

Endoscopic opening of the foramen of Magendie using transaqueductal navigation for membrane obstruction of the fourth ventricle outlets

Technical note

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✓ A membrane obstruction of the foramina of Magendie and Luschka is an uncommon origin of hydrocephalus characterized by unusual clinical symptoms of rhomboid fossa hypertension. Various surgical approaches have been proposed to alleviate this obstruction, including opening the obstructed foramen of Magendie using suboccipital craniectomy, shunting procedures, and more recently, endoscopic third ventriculostomy (ETV). In some cases, however, reshaping of the posterior fossa due to the collapse of the prepontine cistern could make ETV difficult for the surgeon and dangerous to the patient. In these cases, endoscopic opening of the foramen of Magendie by transaqueductal navigation of the fourth ventricle is a suitable and feasible therapeutic option.

KEY WORDS • foramen of Magendie • hydrocephalus • fourth ventricle surgery • neuroendoscopy

IDIOPATHIC stenosis or closure of the foramina of Magendie and Luschka is a rare cause of obstructive hydrocephalus, characterized by clinical signs related to intracranial hypertension and rhomboid fossa compression.⁶ The cause of this obstruction must be distinguished pathologically and clinically from other possibilities, such as Dandy–Walker syndrome and Chiari malformation Type I.⁴ Opening the obstructed foramen of Magendie by suboccipital craniectomy and the use of shunting procedures have proved to be valuable yet aggressive treatments for this pathological condition, and are subject to many complications.^{7,14} In recent years, ETV has also proved to be a very suitable and effective treatment for closure of the Magendie and Luschka foramina and other causes of obstructive hydrocephalus.^{8,10} In some cases, however, enlargement of the fourth ventricle rearranges space in the posterior fossa and specifically constricts the interpeduncular and prepontine cisterns in such a way that even the basilar artery remains encased between the clivus and brainstem. This adverse anatomical situation is recognized as one of the rare conditions in which ETV may not be a suitable approach.^{3,13}

Our center has developed a safe and simple technique for neuronavigation in the fourth ventricle using a flexible endoscope. This technique has been used for treatment in 52 patients with a variety of abnormalities, including the fol-

lowing: 20 patients with intraventricular hemorrhages requiring aspiration; 19 with normal-pressure hydrocephalus; four with aqueductal stenosis after aqueductoplasty; two with aqueductal exophytic soft gliomas; one with a colloid cyst and one with cystic intraventricular craniopharyngioma in whom the fourth ventricle was explored to aspirate fragments of colloid or cholesterinic cyst content; and five patients with tetraventricular hydrocephalus due to membrane occlusion. In this study we present our technique of neuronavigation in the fourth ventricle using a flexible endoscope, illustrated by a single case of successfully treated obstructive tetraventricular hydrocephalus.

Surgical Technique

The patient is placed supine, and general anesthesia is induced. The frontal horn of the lateral ventricle first undergoes cannulation with a 14-French peel-away catheter introducer (Codman, Raynham, MA) through a precoronal right bur hole 2 cm anterior to the coronal suture and 2 cm from the midline. The flexible endoscope (Codman), with an external diameter of 3.9 mm, is then introduced and manipulated throughout the procedure using a freehand technique, taking advantage of the instrument tip's three basic movements of flexion, extension, and rotation. At the third ventricle, the scope is guided backward toward the opening of the aqueduct to the midbrain. In cases of tetraventricular hydrocephalus, the aqueduct is dilated and the scope passes through quite easily (Fig. 1). Once in view of the fourth

Abbreviations used in this paper: CSF = cerebrospinal fluid; ETV = endoscopic third ventriculostomy; MR = magnetic resonance.

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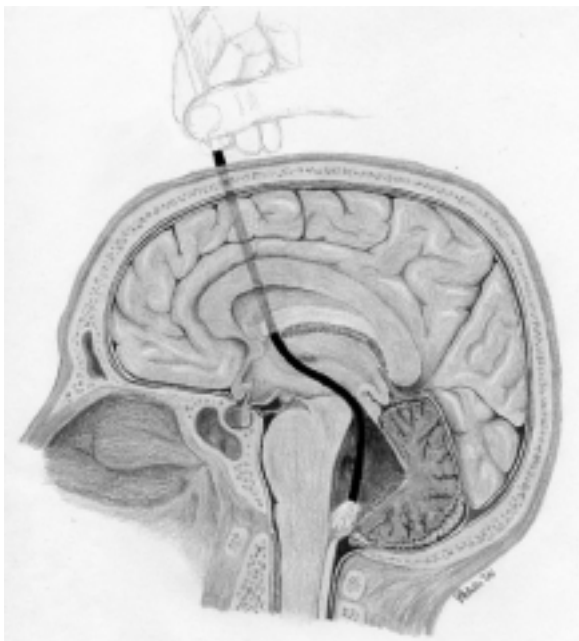


FIG. 1. Illustration showing the path of the endoscope from the lateral ventricles to the fourth ventricle.

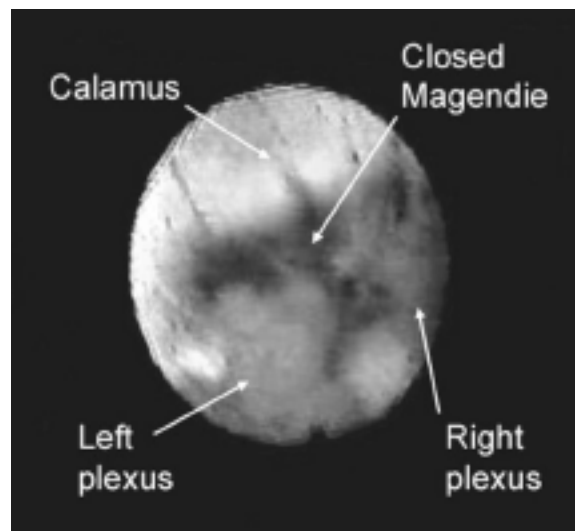


FIG. 2. Endoscopic photograph showing a thick membrane occluding the foramen of Magendie.

ventricle, free irrigation is ceased because the aqueduct is occupied and obstructed by the size of the instrument.⁹ The fourth ventricle in this particular phase is completely trapped and would be clogged by additional liquid volumes, which could result in life-threatening episodes of bradycardia.⁵ If irrigation is necessary, fluids should be administered using a simple syringe so that all additional fluid volume can be carefully balanced by an equivalent volume of fluid withdrawal. The scope is positioned posteriorly; therefore the neurosurgeon should note that the dorsal and ventral anatomical structures are now projected on the screen downward and upward, respectively. After passing the ampulla and posterior part of the aqueduct, the median sulcus of the fourth ventricle leads immediately to the posterior triangle of the rhomboid fossa. The calamus scriptorius then comes into view, with evidence of the hypoglossal triangle, vagal nerve triangle, and central canal of the spinal cord. The lateral recesses appear enlarged and both Luschka foramina are obstructed by thick membranes. A thick membrane is stretched from the borders of the calamus scriptorius to the pyramid of the vermis, occluding the foramen of Magendie (Fig. 2). This membrane is first perforated using a monopolar coagulator, or "saline torch" (ME², Codman), and the opening is enlarged (Fig. 3) with the inflation of a Fogarty balloon. The endoscope can be easily advanced into the cisterna magna to confirm the extent of the cisterna magna and the absence of adhesions. The instrument is then carefully withdrawn, pausing briefly in front of the opening of the aqueduct to check for any signs of microcontusions or ependymal damage. The whole procedure lasts 35 minutes, and the time spent in the fourth ventricle is approximately 20 minutes.

Illustrative Case

History and Examination. This 64-year-old woman pre-

sented with a 2-year history of cervical spine pain, treated pharmacologically without relief, and a 12-month history of recurrent nighttime headaches in the right parietooccipital area, which had become continuous 2 months before admission. The patient reported disturbed gait, dizziness, and progressive cerebellar ataxia, accompanied by nausea and vomiting during head movements. The neurological examination demonstrated impaired cervical motility related to pain, and cerebellar ataxia. Her cranial nerve and sensorimotor functions and brainstem reflexes were normal.

Cerebral computed tomography and MR imaging revealed the presence of an obstructive tetraventricular hydrocephalus, downward displacement of the third ventricle floor, obliteration of the retrocerebellar CSF space (Fig. 4), and a mean herniation of the cerebellar tonsils 3 mm below the basion–opisthion line. The transverse mean diameter of the third ventricle was 29 mm, and the sagittal mean diameter of the fourth ventricle was 38 mm. The interpeduncular and prepontine cisterns were significantly reduced due to dilation of the fourth ventricle. The patient was normotensive with normal coagulation. A standard ETV was scheduled.

Operation. The initial endoscopic inspection showed that the floor of the third ventricle was lifted by the tip of the basilar artery without any available space for a stoma, confirming the concerns raised by MR imaging, which had shown the clivus to be bundled with the basilar artery and brainstem. Endoscopic third ventriculostomy was considered impracticable and was ruled out. We decided to carry out a ventriculostomy of the fourth ventricle to verify the feasibility of opening the foramen of Magendie using transaqueductal endoscopy. This was performed and good CSF flow was restored through the fenestration.

Postoperative Course. The postoperative course was without complications. The patient improved rapidly, with complete headache relief. The following day, a computed tomography scan provided better evidence of the CSF spaces at the convexity of the cerebral hemispheres. The patient was discharged from the hospital on Day 6 after treatment.

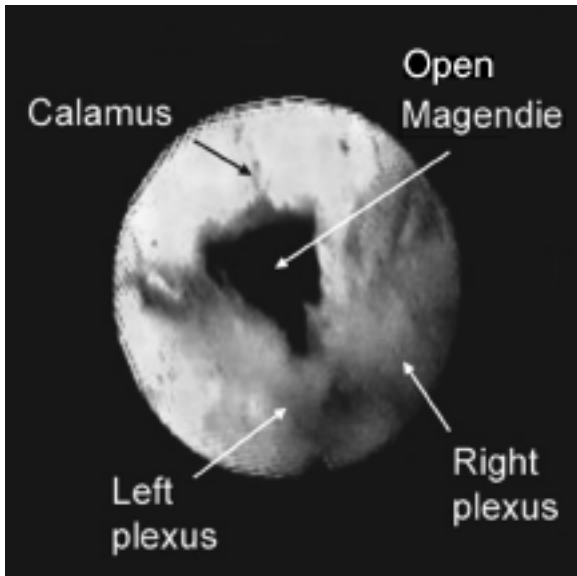


FIG. 3. Endoscopic photograph showing postoperative opening of the fourth ventricle. The obstructing membrane is first perforated using a monopolar coagulator and then completely opened with a Fogarty balloon. Good CSF flux is restored.



FIG. 5. Sagittal T₂-weighted MR image 4 months after surgery, demonstrating a significant reduction of hydrocephalus with enlargement of the interpeduncular and prepontine cisterns and elimination of the downward displacement of the third ventricle floor.

She recovered completely and all adverse neurological symptoms resolved in less than 8 weeks.

A significant reduction in the extent of hydrocephalus was seen using MR imaging 4 months after surgery, with enlargement of the interpeduncular and prepontine cisterns and the absence of downward displacement of the third ventricle floor (Fig. 5). The transverse mean diameter of the third ventricle was now 8 mm, and the sagittal mean diameter of the fourth ventricle was 21 mm.

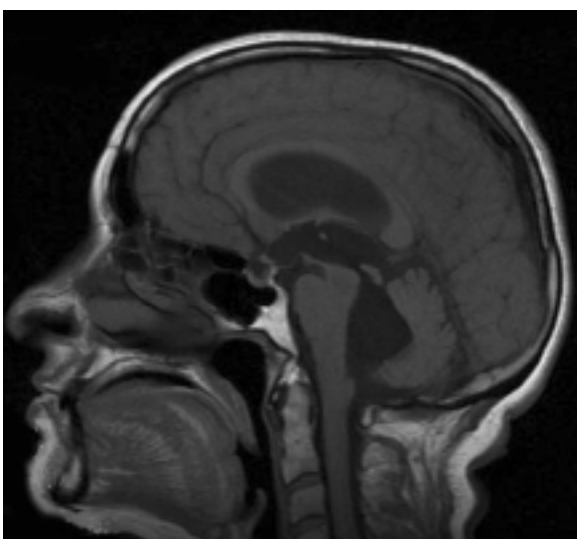


FIG. 4. Sagittal T₁-weighted MR image demonstrating obstructive tetraventricular hydrocephalus. The floor of the third ventricle is displaced downward, the retrocerebellar CSF space is obliterated, and the interpeduncular and prepontine cisterns are reduced.

Discussion

Congenital or acquired membrane obstruction of the fourth ventricle foramina is uncommon and is typically managed by ventriculoperitoneal shunts. Other surgeons have attempted a more physiological approach using microsurgical exploration of the foramen of Magendie, and performed a suboccipital craniectomy to excise the obstructing membranes. These approaches were also associated with positioning a catheter between the fourth ventricle and the cisterna magna.^{6,7} Using ETV is a less physiological approach, but is now an accepted alternative in the management of congenital fourth ventricular imperforation or membrane obstruction, as well as in the other causes of constrictive outlet closure such as Chiari malformation Type I.^{8,10,11}

Neuronavigation beyond the aqueduct can be considered appropriate in only very specific situations. One of these situations would be completely clearing blood clots in intraventricular hemorrhages.⁹ Aspiration of intraventricular neurocysticercosis might be another good indication,^{1,12} as would endoscopic removal or obtaining biopsy specimens of small soft tumors growing from the quadrigeminal plate into the posterior part of the aqueduct (P. Longatti, et al., unpublished data).

Many theoretical objections may be raised against trans-aqueductal navigation of the fourth ventricle. The navigability of the aqueducts and the suitability of our instruments for the task may be two common objections. In pathological conditions, and particularly in tetraventricular hydrocephalus, the shape of the aqueduct loses its anatomical triangularity, becoming oval or circular and thus well suited to navigation. Our own experience in 52 cases of fourth ventricle navigation confirms the navigability of the aqueduct previously shown by cine MR imaging.² At least theoretically, endoscopic opening of the foramen of Magendie by trans-aqueductal navigation of the fourth ventricle has at least two

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advantages over ETV: 1) a more physiological CSF flow is unquestionably restored, and 2) possible damage to neural structures of the third ventricle floor is clearly avoided.

In our experience the transaqueductal navigation of the fourth ventricle is also surprisingly safe. Small asymptomatic ependymal contusions of the opening of the aqueduct, noted when the endoscope exited the fourth ventricle, were seen in two of 52 surgical explorations. The only neurological complication observed in our patient series was a mild transitory diplopia in a case of aqueductoplasty, and the neurological deficit was almost certainly caused by the aqueductoplasty itself rather than by the transaqueductal passage of the endoscope. The endoscope must be withdrawn carefully, because if its tip is not in a straight position, it could lead to serious damage to the areas surrounding the aqueduct. Potential damage to surrounding brain is more difficult to evaluate during neuroendoscopic aspiration of intraventricular hemorrhages.

In cases involving trapped ventricles due to hemorrhages or membrane obstructions, four intraoperative episodes of extreme bradycardia occurred in our series due to excessive irrigation. These episodes immediately resolved after withdrawing small volumes of ventricular fluid. This experience taught us to be much more cautious and accurate when irrigating inside the fourth ventricle. Specific risks in endoscopic opening of the foramen of Magendie by transaqueductal navigation of the fourth ventricle include potential damage to the posterior inferior cerebellar arteries hidden by the thick membrane, and the compression of the calamus scriptorius structures by the Fogarty balloon.

Conclusions

Endoscopic third ventriculostomy remains the standard approach to the treatment of a hydrocephalus due to membrane obstruction of the fourth ventricle outlets. When unfavorable anatomical conditions hinder ETV, however, endoscopic opening of the foramen of Magendie by transaqueductal navigation of the fourth ventricle should be considered as a feasible and effective therapeutic option.

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