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Endoscopic Third Ventriculostomy

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= **Abstract** =

Third ventriculostomy hae been used for the treatment of obstructive hydrocephalus since Dandy first performed such operation in 1922. With the developement of fiberopic technology and new endoscopic equipments, neuroendoscopic procedure has become one of the highlights of recent advance in neurosurgery.

The author has performed endoscopic third ventriculostomies in 26 patients suffering from obstructive hydrocephalus since 1989. The most common cause of obstructive hydrocephalus in those patients was aqueductal stenosis. Twenty of the 26 patients were treated by endoscopic third ventriculostomy only, and 16 of the cases(i. e., 80%) were successful without the need of shunting operation. However, the remaining 4 cases required ventriculoperitoneal shunt. Six patients, who were either under the age of one year old or had previous multiple shunts, received endoscopic third ventriculotomy and ventriculoperitoneal shunt simultaneously. The 10 patients(out of the original group of 26) who received both endoscopy and shunt, required no shunt revision during the follow-up periods of 6 months to 4 years. Of all the cases, while no mortalities occurred, we had encountered 3 complications which consists of 2 transients diabetes insipidus and 1 postoperative epidural hematoma around a burr hole site.

The authors therefore concludes that endoscopic third ventriculostomy is a simple and effective procedure for the treatment of obstructive hydrocephalus. Equipment, procedure, pre and post operative workup and results were fully discussed with literature review.

KEY WORDS : Endoscope · Third ventricle · Ventriculostomy · Hydrocephalus.

Introduction

In the era before shunting of cerebrospinal fluid, the most common operation for the relief of obstructive hydrocephalus was third ventriculostomy[7)17)18)19)26)27)]. The procedure was first performed by Dandy[5)] in 1922. Unfortunately, this operation had a high failure rate when the hydrocephalus was congenital[6)21)]. Third ventriculostomy also had a significant surgical morbidity rate[4)6)22)28)]. The development by Nulsen and Spitz in 1951 of the valved shunt revolutionized the management of hydrocephalus. However, long term result of shunting for hydrocephalus still has numerous drawbacks related to shunt malfunction and infection. Increasing awareness of the longterm morbidity of shunting has prompted a second look at this procedure. In part, this interest was stimulated by the report of Guiot[10] that third ventriculostomy using stereotactic method could be safe and easy. Interest was further stimulated by the report of Sayers [25)]that third ventriculostomy was effective for the control of

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congenital hydrocephalus if it was preceded by a period of low pressure shunting.

Some authors (Guiot[10], Hirsh[12], Patterson and Bergland[21], and Hoffman[13][14]) have indicated the type of patient they thought were suitable candidates for third ventriculostomy. They recommended that the mechanism for reabsorption of cerebrospinal fluid (CSF) under normal intracranial pressure at the arachnoid granulations must exist; thus, the hydrocephalus must primarily be of the non-communicating type. They have strongly suggested that this technique is not suitable for patients who have had meningitis or subarachnoid hemorrhage or who have congenital hydrocephalus[3][16]. Mixter[20] had actually done endoscopic third ventriculostomy as early as 1923, but the procedure never became popular because of the large diameters and poor illumination of the existing instrumentation. That situation changed in the 1960's with the development of fiberoptic technology. The incorporation of this technology into endoscopic equipment permitted the construction of small diameter endoscopes with high intensity external light sources[8][9][30][31][32][33]. This paper describes a simple technique for third ventriculostomy utilizing modern endoscopes. The author has performed endoscopic third ventriculostomy in twenty six patients with non-communicating hydrocephalus since 1989 and reports the results of this procedure with review of literature.

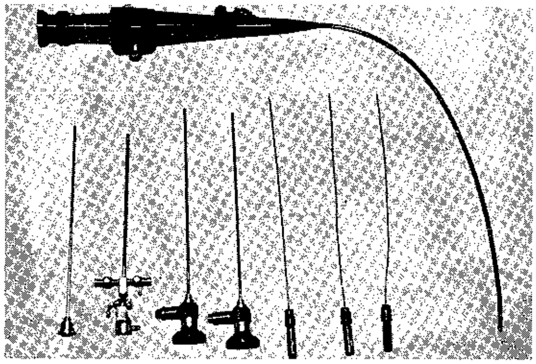

Fig. 1. Equipment used to perform third ventriculostomy.

Method

1. Patient Selection

Non-communicating hydrocephalus is a primary indication for endoscopic third ventriculostomy. The mechanism must exist for reabsorption of CSF under normal intracranial pressure at the arachnoid granulation. Our selection criteria include aqueductal stenosis and non-communicating hydrocephalus due to tumor or cyst. This technique is not suitable for patients who have had meningitis or subarachnoid hemorrhage or who have congenital hydrocephalus. Routine preoperative workups were brain CT, radioisotope or metrizamide CT cisternography, brain MRI and cine MR.

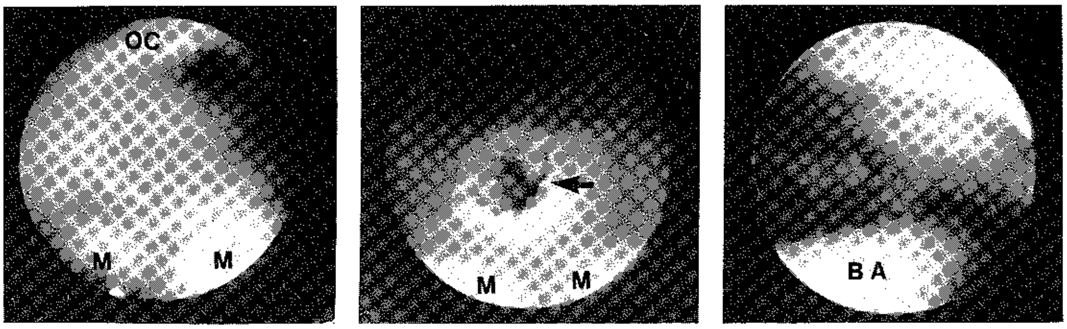

Fig. 2. Endoscopic appearance of third ventricular floor.
Left : Before ventriculostomy. Center : After ventriculostomy.
Right : Endoscope is advanced through the hole into the interpeduncular cistern. M=mamillary body ; OC=optic chiasm
Arrow=site of ventriculostomy ; BA=basilar artery

Fig. 3. Brain MRI after 3rd ventriculostomy. Flow void is clearly seen between the third ventricle and interpeduncular cistern.

2. Instrumentation

The instrumentation for endoscopic third ventriculostomy are consists of a 30 degree Hopkins pediatric telescope with an outside diameter 2.7 mm, a sheath for the telescope with an outside diameter 3.8 mm, a stylet, coagulating electrodes (Karl Stortz, Germany), fiberoptic light guide, Xenon light source and endovision system (Fig. 1). We chose to use the rigid type only for third ventriculostomy, but steerable endoscope can be used with the advantage of changing the direction of view in manipulating the intraventricular structures. Monopolar coagulating electrode was applied via working channel for perforating the third ventricle floor.

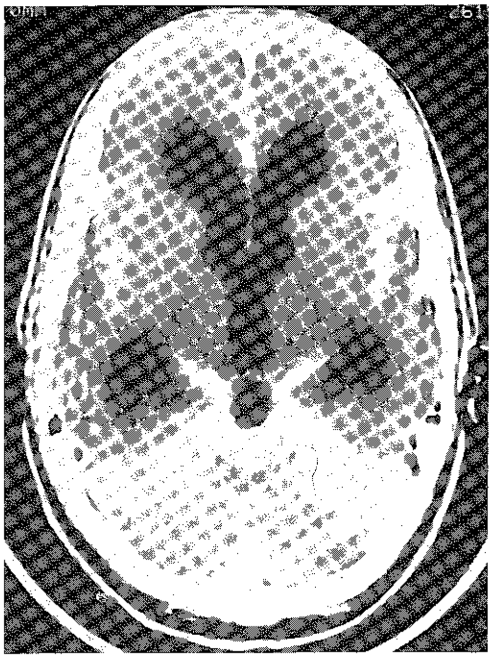

Fig. 4. Metrizamide CT cisternograms demonstrate aqueductal stenosis. Metrizamide fills the fourth ventricle and cisterns but not fill the third and lateral ventricle.

3. Operative technique

Third ventriculostomy is performed under general anesthesia. The patient is positioned supine, and routine skin preparations and draping are used for a burr hole. A burr hole is made 1 cm in front of the coronal suture and 2 – 3 cm lateral to the midline. Right lateral ventricle is tapped using a ventricular catheter through the burr hole . Peelaway catheter was re-

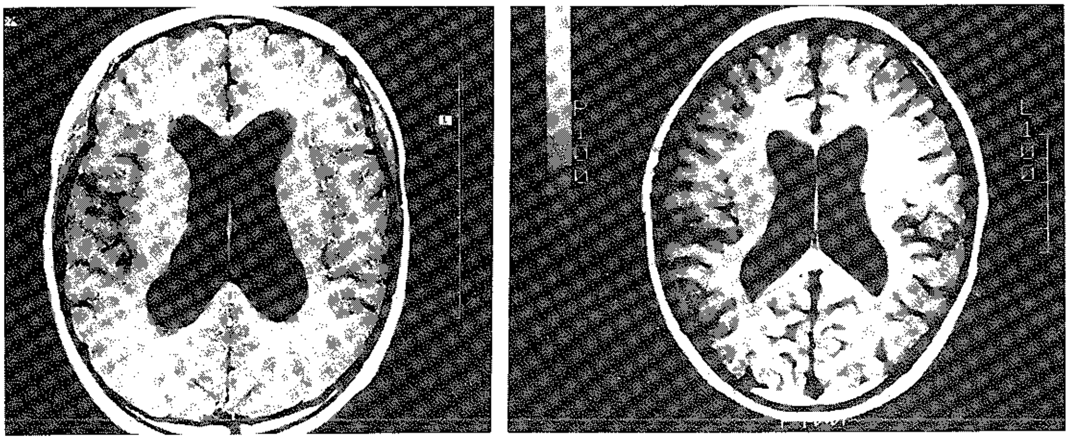

Fig. 5. Brain MRI of 11 year old girl. Left : Beforevntriculostomy. Dilated lateral ventricles with blunting of frontal and occipital horn are seen. Right : After ventriculostomy. Blunting of frontal and occipital horn are reduced.

Table 1. Results of endoscopic third ventriculostomy (Group A)

Causes of hydrocephalus	No. of patients	Result 1	2	3
Aqueductal stenosis	9	5	2	2
Aqueductal stenosis with tectal tumor	4	3	1	
Aqueductal stenosis with shunt malfunction	1	1		
Aqueductal stenosis with arachnoid cyst	3	3		
Pineal tumor	2	1	1	
Cerebellar tumor	1	1		
Total	20	14 70%	2 10%	4 20%

Result 1 : Successful with normal condition
2 : Successful with improvement
3 : Failed, needed shunt

placed via tract. The tip of the tapping catheter is directed to the glabella and tragus of the right ear. The telescope with sheath is then advanced into the lateral ventricle through the Peelaway catheter. The foramen of Monro is identified and the telescope is now advanced through the foramen to visualize the floor of the third ventricle.

The site for third ventriculostomy is located in the midline just in front of the two mamillary bodies, which is about 2/3 posterior between the optic chiasm and the dome of basilar artery. Dome of basilar artery is visualized between both mamillary bodies. To perforate third ventricular floor, the coagulating electrode is advanced via working channel of sheath. Monopolar electrocoagulation with the electrode can thin or perforate the third ventricular floor easily under direct vision(Fig. 2).

The flow of CSF through the hole is usually seen after perforation using telescope. The hole is enlarged with insertion of the telescope and the basilar artery in the interpeduncular cistern is usually inspected. Telescope and its sheath are removed and the cortical incision is packed with a piece of gelfoam. The wound is closed and epidural pressure monitoring sensor can be inserted for postoperative ICP monitoring.

4. Postoperative management and assessment of outcome

Initially, intracranial pressure is monitored for 48 hours until a trend is established. Brain MRI with mid-sagittal thin slices is performed on the 7th postoperative day. A flow void in the floor of the third ventricle can usually be seen. Cine MR would also be useful to confirm the CSF flow via the ventriculostomy site. In axial cut of MRI, blunting of frontal or occipital horn is reduced postoperatively in most cases (Fig. 4).

The assessment of outcome is based on a combination of a) resolution of symptoms of raised intracranial pressure, b) intracranial pressure measurements, c) neuroimaging study: MRI, CT scan, CSF flow study or Cine MR.

Results are classified into 3 criteria :

1) Successful with normal condition

The patient is independent from a shunt and has normal development or no evidence of clinical symptoms.

Table 2. Results of endoscopic third ventriculostomy with ventriculoperitoneal shunt

Timing of V-P shunt	Causes of hydrocephalus	No. of patients	Shunt revision
Simultaneously with endoscopic third ventriculostomy	Aqueductal stenosis with previous shunt malfunction	4	none
(Group B : 6 cases)	Posterior fossa tumor	2	none
After endoscopic third ventriculostomy	Aqueductal stenosis	2	none
failure	Tectal tumor	1	none
(Failed Group A : 4 cases)	Pineal tumor	1	none
Total		10	

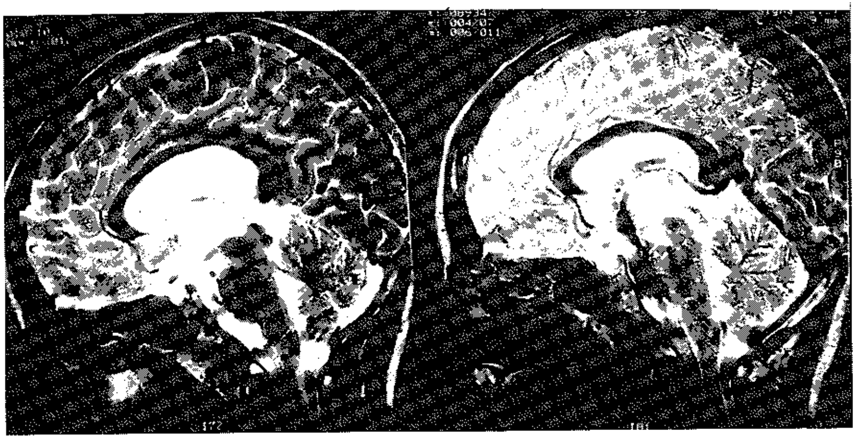

Fig. 6. Brain MRI (T2 weighted midsaggital view) Left : before ventriculostomy. Right : after ventericulostomy. Flow void is seen via ventriculostomy site.

2) Successful with improvement

The patient is not dependent on a shunt but has slowing of development or incomplete relief of symptoms.

3) Failure

There was no significant alteration of development or symptoms in the postoperative period and the patient required placement of an extracranial shunt postoperatively

Results

1. The author's series

Twenty-six consecutive patients with non-communicating hydrocephalus underwent endoscopic third ventriculostomy. Six of 26 patients underwent third ventriculostomy with ventriculoperitoneal shunt simultaneously because we believed these patients might possibly have CSF absorption problems. Sixteen out of twenty patients (group A) treated with endoscopic third ventriculostomy only were considered successful (80%) without the need of shunting operation. Among 16 successful cases 2 patients showed delayed milestone. Endoscopic surgery failed in 4 cases which then had to be treated with ventriculoperitoneal shunt(Table 1). Two of the 4 failed cases were patients with aqueductal stenosis under the age of 1 year.

Other failed cases include a 14-year-old boy who had aqueductal stenosis due to tectal tumor and a 12 year old boy with pineal tumor.

The other group (Group B) of our series includes 6 patients who had been treated with endoscopic third ventriculostomy and ventriculoperitoneal shunt simultaneously. Four patients underwent ventriculoperitoneal shunt to correct aqueductal stenosis previously at other hospitals and were presented with shunt malfunction. These patients were treated with third ventriculostomy and shunt revision. The other 2 cases were hydrocephalus with posterior fossa tumor under age of 1 year. It was believed that these 6 patients need prompt relief of high intracranial pressure or have CSF absorption problems. Ten patients who had finally been treated with endoscopic third ventriculostomy and ventriculoperitoneal shunt did not have any shunt revisions for last 4 years (Table 2). There has been no operative mortality in our series of 26 patients. We had 3 complications which include 2 transient diabetes insipidus and 1 epidural hematoma. The epidural hematoma was evacuated and patient did well.

2. Illustrated case

This 11-year-old girl presented with headache and projectile vomiting for 3 days. Neurological examination revealed mild limitation of upward gaze without other lateralizing signs. Brain CT showed dilated lateral and third ventricle but the size of the fourth ventricle was normal. Brain MRI showed the same finding and aqueductal stenosis was clearly seen on sagittal imaging. Metrizamide CT cisternography confirmed obstruction at the aqueductal level (Fig. 4). Percutanenous endoscopic third ventriculostomy was performed. Postoperatively, symptoms of increased intracranial pressure had subsided.

On the 10th postoperative day, brain MRI was taken. Flow void was seen between third ventricle and the interpeduncular cistern on the mid-sagittal imaging. Blunting of the frontal and occipital horn were reduced after endoscopic surgery (Fig. 5). Postoperative MRI midsaggital view was compared preoperative one. Flow void was seen clearly from third ventricle to interpeduncular cistern in T2 or T1 weighted image (Fig. 6). The patient has been doing very well for the last 2 years.

3. Other series

Hoffman et al[13] reported his own experience of stereotactic third ventriculostomy as well as reviewed 797 cases of third ventriculostomy from literature. A total 569 patients were treated with open craniotomy and 228 cases with percutaneous technique, using predominantly the stereotactic method. The over all success rate was about 53%. Operative mortality was 10.3% in the open method and 3.5% with the percutaneous technique.

Jones et al[15] reported that 8 of 14 patients with non-communicating hydrocephalus were successfully treated using endoscopic third ventriculostomy (58%). Four cases out of 14 showed improvement (29%) but one needed a shunting operation afterwards. Three cases of non-communicating hydrocephalus due to CNS tumors were treated with endoscopic surgery: Two were successful and one patient was unsuccessfully. This unsuccessful patient suffered bradycardia being a limiting factor when the floor was approached.

Saint-Rose[24] reviewed two identical series of patients with aqueductal stenosis. Thirty-eight patients were treated by insertion of a ventriculoperitoneal shunt and thirty had a third ventriculostomy. In the group treated with third ventriculostomy, the ventricle remained enlarged despite clinical normalization in 60% of the patients. Fifty-eight percent in the shunted group developed slit like ventricles on the CT scan during the same follow-up period. From a neurological, endocrinologic, social and behavioral point of view, there were no stastistical difference between these two groups.

Two patients out of 20 in our ventriculostomy series showed marked reduction of ventricular size.

Discussion

Ventriculoscopy was first performed in 1910 by V.L. I'Espinasse, a surgeon from Chicago. He used a rigid cystoscope to fulgurate the choroid plexus bilaterally in two infants[11]. 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 to perform choroid plexus fulguration in two patients. The instrument was primitive and the procedures were only "partially successful". Dandy[5] correctly predicted that ventriculoscopy would be replaced by newer indirect methods of imaging the intracranical contents.

In 1923, Mixter[20] performed the first endoscopic third ventriculostomy for aqueductal stenosis. The patient was a 9-month-old girl with advanced non-communicating hydrocephalus. 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[26]. Its primary use was to inspect the ventricles or to extirpate or cauterize the choroid plexus[69]. 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 valve shunt revolutionized the management of hydrocephalus. However, shunts are troublesome devices, plagued by many complications including infection, obstruction, misplacement, overdrainage and underdrainage etc.[11].

Technical advances in optics, miniaturization, and steerability of instruments have created renewed interest in neuroendoscopy[1)2)23)]. The modern fiberoptic endoscope appears to provide a simple and safe means for performing third ventriculostomy. It has the advantage over the stereotactic technique by requiring less sophisticated equipment, and allowing direct visualization of the ventriculostomy site.

The real problem with third ventriculostomy, however, is the selection of appropriate candidates for the procedure[15)17)]. It is first necessary for all patients to have adequately dilated third and lateral ventricles. Jones et al suggested that the adequate size of the third ventricle for endoscopic surgery is about 1 cm bicoronal diameter. Most successes in the literature were in patients with acquired aqueductal stenosis[17)]. In our series, aqueductal stenosis due to tumors also showed good results. We performed endoscopic third ventriculostomy and ventriculoperitoneal shunt simultaneously in 4 patients with aqueductal stenosis who showed malfunctions of the previously inserted shunts, and 2 young children with posterior fossa tumor, they were believed to have problems in extraventricular CSF circulation. We anticipate that they will remain less dependent on shunts that is now communicating above the level of the tentorium. If one could assess accurately the reabsorptive capacity of the subarachnoid space prior to operation, it would be help making the selection of appropriate candidates for this procedure.

The best results for third ventriculostomy are achieved with patients in which the onset of aqueductal stenosis occurred after 2 years of age; Approximately 80% of these patients are shunt independent after the procedure[24)]. This result appears similar to that of our series..

Major risks of third ventriculostomy are hypothalamic dysfunction arise from extending the fenestration into the infundibular recess and hemorrhage from damage to arteries, ependymal veins or choroid plexus. We experienced transient diabetes inspitus in two patients after third ventriculostomy.

Conclusion

A simple technique for performing the endoscopic third ventriculostomy as well as its results are described. We conclude that this procedure is simple, safe and effective in appropriately selected cases with non-communicating hydrocephalus.

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내시경적 제 3 뇌실 누공술

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최 중 언

= 국 문 초 록 =

폐쇄성 수두증에서 제 3 뇌실 누공술의 치료효과는 인정되어 왔다. 새로운 기구의 발달과 개발로 내시경도 점차 가늘어지고 선명한 영상을 보여주게 됨으로서 신경외과 분야에도 각광을 받고 있다.

1989년 10월부터 1994년 4월까지 연세대학교 의과대학 신경외과에서 폐쇄성 수두증으로 진단되어 내시경적 제3뇌실 누공술을 시행받은 26명의 환자를 대상으로 그 결과를 분석하였다. 폐쇄성 수두증의 원인은 대부분 수도관 폐쇄였으며, 종양 또는 낭종을 동반한 경우도 있었다. 20명의 환자에서는 내시경적 제3뇌실 누공술만을 시행하였는데 그중 16명(80%)에서 수술후 션트수술 없이 증상의 호전을 보여 성공하였으며 4명(20%)은 증상의 호전이 없어 뇌실-복강간 션트수술이 필요하였다. 10명의 환자에서는 내시경수술과 션트수술이 필요하였는데 이 중 4예는 1차 내시경수술이 실패한 후 2차로 션트수술을 시행한 경우이며 6예는 내시경 수술과 션트수술을 동시에 시행한 경우로서 과거 수차례 션트수술을 받았거나 나이가 1세미만인 환자였다. 내시경적 제 3 뇌실 누공술과 션트수술를 병행한 10예에서는 수술후 6개월에서 4년간의 추적조사시 션트재수술이 필요한 경우는 없었다. 내시경수술로 사망한 환자는 없었으며 3명에서 합병증을 보였는데 2명은 일시적인 요붕증이 나타났고, 1명에서는 수술후 경막상 혈종이 병발되어 개두술과 혈종제거술이 필요하였다.

내시경수술은 폐쇄성 수두증 치료에서 간단하고 안전하며 효과적인 치료로 생각된다. 장비, 수술수기, 검사, 결과등을 문헌고찰과 함께 기술한다.