ICA and the patent cavernous sinus. We were able to see fluorescence signals from both the ICA and the cavernous sinus even though the ICA was covered by thin bone. We found ICG endoscopy very useful for ETSS because it yielded real-time high-resolution images. The intensity of the fluorescence signals at each site changed with the passage of time.

The diameter of currently available ICG endoscopes is larger than that of high-resolution rigid endoscopes (5.8 mm vs 4 mm) (Fig. 1A, B) and there is no device for washing their tip. The utility of current ICG endoscope is under investigation and improvements in these instruments will render them important assist devices for ETSS.

Conflicts of Interest Disclosure

None of the authors have any financial interest in the materials and devices described in this article.

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