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Endoscopic Aqueductal Plasty Via the Fourth Ventricle Through the Cerebellar Hemisphere Under Navigating System Guidance

—Technical Note—

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Abstract

A 1-year 8-month-old boy presented with isolated fourth ventricle after ventriculoperitoneal shunting for hydrocephalus associated with ventricular and subarachnoid hemorrhage. The therapeutic endoscope was inserted through the thin left cerebellar hemisphere. Endoscopic aqueductal plasty was performed via the enlarged fourth ventricle under guidance from a navigating system. Endoscopic aqueductal plasty via the fourth ventricle under navigating system guidance is a useful procedure enabling less invasive surgery for isolated fourth ventricle associated with slit-like ventricle after shunt placement.

Key words: aqueductal plasty, isolated fourth ventricle, endoscope, navigation

Introduction

Isolated fourth ventricle is caused by obstruction of both the aqueduct and the foramina of Luschka and Magendie, and is an important complication of ventriculoperitoneal shunting. Isolated fourth ventricle can be treated by a direct approach and excision of the occluding membranous tissue, direct fourth ventricular shunting, drainage in Y with supratentorial shunting, and shunting with a catheter to the subarachnoid space.[1-6,8,10] Recent advances in neuroendoscopic surgery have allowed endoscopic aqueductal plasty in a few successful cases. However, the most appropriate procedures, including the approach to the aqueduct, remain unclear.

We performed aqueductal plasty with a flexible endoscope inserted into the enlarged fourth ventricle through the thin cerebellar hemisphere.

Case Report

A 1-year 8-month-old boy was born by cesarean section at 32 weeks of pregnancy due to preshock state in the mother caused by heavy bleeding into the amniotic cavity. His weight at birth was 2218 g on July 24, 1996. Apnea attacks began on the 8th day after birth. Head ultrasonography revealed hydrocephalus, so he was hospitalized in our department for close examination. Findings at admission were tendency toward somnolence, apnea, and enlargement of the anterior fontanelle. Computed tomography (CT) revealed distinct hydrocephalus with intraventricular and subarachnoid hemorrhage. Emergency ventricular drainage via the anterior horn of the right lateral ventricle was performed. Intensive care for conditions resulting from premature birth and control of intracranial pressure by continuous ventricular drainage were continued for 2 months. Ventriculoperitoneal shunting was then performed with a Medos programmable shunt system (Medos S.A., Le Locle, Switzerland). Follow-up CT on December 9, 1997 revealed slit-like changes of the bilateral lateral and third ventricles, and distinct enlargement of the fourth ventricle (Fig. 1 *upper row*). Magnetic resonance (MR) imaging also showed aqueductal occlusion and thinning of the brain stem. He had truncal ataxia, and motor and mental retardation on second admission. Endoscopic aqueductal plasty

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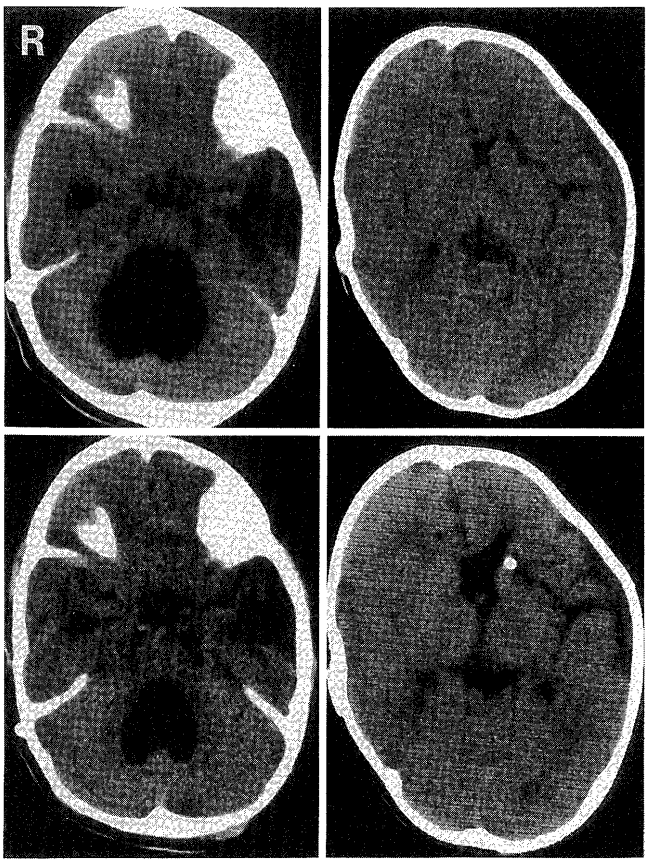

Fig. 1 Preoperative (*upper row*) and postoperative (*lower row*) computed tomography scans showing the fourth ventricle was markedly reduced in size and slit-like ventricle was resolved 2 months after the operation. *left column*: infratentorial, *right column*: supratentorial.

was performed via the fourth ventricle through the cerebellar hemisphere assisted by a navigating system on March 25, 1998.

The aqueduct could not be approached through the narrow lateral and third ventricles, so we performed endoscopic aqueductal plasty via the enlarged fourth ventricle through the thin left cerebellar hemisphere. Under general anesthesia, a suboccipital small craniectomy was performed in the prone position with a linear skin incision. The fourth ventricle was cannulated using a 14-F peel-away sheath through the left cerebellar hemisphere via the small dural incision. A rigid 4-mm-diameter endoscope (Olympus Optical Co., Ltd., Tokyo) linked to navigating system (Evans; Tomiki Medical Instrument Co., Ltd., Kanazawa) was introduced. The fourth ventricle was inspected in detail. Although identification of the aqueduct was difficult only by endoscopic inspection, it could be recognized under navigating system guidance which could monitor the position of the tip of the rigid endoscope on the display in real time.[7] The aqueduct was occluded with membranous tissue (Fig. 2 *left*). The rigid endoscope was then exchanged for a flexible one (Codman, Raynham, Mass., U.S.A.) for therapy. A small stoma was made, and carefully the membranous tissue electrocoagulated with a ME2 (Codman). A percutaneous transluminal angioplasty 3.2-F catheter balloon (Medtronic Micro Interventional System, Sunnyvale, Calif., U.S.A.) was inserted into the tiny stoma and inflated to 4 mm diameters. Then the membranous tissue around the stoma was electrocoagulated and blunted endoscopically. Finally, the massa intermedia in the third ventricle was observed through the opened aqueduct (Fig. 2 *center*, *right*).

Postoperative cine-mode MR imaging demonstrated high signal intensity through the aqueduct, suggesting flow of cerebrospinal fluid and adequate

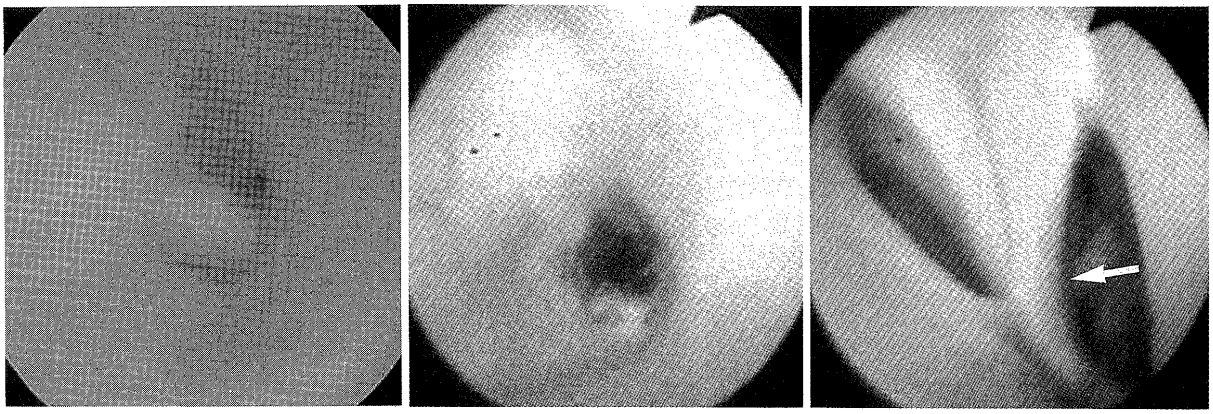

Fig. 2 Endoscopic intraoperative views showing (*left*) the aqueduct occluded with membranous tissue before aqueductal plasty, (*center*) the aqueduct after aqueductal plasty, (*right*) the massa intermedia observed through the opened aqueduct (*arrow*).

Fig. 3 Postoperative cine-mode magnetic resonance image demonstrating high signal intensity through the aqueduct, suggesting flow of cerebrospinal fluid and adequate patency of the aqueduct.

patency of the aqueduct (Fig. 3). CT showed the fourth ventricle was markedly reduced in size and slit-like ventricle was resolved 2 months after the operation (Fig. 1 *lower row*). There were no complications postoperatively and the patient showed a gradual improvement of truncal ataxia.

Discussion

Most cases of isolated fourth ventricle associated with slit-like ventricle after shunt placement have indicated that the approach to the aqueduct through the enlarged fourth ventricle is easier than through the narrow lateral and third ventricles. An excellent method of treating isolated fourth ventricle is endoscopic opening of the aqueduct via the foramen of Magendie.[9] A rigid endoscope was used because of the impossibility of obtaining sufficiently controlled movement with a flexible one. The thin cerebellar hemisphere and enlarged fourth ventricle offer easy access to the aqueduct and adequate working space for the therapeutic flexible fiberscope, so we could perform aqueductal plasty via the fourth ventricle through the cerebellar hemisphere with a flexible fiberscope. Moreover, we approached the aqueduct under guidance of a navigating system, which allowed us to easily and smoothly reach to the aqueduct without disorientation.

Experience with endoscopic aqueductal plasty is limited, and some cases have shown important problems, including re-occlusion of the opened aqueduct and the risk of heat shock during endoscopic procedures. Therefore, further investigations must be continued for evaluation of this procedure. In our opinion, endoscopic aqueductal plasty via the fourth ventricle through the cerebellar hemisphere with a navigating system is useful and enables less invasive neurosurgery for isolated fourth ventricle.

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Commentary

Isolated fourth ventricles are a rare complication of shunting procedure. They occur generally several years after the first implantation and the treatment remains controversial. Some authors recommend a

cysto-subarachnoid or a cysto-peritoneal drainage. Others are in favor of a surgical opening of the fourth ventricle with or without a cannulation of the aqueduct of Sylvius.

The article of Hamada and collaborators presents an interesting technique. A 20-month-old girl presented with ataxia and psycho-motor retardation related with an isolated fourth ventricle. The patient underwent shunting at the age of 2 months for hydrocephalus secondary to a ventricular and subarachnoid hemorrhage. The authors explored the fourth ventricle through the cerebellar hemisphere with an endoscope. With the assistance of a navigating system, an aqueductal plasty was performed successfully.

This technique is interesting since it avoids a more invasive surgical opening of the dilated fourth ventricle and realizes a communication between the third and the entrapped fourth ventricle. Technically, a penetration into the fourth ventricle through an endoscope remains easy. In contrast, localization of the obstructed aqueduct of Sylvius remains a problem in most of the cases, even when the floor of the fourth ventricle is surgically exposed. The authors recommend the use of a flexible endoscope. Moreover they have combined a neuronavigating system in order to detect precisely the entrance of the aqueduct.

The two main risks of the technique are secondary occlusion of the aqueduct, especially in the case of an hemorrhagic procedure, and injury of the brain stem in difficult cases. Nevertheless this elegant technique may be encouraged, even if further cases and explorations are needed.

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The authors have written an interesting and informative article discussing a case of an almost 2-year-old boy who underwent endoscopic aqueductoplasty via the fourth ventricle through the left cerebellar hemisphere assisted by a navigation system for treatment of an isolated fourth ventricle. Their surgical technique is described in detail and their results are well documented. They note that endoscopic aqueductoplasty via the fourth ventricle through the cerebellar hemisphere is a useful and less invasive treatment for isolated fourth ventricle associated with slit-like ventricle after shunt placement.

The most important contribution of the article is the succinct description of the technique. The authors used both rigid and flexible endoscopes. The rigid endoscope was used for inspection of the fourth ventricle and identification of the aqueduct assisted by a navigation system, whereas the flexible endoscope was used (without neuronavigational assistants) for subsequent evaluation and fenestration of the aqueduct using a transluminal angioplasty catheter.

Restoration of the aqueduct is rarely reported in the literature. Dandy[1] performed the first reconstruction of the aqueduct of Sylvius in 1920 via the fourth ventricle. Recently Schroeder and Gaab[3] published a series of 17 patients who underwent endoscopic aqueductoplasty via the third ventricle.

The authors describe an interesting endoscopic trans-fourth ventricle approach in a case of an isolated fourth ventricle associated with slit-like ventricle. According to the authors, and to our opinion,[2] neuronavigation systems seems extremely helpful. We think that a paravermian approach between the cerebellar hemisphere and the vermis may be a good alternative to the approach through the left cerebellar hemisphere. Importantly, it should be pointed out that endoscopic aqueductoplasty is neither an easy technique nor a routine procedure that carries potential risks, and thus cannot be recommended to neuroendoscopy beginners. In our opinion, the technique of endoscopic aqueductoplasty should be restricted to membranous stenoses. In patients with membranous stenoses of the caudal aqueduct and an enlargement of the fourth ventricle, the presented technique seems an alternative to open microsurgical or shunt procedures.

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Advances in neuroendoscopic surgery have allowed the development of new ways for treating complicated or intractable brain diseases. The authors have developed a new procedure for the treatment of isolated fourth ventricle: endoscopic aqueductal plasty under

guidance from a navigation system via the enlarged fourth ventricle through the cerebellar hemisphere. This is a safe method, because the cerebellar hemisphere is usually thin in patients with this condition. Although a navigation system is useful for intraoperative identification of the aqueduct, brain shift caused by CSF leakage during the procedure must be taken into account. Would it be better to use a stent to prevent reobstruction of the aqueduct? In any event, this seems a valid strategy for treatment of isolated fourth ventricle, and is elegantly illustrated in this case presentation.

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The authors have performed an interesting neurosurgical approach to the aqueduct of Sylvius in a patient with a trapped fourth ventricle. Because the lateral and third ventricles were small in this case, the authors chose to use a transcerebellar approach to the dilated fourth ventricle. Using a combination of endoscopic techniques and neuronavigation, the authors successfully performed an aqueductal plasty, and the patient did well.

This case serves to illustrate the value of combining these two techniques. While the endoscope provides outstanding visualization of intraventricular anatomy, the identification of normal anatomical structures like the aqueduct can be difficult in the presence of existing pathology. It is for this reason that the use of a navigational system is indispensable. Without the information provided by the navigational system, the chances for error in performing this procedure may have been high and the outcome deleterious for the patient.

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