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# Minimally-invasive treatment of communicating hydrocephalus using a percutaneous lumboperitoneal shunt*

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**Abstract:** Objective: To investigate the clinical value of a minimally-invasive treatment of communicating hydrocephalus using a percutaneous lumboperitoneal (LP) shunt. Method: The clinical and long-term follow-up data of 256 patients suffering from communicating hydrocephalus and undergoing percutaneous LP shunt during 1998 to 2008 were retrospectively analyzed. Results: After the follow-up, which lasted 6 months to 10 years, 219 cases of communicating hydrocephalus recovered well (ventricular size returned to normal and symptoms completely disappeared), 25 cases were brought under control (ventricle size reduced by 50% and symptoms partially abated), and 12 cases showed no obvious changes. Fifteen obese subjects needed modifications of the shunt due to the obstruction of the abdominal end following wrapping, and one subject underwent extubation as the subject was unable to tolerate stimulation of the cauda equina. The effectiveness of shunting was 91.40% and the probability of shunt-tube obstruction, which occurs predominantly in the abdominal end, was only 5.85%, far lower than that of ventriculoperitoneal (VP) shunt. Three subjects had a history of infection following VP shunting. Conclusion: LP shunting is minimally invasive and effective in treating communicating hydrocephalus, with fewer complications.

**Key words:** Communicating hydrocephalus, Percutaneous lumboperitoneal shunt, Cerebrospinal fluid
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## 1 Introduction

Hydrocephalus is common complication of subarachnoid or intraventricular hemorrhage, traumatic injury, and intracranial infective diseases (Lamprecht *et al.*, 2001; Wang *et al*., 2007). Outcomes of surgical treatment for hydrocephalus have long been unsatisfactory. Thus, more than 20 shunting approaches have been suggested up until now. These include such approaches as ventriculoperitoneal (VP) shunt, ventriculoatrial (VA) shunt, ventriculothoracic duct shunt, ventriculosagittal sinus shunt, lumboperitoneal (LP) shunt, etc., some of which have been abandoned due to severe complications. When compared with other shunting approaches, VP shunt is most-extensively applied. Nevertheless, VP shunts have not been meeting expectations, since its incidence of shunt tube obstruction is as high as 58% (Sood *et al.*, 2005; Li, 2009), in addition to the incidence of epilepsy in 9.4%–24.0% cases (Copeland *et al.*, 1982; Zhang *et al.*, 1996), which is mainly induced by cortical damage resulting from ventricular puncture (Dan and Wade, 1986). Therefore, it is of great urgency to explore a minimally-invasive shunting approach with better results and fewer complications. With the development of shunt tube materials, the application of the

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one-way shunt valve, and improvement of surgical techniques, the percutaneous LP shunt continues to demonstrate its superiority.

In this study, we treated 256 patients with communicating hydrocephalus in our hospital using percutaneous LP shunts during 1998 to 2008. Review of our experience is thus worthwhile.

## 2 Subjects and methods

### 2.1 General information

A total of 256 patients were selected, including 185 males and 71 females, aged between 1 to 91 years [mean (43.2±25.97) years]. The course of their illnesses ranged between two months to one year, with an average of four months.

### 2.2 Clinical manifestation and diagnosis

Subjects suffered disturbance of consciousness ($n$=192), headache and vomiting ($n$=64), disturbance of intelligence ($n$=61), impaired use of bilateral lower limbs ($n$=58), and urinary dysfunction ($n$=45), accompanied by cerebrospinal fluid (CSF) incision leakage ($n$=15) and scalp infection ($n$=13).

Subjects had traumatic hydrocephalus ($n$=189), postoperative aneurysm ($n$=32), post-infective hydrocephalus ($n$=35) including tubercular meningitis ($n$=14) and purulent meningitis ($n$=21), and traumatic hydrocephalus accompanied by skull defects ($n$=175) (Fig. 1).

### 2.3 Imaging examination

Computed tomography (CT) or magnetic resonance imaging (MRI) was performed on each of the subjects, in parallel with a radioisotope scan of the vertebral canal to confirm the communication between the ventricular CSF and the vertebral canal.

### 2.4 Selection of materials

The imported silicone tube, with 1.6-mm caliber, was selected as the shunt tube. A specially designed spinal puncture needle with a caliber of 2.5 mm was selected as the puncture needle, having an interior diameter allowing it to pass through the shunt tube. A high, medium, or low pump was chosen for the one-way shunt valve in line with the level of intracranial pressure.

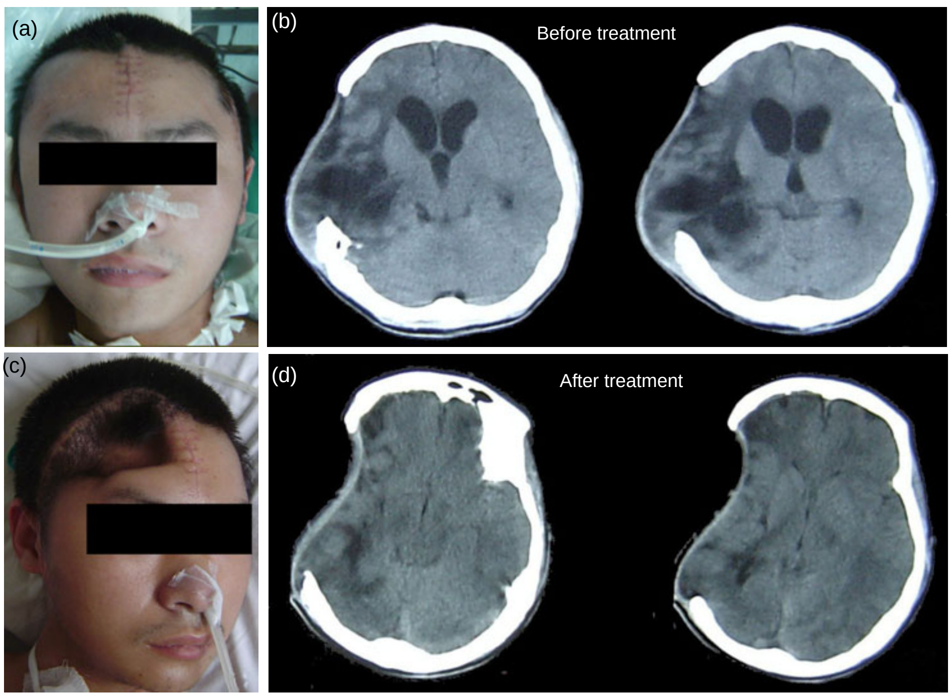


**Fig. 1 Intracranial pressure changes of a young male patient with communicating hydrocephalus after traumatic injury**
(a, c) The states of the patient before (a) and after (c) LP shunt operation. (b, d) Computed tomography (CT) scans of the head: (b) before treatment, bilateral and the third ventricles are apparently enlarged, and intracranial pressure is high; (d) after treatment ventricular size returned to normal, and intracranial pressure is low

### 2.5 Surgical approaches

Urethral catheterization was performed preoperatively. The operation was carried out under epidural or local anesthesia in the right lateral decubitus position, with bilateral lower limbs in the bent position. The $L_{3-4}$ or $L_{4-5}$ intervertebral space was selected as the point of puncture, through which a 0.5-cm opening was made with a sharp knife. A modified spinal puncture needle was inserted 5–7 cm along the midline. When an obvious breakthrough feeling was noted, this indicated that the needle was penetrating the spinal dura mater, at which point the needle core was withdrawn until the needle had been inserted through the subarachnoid cavity, with CSF flowing. Meanwhile, the shunt tube was inserted 3–5 cm into the subarachnoid cavity through the spinal puncture needle, and when CSF flowed through the shunt tube, the spinal puncture needle was pulled out. A 2.5-cm skin incision was made on the posterior superior iliac spine, and the subcutaneous tissue was slightly separated so that the one-way shunt valve could be inserted. A 0.5-cm opening was made with a sharp knife, one-third of the way between the line connecting the anterior superior iliac spine and the umbilicus on the lower left abdominal wall. This was penetrated with the puncture needle towards the lower and inward direction. When an obvious breakthrough feeling was noted, the needle core was withdrawn and the abdominal end of the shunt tube was inserted 30 cm via the puncture needle. The vertebral canal and abdominal ends of the shunt tube were elicited subcutaneously until connecting with the shunt valve on the posterior superior iliac spine. The shunt valve was pressed to test the patency of the shunt tube. Sutures were applied to fix the shunt valve and shunt tube in place, which aided in the avoidance of shifting or movement. Finally, the incision was sutured (Fig. 2).

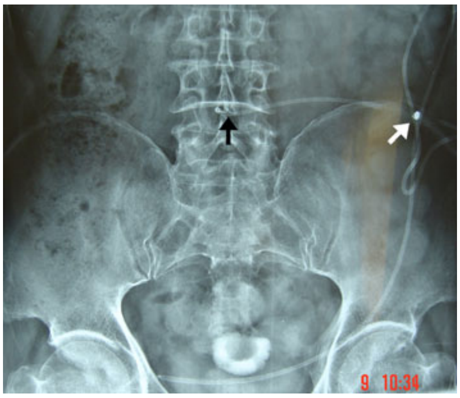


**Fig. 2 Course of the shunt tube in the body**
Black arrow: the point of puncture is selected as $L_{3-4}$ or $L_{4-5}$ intervertebral space; Blank arrow: the point of puncture lies in one-third of the way along the connection line between the anterior superior iliac spine and the umbilicus on the lower left abdominal wall

## 3 Results

After the follow-up ranging from 6 months to 10 years, 219 cases of communicating hydrocephalus recovered well (ventricular size returned to normal and symptoms completely disappeared). Twenty-five cases were brought under control (ventricle size reduced by 50% and symptoms partially abated). Twelve cases showed no obvious improvement. Fifteen obese subjects needed shunt modification due to obstruction of the abdominal end following wrapping. One subject underwent extubation, since the subject was unable to tolerate stimulation of the cauda equina. The effectiveness of shunting was 91.40%, and the probability of shunt tube obstruction, which occurs predominantly in the abdominal end, was only 5.85%, far lower than that (13.5%) of VP shunts (Lamprecht *et al.*, 2001). Three subjects had a history of infection following VP shunting.

## 4 Discussion

### 4.1 Developmental history of LP shunt

Ferguson (1898), for the first time, connected the subarachnoid space with the abdominal cavity using a silver wire following through a hole drilled on the vertebral lamina; the patient died 24 h later. Cushing reported 12 cases undergoing shunting using the silver tube as the shunt tube, among whom two died of intussusceptions (Schmidek, 2000). Matson (1949) reported the production of ureteric ostomy using the plastic tube as the vertebral canal. Nevertheless, due to obvious folding, rupture, and obstruction of the shunt tube, the plastic tube and LP shunt were indeed abandoned. With the amelioration of shunt tube materials as well as the emergence of shunting devices equipped with the valve, the usage of the LP shunt gradually became widespread. Jones

(1967) reported 63 cases of hydrocephalus treated with LP shunt, among whom 57 were brought under control. In the same year, Murtagh and Lehman (1967) adopted the No. 16 lumbar puncture needle to be inserted into a plastic tube percutaneously, followed by LP shunt, which further simplified surgical procedures and reduced complications following laminectomy or laparotomy. However, since the plastic tube was adopted, complications like shunt-tube folding, adhesive arachnoiditis, and shunt tube displacement emerged. Therefore, Spetzler *et al.* (1975; 1977) performed simple percutaneous LP shunt using the silicone tube instead of the plastic tube to avoid the emergence of these complications. Furthermore, Aoki (1990) reported an 11-year study on 207 cases undergoing LP shunt and 120 cases undergoing VP shunt for the treatment of communicating hydrocephalus, confirming the communication between the subarachnoid space and the lateral ventricle through comparisons of complications and the success rate of a one-off operation between the two groups; in addition, as for patients without spinal deformity, an LP shunt should be considered first.

### 4.2 Effects of LP shunt

Jones (1967) reported that the one-off success rate of LP shunt was 91% and the rate of adjustment was 43%. Murtagh and Lehman (1967) reported 46 cases undergoing routine LP shunt, who were followed up for six months to nine years, and the hydrocephalus in 31 of them was brought under control. Eisenberg *et al*. (1971) reported 21 cases undergoing routine LP shunt, who were followed up for a duration of five years. Hydrocephalus in these subjects was brought under control, among whom four needed modification. Our results further support the effectiveness of this procedure.

### 4.3 Benefits of percutaneous LP shunt

The procedures of percutaneous LP shunt are all performed away from the brain tissues (Yadav *et al.*, 2004), which helps to avoid cerebral complications, such as wound tract bleeding following brain puncture, brain damage-induced epilepsy, and intracranial infection (Wang *et al*., 2007). In this study, none of the subjects developed cerebral complications. What is particularly important is that percutaneous LP shunt avoids catheter indwelling in the ventricular end and instead, its vertebral canal indwelling catheter is located in the subarachnoid space, with the cauda equina floating within it, leaving it not liable to obstruct the shunt tube. Moreover, it also avoids the occlusion and wrapping of brain tissues and the choroid plexus while greatly reducing the possibility of ventricular end-occlusion soon after VP shunting (Chumas *et al*., 1993). This is in-line with the research results by Murtagh and Lehman (1967) and Eisenberg *et al*. (1971), as well as the reported results in this study that the occlusion rate of the LP shunt tube was less than that with a VP shunt.

The second difference between the percutaneous LP shunt and the traditional LP shunt lies in its adoption of spinal puncture for catheter indwelling, instead of vertebral canal incision for catheter indwelling, which simplifies previous surgical procedures and reduces lumbar complications resulting from laminectomy, such as spinal deformity. Percutaneous LP shunt also reduces operative time significantly, which averages 20–30 min, being shortened by two thirds compared to the method of catheter indwelling by vertebral canal incision (90 min). Another difference between the percutaneous LP shunt and the traditional LP shunt lies in its adoption of abdominal puncture for catheter indwelling instead of laparotomy for catheter indwelling, which reduces abdominal adhesion caused by operation interference of the abdominal cavity and thereafter reduces obstruction of the abdominal end.

Through clinical improvement, the silicone shunt tubes and shunt devices attached to valves are adopted, and the shunt tube caliber was enlarged to 1.6 mm, with the interior diameter of 1.0 mm. In doing so, the occlusion rate of the shunt tube is reduced, and plastic tube folding, rupture, and occlusion are avoided. Compared to VP shunt, this method avoids the comparative shortening of the shunt tube and the operation with an altered shunt tube due to the growth and development of children.

It is well known that CSF is endowed with the physiological functions such as providing nutrition and protection from or buffering of spinal injury. VP shunts result in the loss of the physiological functions of CSF, due to drainage of the CSF where it is secreted. In contrast to the VP shunt, CSF shunting via a percutaneous LP shunt occurs in the distal end of CSF circulation, which is much more in-line with the physiological functions of CSF.

A total of 20 subjects underwent operations under continuous epidural anesthesia, which may also alleviate the risks associated with the use of general anesthesia.

## 5 Conclusions

With the LP shunt, the operative time is greatly shortened because of the amelioration and simplification of surgical techniques. One-off success rates of the operation are high and the complications are few. Thus, the LP shunt should be considered as a primary option for patients with communicating hydrocephalus.

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