Endoscopic ventricular fenestration using a “saline torch”

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The fiberoptic endoscope has never gained popularity among neurosurgeons although it is ideally suited for navigating within the cerebral ventricles. Recent advances in optics and miniaturization make the application of endoscopy in neurosurgery more practical. The authors report eight children who underwent ventriculoscopic fenestration of symptomatic loculated cerebrospinal fluid (CSF) collections. These CSF collections were either isolated ventricular cysts or trapped lateral ventricles secondary to obstruction at the foramen of Monro. Cyst wall dissection was carried out with a “saline torch” dissector which was introduced through a working channel in the ventriculoscope. The torch was used to coagulate vessels and to sculpt large windows in cyst walls or in the septum pellucidum. Ventriculoscope-guided cyst fenestration can be performed safely and easily under direct vision. The technique may permit simplification of shunt systems in some patients and elimination of shunts in others.

KEY WORDS • cyst • endoscopy • hydrocephalus • ventriculoscope • instrumentation

Loculated collections of cerebrospinal fluid (CSF) may occur alone or in association with hydrocephalus. Such CSF collections include: parenchymal or intraventricular cysts associated with germinal matrix hemorrhage; trapped lateral ventricles secondary to obstruction at the foramen of Monro; arachnoid or ependymal cysts; and congenital malformations. If a symptomatic loculated collection of CSF occurs in the absence of hydrocephalus, a simple cyst-peritoneal shunt is effective treatment. If a loculated collection of CSF occurs in association with hydrocephalus, effective treatment often requires shunt placement in both compartments. Attempts to mechanically create a communication between compartments and place a single shunt have often been unsuccessful, presumably because of scarring and closure of the site of communication.

Recent advances in optics and miniaturization have led to the development of a new flexible fiberoptic endoscope which is ideally suited for working within the cerebral ventricles. One can now visualize detailed ventricular anatomy using an endoscope not much larger in diameter than a ventricular shunt. The addition of a working channel allows the operator to introduce microinstruments for suction, irrigation, coagulation, and biopsy.

We have used a fiberoptic ventriculoscope to treat patients with loculated ventricular cysts or trapped lateral ventricles. Large windows were sculpted in cyst walls or the septum pellucidum, which allowed free communication of the fluid in these collections with the ventricles. The large fenestrations were created with a “saline torch” introduced through the working channel of the ventriculoscope. The saline torch is a modification of the radiofrequency dissecting needle developed by Manwaring, et al. With this technique, a monopolar current is transmitted through a jet of saline, allowing the surgeon to dissect tissue and to coagulate vessels completely immersed in CSF.

Clinical Material and Methods

Between May, 1989, and May, 1990, eight patients with compartmentalized hydrocephalus presented to the New England Medical Center/Floating Hospital for Infants and Children. Six patients had loculated collections of CSF and two had trapped lateral ventricles. Ventricular and cyst anatomy were documented by preoperative computerized tomography (CT)-ventriculography examinations in six of the eight patients. The CT-ventriculography studies were performed via percutaneous transfontanel catheterization of the right lateral ventricle and instillation of 2 to 3 ml of iohexol (Omnipaque 180).

Through a standard right coronal burr hole, a No. 12 French peel-away Swan-Ganz introducer catheter* was...

* Introducer catheter manufactured by Daig, Minnetonka, Minnesota.
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passed into the frontal horn of the right lateral ventricle. A flexible steerable fiberoptic ventriculoscope† was then inserted into the ventricle through the peel-away catheter, and anatomical landmarks were identified. The foramen of Monro, septal and thalamostriate veins, and choroid plexus were constant landmarks (Fig. 1). A No. 19 Teflon epidural catheter with an internal wire was connected to a Tuohy Borst adapter.‡ The internal wire was withdrawn slightly from the catheter so that 1 cm of wire was extending proximally from the Tuohy Borst hub. The tip of the Teflon catheter was then amputated 1 mm distal to the end of the internal wire. Normal saline in a pressure bag was connected to the side port of the Tuohy Borst adapter and was infused at a continuous rate (three or four drops/sec). The catheter was then passed through the working channel of the ventriculoscope, thus constituting the saline torch (Fig. 2).

The torch was advanced until it was in contact with the wall of the cyst or the septum pellucidum. A monopolar current was then passed through the internal wire while pressurized saline was forced through the catheter. The stream of saline carried the radiofrequency charge and dissected tissue and even coagulated small blood vessels. By gently moving the ventriculoscope and firing the torch one could sculpt large windows. Once free communication of CSF between compartments was established, the ventriculoscope was removed and a standard ventricular catheter was inserted into the right frontal horn through the peel-away catheter. The peel-away catheter was removed and ventriculoperitoneal (VP) shunting was completed in routine fashion. Postoperative CT-ventriculography studies were performed to confirm patency of the fenestration.

Illustrative Cases

Case 1

This 3-month-old boy presented with progressive macrocephaly. He was born with a large thoracolumbar myelomeningocele, a severe kyphos deformity, and hydrocephalus. His myelomeningocele was repaired on the 2nd day of life and a right frontal VP shunt was inserted. A postoperative CT scan showed that the ventricles were well decompressed, but a large interhemispheric cyst was present.

The child returned for follow-up examination at 3 months of age. The head circumference had increased from 39 cm on discharge to 45 cm. A shunt tap was performed and the ventricular pressure was measured at 20 cm of CSF. A CT scan showed dilatation of the lateral ventricles in addition to a large interhemispheric cyst (Fig. 3 left).

The patient underwent ventriculoscopic cyst wall fenestration with the saline torch and revision of the shunt. Both foramina of Monro were occluded. The septum pellucidum was absent and both lateral ventricles communicated freely. Posteriorly, a thin veil of gliotic tissue was bulging forward into the lateral ventricles. A large window was sculpted in this membrane until there was a wide communication between the two compartments. An immediate postoperative CT-ventriculography study showed free communication of the cyst with the ventricular cavity (Fig. 3 center).

One month following surgery, the patient's head circumference remained at 45 cm and the fontanel was full. A CT scan showed no change in the ventricular

† Ventriculoscope manufactured by Codman and Shurtleff, Inc., Randolph, Massachusetts.
‡ Teflon epidural catheter manufactured by Deseret, Sandy, Utah; Tuohy Borst adapter manufactured by Bard, Billerica, Massachusetts.
size or in the appearance of the interhemispheric cyst. A distal shunt revision was performed. The fontanel became sunken and the child has remained well for 10 months postoperatively. A follow-up CT scan showed a decrease in the size of the ventricles and the cyst (Fig. 3 right).

Case 2

This 3-year-old boy presented with vesicoureteral reflux. He was born with myelodysplasia and hydrocephalus, and a VP shunt was placed at 1 week of age. The shunt was revised at 11 days and 2 years of age. The child was well until his present admission. Lumbar spine magnetic resonance (MR) imaging showed a tethered cord at L-3 with an associated syrinx. An MR image of the head showed that the ventricular catheter had migrated out of the ventricle. There was hydrocephalus and a large loculated right frontal ventricular diverticulum (Fig. 4 upper).

The patient underwent VP shunt revision with ventriculoscopic torch fenestration of the membrane between the diverticulum and the ventricle. A postoperative CT-ventriculographic study showed decompression of both the lateral ventricles and the diverticulum and free communication between these two compartments (Fig. 4 lower right). The child has been without problems during the 9 months since surgery.

Case 3

This 1-year-old boy presented with a full fontanel and an enlarging trapped lateral ventricle. He was born at 26 weeks gestation and suffered a grade IV germinal matrix hemorrhage. The patient developed progressive unilateral dilatation of the right lateral ventricle, presumably due to obstruction at the foramen of Monro. A right frontal Leroy catheter was inserted shortly after birth and serial taps were performed to remove CSF, but the ventricle continued to enlarge. When the patient was 4 months old, a small septostomy was created by bluntly passing the ventriculoscope through the septum pellucidum. One month later the patient's fontanel was full. A CT-ventriculographic study showed enlargement of the right lateral ventricle without communication between the lateral ventricles (Fig. 5 upper). The patient underwent ventriculoscopic saline torch fenestration of the septum pellucidum and placement of a right frontal VP shunt. Postoperative CT-ventriculography showed free communication between the ventricles and a decrease in the size of the right lateral ventricle (Fig. 5 lower). The patient has been well during the 8 months since surgery.
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**Fig. 3.** Case 1. *Left:* Preoperative computerized tomography (CT) scan demonstrating a large interhemispheric cyst, mild dilatation of the lateral ventricles, and absence of the septum pellucidum. A thin membrane is visible between the cyst and the ventricles (*arrowheads*). *Center:* Immediate postoperative CT-ventriculography study demonstrating a large window of communication between the ventricles and the interhemispheric cyst. *Right:* Ten months later, a CT showed shunted hydrocephalus with a decrease in size of the ventricles and cyst.

**Fig. 4.** Case 2. *Upper Pair:* Axial (left) and sagittal (right) T₁-weighted magnetic resonance images of the brain demonstrating a right frontal "diverticulum" and hydrocephalus. *Lower Pair:* Computerized tomography-ventriculography studies, preoperative view (left), demonstrating no communication of cerebrospinal fluid between the loculated ventricular diverticulum and the ventricles, and postoperative view (right), showing a decrease in the size of the cyst and the lateral ventricles with free communication of contrast between compartments.

**Fig. 5.** Computerized tomography-ventriculographic studies in Case 3. *Upper Pair:* Preoperative studies demonstrating a large trapped right lateral ventricle. The left lateral ventricle (*arrowheads*) is not enlarged. The single *arrowhead* indicates the foramen of Monro. *Lower Pair:* Postoperative studies showing decompression of the right lateral ventricle with free communication of contrast material across the septum pellucidum.
Results

Eight consecutive patients with isolated collections of CSF underwent saline torch fenestration with the fiberoptic ventriculoscope. Large windows were created and communication of CSF between compartments was documented on postoperative CT-ventriculographic studies in six patients. All eight patients were managed with a single VP shunt. There were no complications.

Discussion

Ventriculoscopy was first performed in 1910 by V. L. l'Espinasse, a surgeon from Chicago. He used a rigid cystoscope to fulgurate the choroid plexus bilaterally in two infants. One child died immediately and the other lived for five years. The event received little attention and passed almost unnoticed at the time.

In 1922, Dandy used a rigid cystoscope in an attempt at choroid plexus fulguration in two patients. The instrument was primitive and the procedures were only "partially successful." He subsequently found it necessary to remove the plexus in the "usual way," avulsing it with alligator forceps. Dandy correctly predicted that ventriculoscopy would be replaced by newer indirect methods of imaging the intracranial contents.

In 1923, W. Jason Mixter of Boston performed the first endoscopic third ventriculostomy. The patient was a 9-month-old girl with advanced noncommunicating hydrocephalus. Having practiced the technique on a cadaver brain, Mixter introduced a small urethroscope into the lateral ventricle and then through the dilated foramen of Monro. Under visual guidance, he pushed a flexible sound through the floor of the third ventricle and successfully communicated the third ventricle with the basal subarachnoid space.

Although investigators continued to perform ventricular endoscopy, the procedure gradually fell out of favor. Its primary use was to inspect the ventricles or to extirpate or cauterize the choroid plexus. Therapy was often ineffective and morbidity and mortality rates were prohibitive. Improved neuroimaging techniques made it unnecessary to inspect the ventricular system directly. In addition, the development by Nulsen and Spitz in 1951 of the valved shunt revolutionized the management of hydrocephalus.

Shunts are troublesome devices, however, plagued by complications including infection, misplacement, overdrainage, and underdrainage. In addition, hydrocephalus may be complicated by isolation of a ventricular cavity or by the formation of loculated cyst cavities. The ability to make large windows in cyst walls would permit multiple isolated fluid cavities to be drained by a single shunt.

Technical advances in optics, miniaturization, and steerability of instruments have created renewed interest in neuroendoscopy. Fiberoptic endoscopes have been used in the cerebral ventricles to biopsy and aspirate tumors, drain hematomas, and perform third ventriculostomy. We believe that the ventriculoscope is ideally suited for making large fenestrations in ventricular or cyst walls and have used it to treat complicated hydrocephalus.

We report eight patients with isolated cavities containing CSF. Six patients had hydrocephalus and a loculated cyst and two patients had trapped lateral ventricles. The cyst wall or septum pellucidum was successfully fenestrated in each case. Large windows were sculpted using the saline torch to ensure free flow of CSF. This technique permitted the placement of only a single VP shunt in each case. Although all patients in the present study underwent both fenestration and shunt insertion, we consider that there are some patients who might be managed by fenestration alone.

Ventriculoscopic saline torch fenestration is ideally suited for performing third ventriculostomy. We are currently investigating this technique and have performed it successfully in two patients with hydrocephalus secondary to aqueductal stenosis. In each case, a window was created in the third ventricular floor just anterior to the mammillary bodies. We believe this procedure should be performed only when the third ventricle is enlarged and the third ventricular floor is stretched out and translucent.

We conclude that saline fenestration of loculated CSF collections is simple, safe, and effective. Long-term follow-up monitoring is needed to determine if the fenestrations remain patent. This technique allows simplification of shunt systems in some cases and may permit elimination of shunts in others.

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