

Lumbosubarachnoid–Lumboepidural Shunting in Patients With Idiopathic Normal-Pressure Hydrocephalus: Surgical Procedures and Follow-up Study of Five Cases —Technical Note

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Abstract

The objective of the study is to introduce the surgical procedure of the lumbosubarachnoid–lumboepidural (L–L) shunting performed as treatment for idiopathic normal-pressure hydrocephalus (iNPH) and its follow-up. The subjects were five patients with probable iNPH (aged 78–85 years; mean age 81 years; four males and one female) who were judged to be at high risk from general or lumbar anesthesia due to their systemic complications and age. The L–L shunt operation was performed for all the patients under local anesthesia using Codman–Hakim Programmable Valve® (Codman & Shurtleff, Inc., Raynham, Massachusetts, USA). The initial pressure for all patients was set at 8 cmH₂O. The evaluation of shunt efficacy and the lumbar epidural space cerebrospinal fluid (CSF) absorption test (injection of contrast media into epidural space) were performed both on the operation day and during follow-up period (9–12 months). The shunt operation was judged to be effective in four out of five patients (regarded as shunt responders), whereas no improvement in symptoms was seen in one patient (regarded as shunt nonresponder) where the shunting had no effect after the initial pressure was changed to 4 cmH₂O. The lumbar epidural space CSF absorption test both on the operation day and during the follow-up period confirmed absorption in all patients. The L–L shunting is useful for patients with probable iNPH who are at high risk from general or lumbar anesthesia due to their systemic complications and age. CSF was continuously absorbed in the lumbar epidural space during postoperative follow-up period. A longer follow-up is required to establish this surgical procedure.

Key words: normal-pressure hydrocephalus, idiopathic, lumbosubarachnoid–lumboepidural shunting

Introduction

We have determined the indications for shunting in patients with possible idiopathic normal-pressure hydrocephalus (possible iNPH)⁵⁾ based on the nature of clinical symptoms, findings on magnetic resonance imaging (MRI), the dynamics of the cerebral circulation as assessed by single-photon emission computed tomography (SPECT), the “lumbar tap test,” and a further supplementary test (the cerebrospinal fluid [CSF] outflow resistance value, Ro).^{14,17–24)} Using this approach we have managed over 500 iNPH patients with long-term follow-up.^{15,16)} Of these patients, many who were diagnosed as having probable iNPH⁵⁾ could only be managed with intermittent lumbar puncture on an outpatient basis because they were judged to be at high risk from shunting

under either general or lumbar anesthesia, due to their advanced age or systemic complications. We here report the satisfactory results achieved with lumbosubarachnoid–lumboepidural (L–L) shunting under local anesthesia, which we developed for use in five patients who were at high risk from conventional shunting.

Materials and Methods

The subjects were five patients (aged 78–85 years; mean age 81 years; four males and one female) with probable iNPH as defined by the guidelines,⁵⁾ in whom shunting was determined to be appropriate but who were considered to be at high risk from general or lumbar anesthesia due to the presence of serious systemic complications (Table 1). L–L shunting was performed under local anesthesia in all five patients. The shunting system used was

the Codman–Hakim Programmable Valve® (Codman & Shurtleff, Inc., Raynham, Massachusetts, USA), with a lumboperitoneal (LP) shunt catheter. An epidural drainage catheter with a diameter of 0.8 mm (Hakko Co., Naniwa, Osaka) was utilized as a guide-wire when inserting the epidural catheter (Fig. 1).

The patients were assessed as follows. (1) Symptom evaluation: changes in presurgical symptoms during the follow-up period (9–12 months; mean 10.4 months), assessed using the Japan Normal Pressure Hydrocephalus Grading Scale—Revised (JNPHGS-R)⁵; (2) evaluation of the lumbar epidural space CSF absorption capacity: CSF absorption capacity was

assessed by lumbar epidural space CSF absorption tests performed immediately after surgery and during the follow-up period (axial and sagittal computed tomographic [CT] images performed immediately after and 48 hours after injection of 2–5 ml of Omnipaque® [iohexol] into the valve pump); and (3) postoperative complications. On evaluation of symptoms, patients with an improvement in symptoms of ≥ 1 point based on the JNPHGS-R in the follow-up period were defined as shunt responders, and patients without improvement were defined as shunt nonresponders. In the evaluation of lumbar epidural space CSF absorption capacity, patients in whom the contrast medium disappeared in the CT images acquired 48 hours after injection were defined as CSF absorption positive (+) (Fig. 2) and patients in whom this did not occur were defined as CSF absorption negative (-).

Table 1 Objective cases (n = 5)

Case	Age, Sex	Systemic complication	JNPHGS-R	mRS	LTT	Ro (mmHg/ml/min)
1	78, M	Recurrent angina pectoris Colon cancer Prostate cancer	G ₄ D ₃ U ₃ = 10p	4	Positive	16.28
2	79, M	Heart failure DM, HT	G ₂ D ₃ U ₃ = 8p	3	Positive	10.36
3	80, F	COPD, DM	G ₃ D ₃ U ₄ = 10p	4	Positive	7.41
4	83, M	Heart failure HT	G ₃ D ₀ U ₁ = 4p	2	Positive	23.28
5	85, M	Liver dysfunction Renal dysfunction	G ₃ D ₂ U ₂ = 7p	3	Positive	15.02

COPD: chronic obstructive pulmonary disease, DM: diabetes mellitus, HT: hypertension, JNPHGS-R: Japanese Normal Pressure Hydrocephalus Grading Scale—Revised, LTT: lumbar tap test, mRS: modified Rankin scale, Ro: cerebrospinal fluid outflow resistance value.

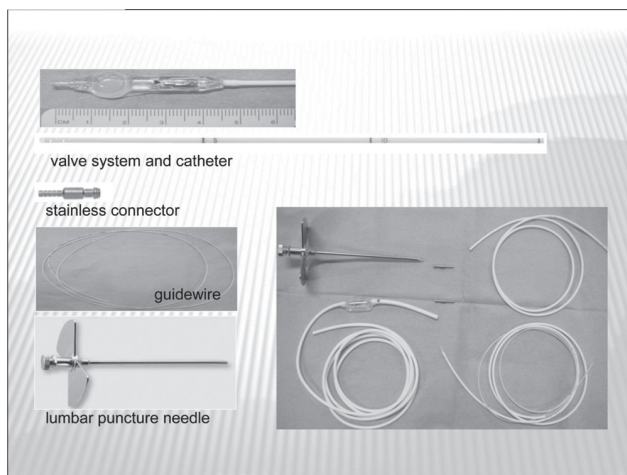


Fig. 1 Operative instruments of lumbosubarachnoid-lumboepidural (L-L) shunting.

Operative Technique

The following steps were performed as part of the operative technique:

- 1) Insert the shunt catheter and guidewire into the lumbar epidural space between the fourth and

operation day (case 1)

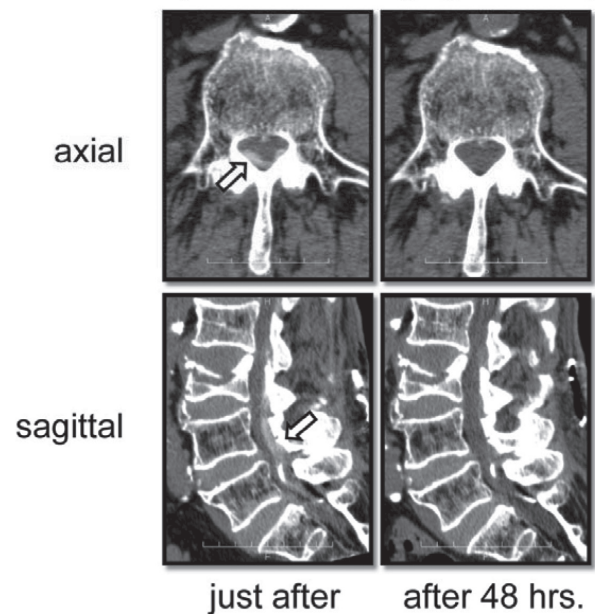


Fig. 2 A three-dimensional computed tomography (3D-CT) image of the lumbar epidural space CSF absorption test on the operation day (Case 1, block arrow: contrast media).

fifth lumbar vertebrae to a depth of approximately 5 cm using the loss-of-resistance method with saline.

- 2) Insert the catheters ≥ 5 cm into the lumbar subarachnoid space between the second and third lumbar vertebrae (or between the first and second lumbar vertebrae, depending on the case) using the same procedure as that used for LP shunting.
- 3) Make an approximately 5 cm longitudinal skin incision along the spine in the midline between the fascia insertion sites of the two catheters.
- 4) Connect the epidural space and subarachnoid space catheters to the shunt valve using a stainless steel straight connector. The catheters should not be connected too firmly so as to avoid kinking at the connector site of the catheter and the shunt valve.
- 5) Loop both the catheters, close the fascia insertion sites of the two catheters, and fix the catheter loop and valve to the paravertebral fascia.
- 6) Suture the skin (Fig. 3). The surgical position is as specified for LP shunting^{1,12,13,25} (i.e., lying on the left side, with the neck bent slightly forward, and the legs flexed). The initial pressure was set at 8 cmH₂O in all patients. The surgery took between 80 and 120 minutes (mean duration 105 minutes). The postoperative catheter and valve positions were confirmed on lumbar three-dimensional CT (3D-CT) images (Fig. 4).

Results

I. Symptom evaluation

During the follow-up period, an improvement in symptoms of ≥ 1 point, based on the JNPHGS-R, was noted in four of the five patients who were considered to be responders. Symptoms did not improve after the surgery in one patient (Case 3), the sole nonresponder, in whom symptoms did not change even with modification of the initial pressure from 8- to 4-cmH₂O (Table 2).

II. Evaluation of the lumbar epidural space CSF absorption capacity

Lumbar epidural space CSF absorption tests performed immediately after surgery and during the follow-up period revealed absorption of contrast medium 48 hours after injection in all patients; the patients were determined to be lumbar epidural space CSF absorption positive (+) (Table 2, Fig. 5).

III. Relationship between shunt responder and CT image

The typical disproportionately enlarged subarachnoid-space hydrocephalus sign was revealed only in one case (Case 5) out of four shunt responders on preoperative CT image. In this case, decreased ventricular size and appearance of high convexity cerebral sulcus were appreciated on postoperative follow-up period on CT image (Fig. 6).

IV. Postoperative complications

Subcutaneous leakage of CSF due to "side-leakage"

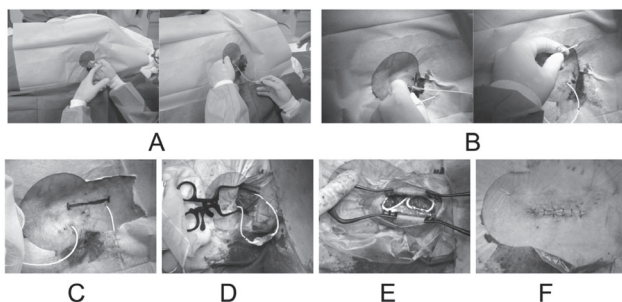


Fig. 3 Surgical procedures of lumbosubarachnoid-lumboepidural (L-L) shunting. A: Insertion of the lumboepidural catheter. B: Insertion of the lumbosubarachnoid catheter. C: Cutting out of the skin. D: Coupling between valve and catheter. E: Setting the catheter with loop formation and fixation of the valve on paravertebral fascia. F: Suturing of the skin.

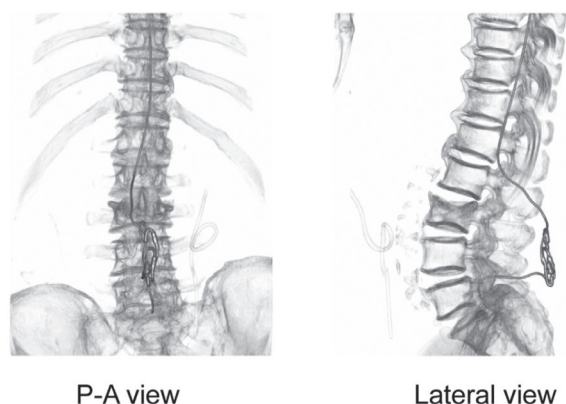


Fig. 4 A three-dimensional computed tomography (3D-CT) image of lumbosubarachnoid-lumboepidural (L-L) shunting after operation.

Table 2 Postoperative follow-up (n = 5)

Case	Age, Sex	Follow-up period	Preope. and Postope. JNPHGS-R	Preope. and Postope. mRS	Epidural space absorption test	Shunt efficacy
1	78, M	12 mos	G ₄ D ₃ U ₃ = 10p G ₃ D ₃ U ₀ = 6p	4 3	Absorption (+)	R
2	79, M	11 mos	G ₂ D ₃ U ₃ = 8p G ₁ D ₂ U ₁ = 5p	3 2	Absorption (+)	R
3	80, F	10 mos	G ₃ D ₃ U ₄ = 10p G ₃ D ₃ U ₄ = 10p ↓ Pressure reset (8- → 4-cmH ₂ O) ↓ G ₃ D ₃ U ₄ = 10p	4 4 4	Absorption (+)	NR
4	83, M	10 mos	G ₃ D ₀ U ₁ = 4p G ₂ D ₀ U ₀ = 2p	2 2	Absorption (+)	R
5	85, M	9 mos	G ₃ D ₂ U ₂ = 7p G ₁ D ₂ U ₀ = 3p	3 2	Absorption (+)	R

JNPHGS-R: Japanese Normal Pressure Hydrocephalus Grading Scale—Revised, mos: months, mRS: modified Rankin scale, NR: shunt nonresponder, R: shunt responder.

operation day (case 3) follow up (case 3)

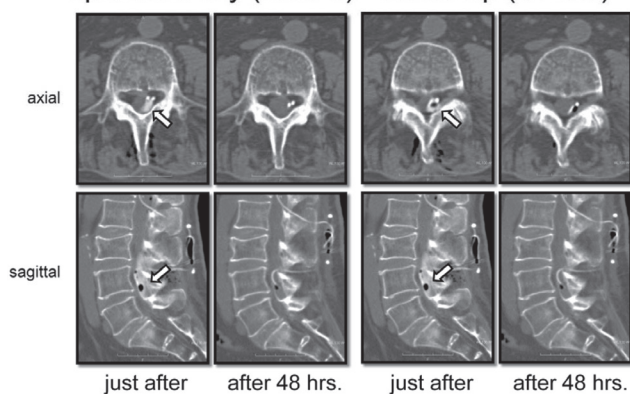


Fig. 5 A three-dimensional computed tomography (3D-CT) image of the lumbar epidural space cerebrospinal fluid (CSF) absorption test on the operation day and during the follow-up period (Case 3, *block arrow*: contrast media).

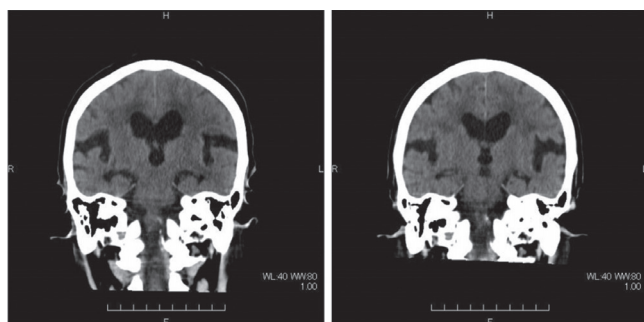


Fig. 6 Preoperative (*left*) and postoperative follow-up period (*right*) coronal computed tomography (CT) image on Case 5.

of CSF was noted in one patient (Case 5) on postoperative Day 5; this resolved after the initial pressure was changed (from 8 to 12 cmH₂O).

Discussion

Unlike the intracranial dura mater, the spinal dura mater is divided into outer and inner layers. The outer layer is attached to the periosteal tissue that lines the spinal canal, whereas the inner layer alone covers the spinal cord. Therefore, the commonly used term “spinal epidural space” refers to the space between the inner and outer layers of the spinal dura mater. The spinal epidural space is under negative pressure relative to atmospheric pressure and contains connective tissue, venous plexuses, and fat tissue. This space is used for various tests and therapeutic maneuvers such as epidural nerve blocks with injection of local anesthetic for sciatica. This usage shows that the spinal epidural space is capable of absorbing drugs and contrast media.¹⁰⁾ Furthermore, Kaijima et al.⁶⁾ recently reported two cases of overdrainage induced by CSF side-leakage into the lumbar epidural space after LP shunting. This report clearly indicates that the lumbar epidural space can absorb CSF.

Based on this evidence, we developed L-L shunting under local anesthesia. This procedure can be performed in patients with high risk for ventriculoperitoneal shunting^{2-4,7-9,11,26)} or LP shunting^{1,12,13,25)} under general or lumbar anesthesia because of their advanced age or systemic complications, including the cases where it is not possible to insert the catheter into

abdominal cavity because of the existence of severe abdominal disease. The follow-up results in our five patients who underwent L–L shunting demonstrated that four of them were shunt responders during the follow-up period (mean duration 10.4 months), and CSF was absorbed from the lumbar epidural space during the follow-up period in all patients, including the single nonresponder. The postoperative complication of subcutaneous leakage of CSF was noted in one patient. Because this problem resolved after an increase in the initial pressure, it was assumed to be due to the CSF outflow volume exceeding the absorptive capacity of the epidural space.

Future investigation should establish the initial pressure setting for L–L shunting and the duration of the shunt effect because no treatise on lumbar epidural space absorption capacity or relationship between lumbar CSF pressure and lumbar epidural pressure are reported till now. Further long-term follow-up is essential in order to establish the indications for this procedure.

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Conflicts of Interest Disclosure

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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