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Experience with Lumber Puncture for Obstructive Hydrocephalus Patients following Endoscopic Surgery

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Abstract

Background: Following endoscopic third ventriculostomy (ETV), the intracranial pressure (ICP) of some patients remains high immediately. The cause of this phenomenon is still controversial. The objective of this study is to explore the effect of postoperative lumbar puncture following ETV for obstructive hydrocephalus patients.

Methods: 145 patients presenting with obstructive hydrocephalus underwent ETV in our department between 2009 and 2014. Following ETV, all patients received lumbar punctures 1 and 3 days after surgery.

Results: For 106 patients, intracranial pressure (ICP) returned to normal levels and symptoms associated with high ICP ceased. In 39 patients, intracranial pressure remained high and they continued to receive lumbar punctures every other day for a period of 11 days post-surgery. These patients were divided into two groups for analysis: group A (<18 years old) and group B (>18 years old). Intracranial pressure of both groups increased initially before decreasing to normal values. Peak values of ICP for groups A and B occurred on days 3 and 5, respectively.

Conclusions: Postoperative lumbar puncture is important to determine the effect of surgery or treatment on transient high ICP after ETV. For most of these symptomatic patients with obstructive hydrocephalus, lumbar punctures were effective in bringing about fast normalization of ICP and cessation of adverse symptoms.

Keywords: Cerebrospinal fluid circulation; Endoscopic third ventriculostomy; Intracranial pressure; Lumbar puncture; Subarachnoid space

Introduction

With the advent of endoscopic techniques, endoscopic third ventriculostomy (ETV) became a preferred procedure for obstructive hydrocephalus [1]. The benefit of shunt independence with minimal risks offers a remarkable advantage which has made this procedure widely popular. But following ETV, the intracranial pressure (ICP) of some patients remains high immediately following ETV. The cause of this phenomenon is still controversial. Part of the reason may be that the SAS may not be fully open due to excess cerebrospinal fluid (CSF) and lumbar puncture is an essential treatment after third ventriculostomy for obstructive hydrocephalus [2-4].

Between 2009 and 2014, we treated 145 cases of obstructive hydrocephalus in our department. All patients underwent ETV and post-operative lumbar punctures with good results. In this study we performed an analysis of the patients' progress through the post-operative lumbar puncture treatment.

Methods and Materials

Population

Following human ethics approval from the Human Ethics Committee (Beijing Shijitan Hospital), 145 patients (93 male and 52 female) diagnosed with obstructive hydrocephalus were recruited from Beijing Shijitan hospital between September 2009 and May 2014. The age at surgery ranged from 3 months to 68 years. For infant participants, the cardinal symptoms were enlarged head circumference and anterior fontanels bulging. During the head percussion, Macewen would appear and in severe cases infant patients had visible Setting-sun sign. For adult participants, the cardinal symptoms were headache, vomiting and instability of gait.

Treatment

All participants received post-operative lumbar punctures, and ICP values were measured before and after the procedure. To minimize the risk of complications following lumbar puncture, patients were asked to lay on a bed without a pillow for 2-4 h, avoiding excitement, crying and water-electrolyte imbalance while also maintaining clear respiratory track during the post-operative recovery period. One hundred and six patients showed normal ICP values (infant 50-100 mm H_2O, adult 70-180 mm H_2O) after receiving lumbar punctures 1 and 3 days post-surgery. In 39 patients (25 male and 14 female), high ICP symptoms persisted and their ICP level increased. These patients received lumbar puncture 1, 3, 5, 7, 9 and 11 days post-surgery, and

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were separated into two groups for analysis: group A (<18 years) and group B (>18 years). We set the group A for children group and their causation of disease are congenital hydrocephalus. Group B is set for adult group and their causation of disease are secondary injury leading to hydrocephalus. Group A consisted of 34 patients ranging from 3 months to 15 years of age and the average age was 5.8 years. Including: 12 cases of cerebral aqueduct stenosis, 8 cases of Dandy-Walker syndrome, 7 cases of Arnold-Chiari and 7 cases of shunt obstruction after V-P shunt. Group B consisted of 5 patients ranging from 21 years to 68 years of age and the average age was 44.2 years. In this group there were 2 cases of secondary obstructive hydrocephalus after hypertensive cerebral hemorrhage, 1 case of secondary obstructive hydrocephalus after an operation for traumatic brain injury and 2 cases of shunt obstruction after V-P shunt.

Statistical Analysis

Data are expressed as mean + SD (number of patients). Statistical difference between groups was determined by the unpaired multifactor analysis of variance.

Results

For 106 patients, lumbar punctures 1 and 3 days after ETV were sufficient in relieving symptoms of high ICP, leading to a full recovery after one week. For the remaining 39 patients ICP remained abnormal and they received 4 additional lumbar puncture treatments, leading to a full recovery after two weeks. In group A, the average ICP of patients fell from 105 ± 6 mm H_2O to 70 ± 8 mm H_2O ($P<0.05$) after the first day of lumbar puncture (Figure 1). On the third day, ICP rose sharply and the values of ICP were 180 ± 7 mm H_2O and 132 ± 8 mm H_2O ($P<0.05$) before and after lumbar puncture, respectively (Figure 1). On the eleventh day, ICP values returned to normal (Figure 1).

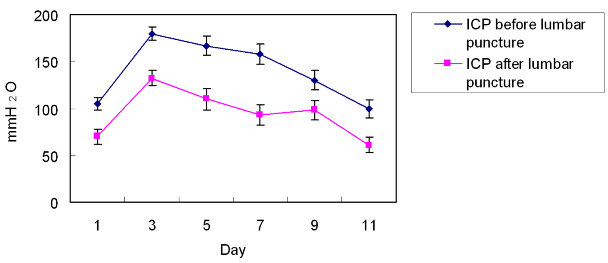

Figure 1 : (group A) Average ICP values of group A patients before and after lumber puncture over a period of 11 days following ETV. ICP values peak on the third day before dropping to normal.

In group B, the average ICP of patients fell from 171 ± 12 mm H_2O to 97 ± 10 mm H_2O ($P<0.05$) after the first day of lumbar puncture (Figure 2). ICP increased on the third day and peaked on the fifth day (Figure 2). Peak ICP values coincided with headache and dizziness symptoms in the patients. On the eleventh day ICP values fell to normal after lumbar puncture (Figure 2).

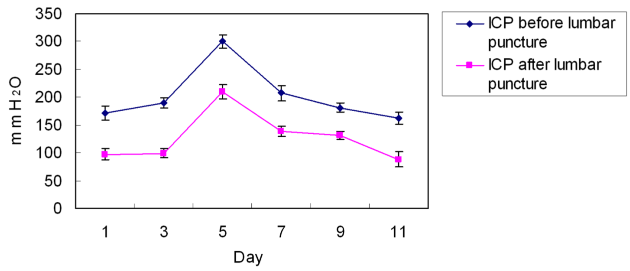

Figure 2: (group B) Average ICP values of group B patients before and after lumber puncture over a period of 11 days following ETV. ICP values peak on the fifth day before dropping to normal.

Following-up investigation for 39 patients with high ICP for one year, we discovered that 31 patients were efficient and 3 patients were inefficient for group A, at the same time, 4 patients were efficient and 1 patients were inefficient for group B. 3 patients of group A and 1 patients of group B that is inefficient received lumbar puncture treatments performed V-P shunt again during one year. The high ICP symptoms were relieved after surgery.

One typical case is discussed below: The patient is a 36 years old male who arrived at our hospital on the 25th of September, 2010. He was diagnosed at his local hospital four years ago with obstructive hydrocephalus and received a V-P shunt. The patient was in good condition after the surgery until recently when he began to experience recurring headache, dizziness, nausea and vomiting. Physical examination showed a cystic mass in the left abdomen, CT scan showed hydrocephalus, B ultrasonic examination showed an abdominal cystic mass. It is most likely that the greater omentum wrap shunt lead to a blockage in the abdominal shunt. ETV and V-P shunt were performed for the patient and, simultaneously, the cystic mass in the left abdomen was punctured and drained. Post-operative CT scan showed that the situation of ventricle size (Figure 3A). Initial and terminal pressures during lumbar puncture on the first day after ETV were 188 mm H_2O and 104 mm H_2O, respectively. On the third day, the patient showed symptoms of high ICP including, headache, dizziness and nausea. On the fifth day, initial and terminal pressures during lumbar puncture were 310 mm H_2O and 222 mm H_2O, respectively, and another CT scan was performed (Figure 3B), which showed ventricular dilation. On the eleventh day, a final CT scan was taken (Figure 3C), which showed no enlargement of the ventricular system. The patient was discharged two weeks later.

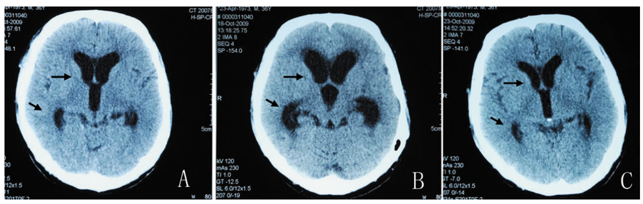

Figure 3: CT scan of a typical patient at 1、5 and 11 days after endoscopic surgery.

Discussion

The symptoms of intracranial hypertension in patients ceased quickly after ETV. ETV restores CSF circulation and, once unobstructed, forms a new orifice fistulae. However, in some cases, symptoms can persist or recur in the early post-operative period. This phenomenon has been observed since the time of Matson, who described the post-operative period of a ventriculocervical subarachnoid shunt, implanted to bypass aqueductal stenosis, as appearing ineffective for several days before gradually freeing communication between the ventricle and the lumbar SAS over the next few days. Thus, during this ‘adaptation period’, the surgical procedure may be viewed as a failure and a VP shunt is required to be implanted [3]. In the literature, there are also reports that complex hydrocephalus can be further sub-classified as temporary or permanent, based on whether the defective absorption and/or defective permeation of CSF through SAS is transient or persistent [5-8]. Repeated lumbar punctures could solve the problem if it is due to a temporary pathology [6,9]. As a result, it is critical to perform lumbar punctures and monitor ICP after ETV.

The patients in groups A and B were built a CSF path after ETV and monitored for changes in ICP. Since the path is clear, ICP was significantly reduced after ETV. However, in patients whose SAS have been blocked for a long time, circulation and absorption of CSF cannot achieve the desired level immediately. After the obstruction is relieved, a large quantity of CSF flows into the SAS leading to an increase in ICP again. In these patients, administering lumbar puncture helps clear the SAS by releasing excess CSF and reducing ICP to normal. The patients in group A reached peak ICP value on the third day after ETV while the patients in group B reached peak ICP value on the fifth day. This discrepancy is probably related to differences in the opening of the SAS between patient groups. All the patients in group A (Children group) suffered from obstructive hydrocephalus, which most likely resulted from incomplete neural development, whereby no CSF flowed out of the third ventriculostomy. In group B (Adult group), however, blood entering the SAS after cerebral hemorrhage is the most probable cause of SAS obstruction. Following a V-P shunt, there are a many factors that can lead to an obstructed SAS, such as choroid plexus encapsulation in the ventricular side, shunt retrace into brain parenchyma when ventricle grows downwards leading to shunt prolapsed, and omentum encapsulation in the abdominal cavity.

As early as 1932, Dandy cautioned that before performing a third ventriculostomy for obstructive hydrocephalus, it was necessary to establish whether the distal subarachnoid pathways were open or closed. The difficulty in pre-operatively detecting the presence of coexisting obstruction in the basilar cisterns or in the subarachnoid space of the surface may account for the 25-40% failure rate reported in the literature [3,10,11]. Further complicating this scenario is the observation that obstruction of the ventricular system may cause a secondary reversible obstruction in the SAS [12]. Experimental occlusion of the aqueduct in monkeys has been found to cause compression of the brain against the undersurface of the cranium, resulting in progressive obliteration of the convexity SAS, and, in a second phase, impaction of the temporal lobes through the incisura that resulted in obstruction of the basilar cisterns. However, no histological evidence of irreversible obstruction was observed [6]. Milhorat et al. [13] reported two children affected by aqueductal stenosis resulting from complete cisternal blocks, demonstrated by isotope cisternography, were eliminated by temporary ventricular drainage. In these cases, relieving ICP re-expanded the SAS. According to the authors, the completeness of the re-expansion depends upon multiple factors, including the duration and the completeness of the obstruction, the effectiveness of previous shunts, and the presence or absence of associated meningeal infections or other inflammatory process. These observations may account for the lack of a pre-operative test that is able to predict whether the SAS are competent. Also, invasive and dynamic techniques, including isotope studies, CSF infusion tests, and CT ventriculography, may fail to adequately investigate the total absorptive capacity. Isotope studies have indicated that absorptive capacity and CSF circulation through the SAS may continue to improve for several months after ETV.

Following ETV, ICP increases suddenly then gradually declines. Although the cause of this phenomenon is still controversial, part of the reason is that the SAS may not be fully open due to excess CSF. This may also be due to the reduced permeability of arachnoid granulations (AGs) [6]. A long period of obstruction will cause AGs to be idle, which leads to CSF absorption dysfunction. The smooth CSF into the SAS cannot be absorbed into the CSF circulation. Lumbar puncture can release excess CSF, which assists the functional recovery of AGs. Some scholars [2-4] believe that lumbar puncture is an essential treatment after third ventriculostomy for obstructive hydrocephalus. Releasing CSF can improve the compliance and buffering capacity of the SAS, which may promote AGs to open, increasing CSF absorption and reducing the resistance of CSF from the ventricular system into the SAS. Thus, the CSF can enter the SAS faster through the stoma and normal CSF circulation can be restored. When the CSF pulse pressure is reduced, ventricle and brain ventricle volume is reduced and hydrocephalus improves, promoting brain tissue development. ETV surgery for obstructive hydrocephalus is a minimally invasive procedure; however, it is still hard to avoid damaging brain tissue and blood vessels in the ventricle. Damage will cause red blood cells to dissolve, releasing oxyhemoglobin, which stimulates brain blood vessel walls and induces cerebral vascular spasm. The red blood cells may also aggregate and block the SAS, impairing CSF reflux and absorption, causing intracranial hypertension. Lumbar puncture may prevent the secondary lesion which forms after decomposition of blood in the CSF and minimize the risk of intracranial hypertension and reduce intracranial nerve damage. In addition, lumbar puncture may maintain relatively stable intracranial pressure and dilute bloody CSF, which can reduce stimulation of the meninges and relieve pain. Lumbar puncture may also reduce delayed communication in hydrocephalus patients due to obstruction of AGs, caused by the absorption of blood in CSF, and may also help to reduce arachnoids adhesions.

Lumbar puncture may remove part of the blood components in the CSF in a timely and effectively manner and reduce the meningismus, which may prevent cerebral vasospasm. However, lumbar puncture cannot wash out red blood cells that aggregate and deposit in the skull base and SAS. Hakeems [4] have suggested that injecting oxygen into the SAS through lumbar punctures can solve this problem. The oxygen is introduced into the SAS, which can breakdown the adhesion of red blood cells in the skull base and SAS. These red blood cells then rejoin the CSF and can be extracted through lumbar puncture. The ‘placeholder’ effect does not increase after injecting oxygen into the SAS and ICP also does not increase. Injecting oxygen into the SAS through lumbar punctures can accelerate the elimination of blood components in the SAS and reduce the meningismus, which can relieve clinical symptoms and minimize the adhesion of AGs.

Ultimately, this can reduce post-surgical complications and offer therapeutic benefits.

Although ETV surgery is a minimally invasive surgery, tissue destruction cannot be avoided and, since the stimulation of electric coagulation injury or cell disintegration can lead to aseptic fever, patients often suffer from high ICP and poor CFS circulation for extended periods. Lumbar puncture releases excess CSF promoting CSF circulation, which also aids in replacing old CSF. It may avoid damaging the body during the early aseptic inflammation period, while reducing post-operative prophylactic medication and reduce antibiotic dosage. Furthermore, lumbar puncture can reduce ICP, which reduces the amount of drug dehydration. This may reduce the negative impacts of medication and protect the patient’s liver and kidney function [14].

Conclusions

Patients who had high ICP and remained symptomatic or showed a tendency toward increased ICP values or presented with increased ventricular dilatation on CT scans received at least one lumbar puncture to expedite the process of ICP normalization and reduce adverse symptoms. All lumbar puncture procedures were uneventful and well tolerated by the patients, except sporadic cases of mild lumbar pain for 3-4 days after the procedure. In most cases, lumbar punctures were effective in bringing about fast normalization of ICP and cessation of adverse symptoms. When comparing the results of lumbar punctures 3 and 7 days after ETV and V-P shunt, the most notable difference is ICP falls to a normal value at a slower rate after ETV than after a V-P shunt, which corresponds with the literature [4,8,14]. In fact, for most of these symptomatic patients, this period may be transient and complete resolution was observed in most cases either spontaneously or after lumbar puncture. Consequently, lumbar punctures maybe important to determine the effect of surgery or treatment on transient high ICP after ETV in obstructive hydrocephalus patients.

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