Use of lumboperitoneal shunts with the Strata NSC valve: a single-center experience

Clinical article


Victor Horsley Department of Neurosurgery, National Hospital for Neurology and Neurosurgery, London, United Kingdom

Object. The lumboperitoneal (LP) shunt with the adjustable PS Medical Strata NSC LP valve and small lumen peritoneal catheter was introduced in the authors’ unit in 2007. The object of this study was to audit the unit’s experience with this new shunt system.

Methods. The authors performed a retrospective review of the clinical records of patients who underwent Strata NSC LP shunt insertion. Demographic and clinical data as well as information about complications and revisions were reported.

Results. Between August 2007 and November 2009, 20 patients underwent placement of an LP shunt with an adjustable Strata NSC valve and small lumen peritoneal catheter at the authors’ institution. Their mean age was 40.3 years and the mean duration of follow-up was 12 months. Preoperatively, 18 patients had headache and 15 patients had visual signs and symptoms. Fourteen of the 18 patients with preoperative headache did not complain of headache postoperatively, and 4 had headache that was found not to be related to shunt function. Two of the patients with preoperative visual complaints had ongoing visual problems postoperatively. None of the patients had infection or subdural hematoma. The only overdrainage symptoms occurred in association with spontaneous readjustment of the valve and resolved when the valve was reset.

Thirteen patients (65%) did not require shunt revision. Seven patients (35%) required 13 shunt exploration or revision procedures, mainly due to distal obstruction. Placement of an LP shunt failed to completely resolve the raised intracranial pressure problem in 2 patients.

Conclusions. The use of the Strata NSC valve and small lumen peritoneal catheter is effective in treating pseudotumor cerebri and is beneficial in terms of markedly reducing overdrainage complications compared with other reported series of cases in which an LP shunt has been placed. However, the use of the Strata NSC valve and small lumen peritoneal catheter did not have a marked impact on other causes of shunt failure, particularly distal obstruction. (DOI: 10.3171/2010.6.JNS1020)

KEY WORDS • lumboperitoneal shunt • adjustable valve • programmable valve • cerebrospinal fluid shunt • pseudotumor cerebri • overdrainage

Abbreviations used in this paper: ICP = intracranial pressure; LP = lumboperitoneal; NSC = non–siphon control; PTC = pseudotumor cerebri; VP = ventriculoperitoneal.

LUMBOPERITONEAL shunt placement is a common CSF diversion technique used mainly in patients with pseudotumor cerebri (PTC) as well as in patients with CSF leak and communicating hydrocephalus.

This technique has the advantage of avoiding the brain and thus avoiding the small risk of cerebral hemorrhage, infection, or seizures associated with ventricular shunts; another positive factor is the relative ease of insertion of the LP shunt especially in patients with small ventricles.2

Ferguson inserted the first LP shunt in 1898 by inserting a loop of silver wire through a vertebral body, connecting the spinal canal and the peritoneal cavity. In 1905, Cushing adapted the technique and used a transvertebral silver cannula. In 1959, Luyendijk used a catheter to connect the lumbar thecal sac and peritoneum, and
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Murtagh, in 1967, was the first to incorporate a valve into an LP shunt; he was also the first to use a Tuohy needle to introduce the lumbar catheter into the spinal canal.¹

A conventional LP shunt consists of a valveless thin Silastic tube with a slit end. The control of CSF flow is dependent on gravity and resistance encountered through the tube and the slit end.²²³

Published series have shown a high risk of shunt failure due to obstruction as well as overdrainage complications: low pressure headache, nausea and vomiting, nuchal rigidity, disturbances of vision, vertigo, tinnitus, reduced hearing, and acquired Chiari malformation due to tonsillar herniation.²

The use of a valve has been suggested to reduce low pressure symptoms.²²³

An LP shunt with the adjustable PS Medical Strata NSC LP valve (Medtronic, Inc.) and small lumen peritoneal catheter was introduced in our unit in 2007; in this study we audited our unit experience with this new shunt system.

Methods

The clinical records of patients who underwent placement of a PS Medical Strata NSC LP shunt between 2007 and 2009 were retrospectively reviewed. Data related to patient age, sex, diagnosis, previous CSF diversion techniques, pre- and postoperative headache, and visual problems were collected. Initial settings and subsequent adjustments of the adjustable valves, shunt revisions and indications, complications, and duration of follow-up were also recorded.

The PS Medical Strata NSC LP valve incorporates a ball-and-cone pressure valve (Fig. 1). Flow control is accomplished by resistance of the ball and cone. The degree of resistance determines the performance characteristics of the valve, and retrograde flow is prevented by the ball and cone. The valve provides a full range of performance levels (acceptable pressure ranges are given in parentheses): 0.5 mm H₂O (0–30 mm H₂O), 1.0 mm H₂O (1–60 mm H₂O), 1.5 mm H₂O (55–115 mm H₂O), 2.0 mm H₂O (105–170 mm H₂O), and 2.5 mm H₂O (155–225 mm H₂O). It has a reservoir and proximal and distal occluders, allowing injection, CSF sampling, and flushing in the distal or proximal direction. The performance level can be checked through the use of the StrataVarius adjustment system (Medtronic) or by radiographic confirmation.

The small lumen peritoneal catheter has relatively firm catheter tubing, which provides resistance to kinking and occlusion. The small inner diameter provides an average resistance to flow of 0.1 cm H₂O per centimeter of catheter length at a constant flow rate of 20 ml/hour. The flow-limiting properties of the small lumen peritoneal catheter may decrease the risk of overdrainage. Conversely, the risk of underdrainage may be increased in some circumstances.

Surgical Technique

Valves were preset prior to implantation, with the initial setting tailored to patient circumstances: in those with a history of low-pressure headache, the highest setting was used; in those with endangered vision or with a history of low cerebral compliance, a low setting was used.

All implantation procedures were performed with the patient under general anesthesia and in a lateral position, with routine skin preparation and draping. Three incisions were made: a 10-cm midline lumbar incision exposing the lumbar fascia, a 5-cm curved incision parallel to the iliac crest, and a lateral transverse abdominal incision (Video 1).

Video 1. Video clip showing the surgical insertion of an LP shunt and PS Medical Strata NSC valve. Click here to view with Windows Media Player. Click here to view with Quicktime.

The abdominal wall layers were dissected, exposing and opening the peritoneum. A subcutaneous pouch was fashioned at the iliac incision to lodge the valve. A small lumen peritoneal catheter was tunneled between the abdominal and iliac incisions. The enlarged end of the peritoneal catheter was connected to the distal end of the valve. A Tuohy needle was used to introduce 15 cm of lumbar catheter into the thecal sac. The tube was then tunnelled subcutaneously to the iliac incision, where it was secured to the proximal end of the valve. Following confirmation of free distal CSF flow, the distal end was introduced intraperitoneally. Fixation tabs were used to fix the proximal and distal catheters to the surrounding fascia. The plastic base of the valve was sutured to the iliac fascia. Then all 3 wounds were closed in layers (Fig. 2).

Results

Between August 2007 and November 2009, 20 patients (18 women and 2 men) underwent insertion of an LP shunt with the Strata NSC valve and small lumen peritoneal catheter in our institution (Table 1). The mean age (±SD) of the patients was 40.3 ± 10.3 years (range 22–57 years). The mean duration of follow-up was 12 ± 8 months (range 1–27 months).

This LP shunt placement was the first CSF diversion procedure in 10 patients; 2 had previously undergone placement of conventional LP shunts, 3 had undergone VP shunt placement, and 5 had both VP and LP shunts inserted on separate occasions.
Thirteen patients had pseudotumor cerebri, and 4 had intracranial hypertension secondary to cerebral venous thrombosis (2 cases), glomus jugulare tumor (1 case), or previous Chiari malformation (1 case); 1 patient had communicating hydrocephalus, 1 patient had hydrocephalus secondary to arachnoid cyst surgery, and 1 patient had CSF leak.

Thirteen patients required 22 readjustment procedures, yielding a readjustment rate of 0.65 and readjustment number of 1.1 times/patient.

Preoperatively, 18 patients had headache (high-pressure headache in 17 cases and low-pressure in 1); 15 patients had visual signs and symptoms.

Of the 18 patients with preoperative headache, 14 did not complain of headache postoperatively, and 4 had headache that was found not to be related to shunt function after extensive work up including ICP monitoring. Two patients had ongoing visual problems. Two patients had back pain that was managed conservatively with no surgical lesion on MR imaging of the spine. None of the patients had infection or subdural hematoma. There were no symptoms of overdrainage in 19 of 20 patients; in 1 case the valve spontaneously readjusted to 0.5 and the patient experienced low-pressure headache that responded to readjustment of the valve to a higher setting.

Thirteen patients (65%) had not required shunt revision after a mean follow-up period of 10 ± 8 months. Seven patients (35%) required primary shunt exploration or revision after a mean of 6 ± 5 months: 3 due to distal obstruction, 1 due to proximal obstruction, 1 due to CSF leak (probably caused by damage to the valve during the initial surgery), and 1 due to possible valve malfunction (inability to adjust valve opening pressure). The seventh patient presented with recurrent headache that followed her experiencing a snap-like sensation in the valve area. A plain radiograph was obtained and the findings added to the suspicion of shunt disconnection (radiolucent end), but subsequent exploration proved the shunt system to be intact and ICP monitoring and subsequent headache/neurology team review excluded shunt-related problems. Four patients required secondary exploration or revision after a mean of 3.7 ± 2.8 months due to distal obstruction, proximal tube fracture, CSF leak, or persistent high ICP (thought to be related to high intraabdominal pressure). Two patients required a fourth surgery, for addition of a VP shunt due to persistent symptoms in one case and for exploration for distal obstruction in the other.

Lumboperitoneal shunt placement failed to completely resolve the raised ICP problem in 2 patients: one subsequently underwent ligation of the LP shunt and stereotactic insertion of a VP shunt with an adjustable valve; the other underwent stereotactic insertion of a ventriculoatrial shunt with an adjustable valve.

**Discussion**

Studies have shown that LP shunts can control symptoms and signs in the majority of patients with intracranial hypertension efficiently. However, reported shunt revision rates are very high, with the percentage of patients requiring at least 1 reoperation being as high as 39%–60%. Shunt obstruction has been found to be the most common complication of LP shunts, followed by secondary intracranial hypotension caused by excessive drainage of the CSF via the shunt; the rate of revisions due to low-pressure headache has been reported to be as high as 25%.

The recent availability of a programmable LP shunt has been predicted to result in a lower incidence of symptomatic intracranial hypotension.

**Findings**

In the relatively short follow-up period of this study, the Strata valve was successful in controlling the ICP related symptoms and signs in 18 out of 20 patients. The fact that 2 patients required an alternative CSF shunting technique is in line with findings of other studies. Four patients had migraine-type headache that was found to be unrelated to ICP. It has been shown that up to 50% of PTC patients develop tension-type headache or migraine.

None of the patients developed overdrainage symptoms. One patient presented to the outpatient clinic with low-pressure headache, and his valve setting was found to be lower than the discharge setting; this patient did not have an MR imaging study and did not recall exposure to a strong magnet. The resulting low-pressure headache responded to adjusting the valve to a higher setting. Patients in this series did not undergo imaging examinations to detect possible acquired Chiari malformation since none of them had symptoms suggestive of that condition.
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The revision rate of 35% due to other causes of shunt malfunction is similar to that reported by other authors. Hence, although this type of shunt has a marked impact on complications related to overdrainage, it did not have a marked impact on other causes of shunt failure, particularly distal obstruction.

Literature Review

Wang et al.\textsuperscript{13} reported a series of 67 patients treated with LP shunts as their first CSF diversion technique. In 46 patients, the authors used the Integra Horizontal-Vertical (H/V) lumbar valve system (Integra LifeSciences) that incorporates 2 different valves to allow for control of CSF flow when a patient is upright or recumbent; in 21 patients conventional Silastic LP shunts were used. There were a total of 44 revisions for the entire group: 27 patients had 1 revision, 10 patients had 2 or 3 revisions, and 1 patient had 5 revisions. Obstruction or migration of the peritoneal catheter was the most common reason for revision. The H/V valve was responsible for shunt malfunction in 9 out of 46 patients. Overdrainage symptoms were observed in 11 patients (7 [33\%] without a valve and 4 [8.6\%] with the H/V valve system). Nine of the 11 patients required revision surgery. Acquired Chiari malformation was not seen in any of the patients in whom the H/V valve system was used. There were 3 cases of infection, 2 of which required removal of the LP shunt.

Nadkarni et al.\textsuperscript{11} reported on a series of 40 PTC patients who underwent insertion of an LP shunt system with a Codman Hakim Programmable Valve (Codman & Shurtleff) modified to include a flat-bottomed stage to prevent it from rotating. The Siphonguard device (Codman & Shurtleff) was used to prevent overdrainage. A ventricular access device was inserted in the same setting to allow investigation of shunt function. The mean duration of follow-up was 18 months (range 3–72 months). Low-pressure headaches were reversed by increasing valve resistance, and high-pressure headaches were reversed by decreasing valve resistance. On 16 occasions, 10 patients required revision procedures for shunt failure. Five patients required 1 revision, 4 patients required 2 revisions, and 1 patient required 3 revisions. The indications for revision were obstruction in 12 patients, shunt migration in 3, and valve dysfunction in 1 patient. In the last case, the valve could not be adjusted and had to be replaced. No patient treated with a shunt developed a Chiari malformation. The LP shunt was revised in 2 patients who developed a pseudomeningocele. Seven patients had headaches despite documented normal ICP and were referred to a pain management clinic. In 3 patients exposed to a magnetic field, the valve had to be reset due to changes in opening pressure. Two of these patients had undergone MR imaging for an unrelated disorder, and 1 patient had undergone wand surveillance at the security gate at the airport.\textsuperscript{11}

Alternative Surgical Treatments

Ventriculoperitoneal shunt placement is another possible treatment for PTC. The problem of small ventricles has been solved with the advent of frame-based and frameless stereotactic techniques. Few studies have looked into the results of stereotactically inserted VP shunts for

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* FU = follow-up; IHT = intracranial hypertension; LPS = LP shunt placement; VPS = ventriculoperitoneal shunt placement.
PTC, and in most of these, the authors have concluded that the obstruction rates were significantly lower and consequently patients required fewer revisions.\textsuperscript{2,3,9,14} These studies, however, were not controlled.

Optic nerve sheath fenestration is an effective technique in protecting the vision but is less effective in relieving the headache. Long-term visual function follow-up is essential as the probability of functioning of optic nerve sheath fenestration steadily decreases after 6 months.\textsuperscript{2}

A few studies have suggested that transverse sinus narrowing might be the underlying pathological condition in PTC and that it can be treated with dural venous sinus stenting.\textsuperscript{2,6,12} It is not certain whether the stenosis is the cause or the result of PTC and resolution of transverse sinus stenosis in PTC after LP shunt placement has been reported.\textsuperscript{2,3}

Conclusions

The use of the Strata NSC valve and small lumen peritoneal catheter is effective in treating PTC and is beneficial in terms of markedly reducing overdrainage complications compared with other reported case series involving LP shunt placement. Nevertheless, the shunt revision rate is still high, mainly due to distal obstruction. A prospective, randomized study comparing different surgical procedures used in the treatment of PTC is warranted.

Disclosure

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Author contributions to the study and manuscript preparation include the following: Conception and design: Toma, Watkins. Acquisition of data: Toma. Analysis and interpretation of data: Toma. Drafting the article: Toma. Critically revising the article: Watkins, Watkins. Reviewed final version of the manuscript and approved it for submission: all authors. Administrative/technical/material support: Dherijha. Study supervision: Watkins, Watkins.

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