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Surgical Indications and Operative Results of Lumbosubarachnoid-Lumboepidural Shunting in 29 Patients with Idiopathic Normal Pressure Hydrocephalus under Local Anesthesia

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Abstract

This study consisted of 29 patients with idiopathic normal pressure hydrocephalus (iNPH) who underwent lumbosubarachnoid-lumboepidural (L-L) shunting under local anesthesia in accordance with our surgical indications of L-L shunting. (1) CSF absorption within the lumbar epidural space and shunt clearance were confirmed in all patients after operation. (2) Shunt responders (R) were 25 of 29 cases (86.2%) 3 months after surgery. Among the R, symptom exacerbation was confirmed in three patients (12%) within the follow-up period (mean, 25.1 months). In each of these patients, shunt function were maintained and remained unchanged even with pressure resetting, the cause being an intracranial/extracranial disease other than iNPH. (3) The initial pressure setting for this method was 8 cmH_2O, with gradual change to higher pressures, such that the setting for Patient 11 and thereafter became 20 cmH_2O. (4) As postsurgical complications, subcutaneous cerebral spinal fluid collection (SCC) was confirmed in five patients (17.2%). In high-pressure resetting and follow-up observation, SCC was not observed in all patients. Epidural catheter displacement was confirmed in three patients (10.3%). No recurrence was noted after the secure fixation of the catheter at the fascia insertion portion and 2 days' postsurgical bed rest. Hence, L-L shunting is an effective shunt therapy for iNPH.

Key words: normal pressure hydrocephalus, idiopathic, lumbosubarachnoid-lumboepidural (L-L) shunting

Introduction

We have developed lumbosubarachnoid-lumboepidural (L-L) shunting under local anesthesia for patients where conventional shunt surgery—via general anesthesia or lumbar anesthesia—is considered difficult; such patients include those who are already old, those with systemic complications, and those with intra-abdominal lesions. We have previously reported topics on surgical technique manipulations and initial pressure settings.[1,2] The present paper reports on the postsurgical follow-up investigation results in 29 patients who underwent L-L shunting. From these results, the following are reported: surgical indications of L-L shunting; cerebrospinal fluid (CSF) outflow and absorption functions; reasons why the shunt was not effective and, for postsurgical exacerbation cases despite of why the shunt was effective or appropriate initial pressure settings changes; reason why appropriate initial pressure (20 cmH_2O) and pathological conditions of postsurgical complications and methods of dealing such conditions.

Materials and Methods

This study consisted of 29 patients (ages, 66–98 years; mean age, 80.8 years; male-to-female ratio, 18:11; Table 1) with probable idiopathic normal pressure hydrocephalus (iNPH), according to the definition of guidelines,[3,4] who were about to undergo L-L shunting in accordance with our surgical indications of L-L shunting (Table 2). Hence, under local anesthesia, L-L shunting was performed on these patients (Fig. 1).

We also herewith state that the performance of our method was under the approval of the ethics committee of our hospital in September 2011, and prior to the

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Table 1 Objective cases (*N* = 29)

	Age	Sex	General complication	Set-up pressure (cmH_2O)	Postop. complication		JNPHGS-R		Shunt efficacy
					SCC	Deviation of catheter	Preop.	Postop. 3 months	
1	77	M	HD, Cancer	8			$G_2 D_3 U_2$	$G_1 D_3 U_0$	R
2	79	M	HD, DM, HT	8			$G_4 D_4 U_3$	$G_2 D_3 U_1$	R
3	80	F	COPD, DM	8 → 6 → 4			$G_3 D_2 U_1$	$G_3 D_2 U_1$	NR
4	83	M	HD, HT	8			$G_3 D_1 U_2$	$G_1 D_1 U_0$	R
5	85	M	LD, RD	8 → 6 → 10 → 12	+	+	$G_2 D_2 U_2$	$G_1 D_2 U_1$	R
6	86	M	COPD, HD	8 → 4 → 2			$G_4 D_3 U_1$	$G_4 D_3 U_1$	NR
7	87	F	Cancer	8 → 10 → 12	+		$G_2 D_1 U_1$	$G_2 D_1 U_0$	R
8	66	F	Abdominal cyst	12			$G_3 D_2 U_3$	$G_2 D_1 U_1$	R
9	73	M	HD	12 → 15 → 20	+		$G_2 D_2 U_3$	$G_1 D_2 U_0$	R
10	87	M	Colon cancer	15 → 20	+		$G_3 D_3 U_3$	$G_2 D_2 U_1$	R
11	98	M	HD, RD	20			$G_2 D_2 U_3$	$G_1 D_2 U_1$	R
12	96	F	COPD, HT	20			$G_3 D_2 U_1$	$G_2 D_1 U_0$	R
13	76	M	RD (hemodialysis)	20			$G_3 D_3 U_2$	$G_2 D_3 U_1$	R*
14	86	M	RD (hemodialysis)	20 → 15			$G_4 D_3 U_4$	$G_3 D_3 U_2$	R
15	86	F	HD, DM, HT	20 → 15 → 10 → 8			$G_3 D_2 U_2$	$G_3 D_2 U_2$	NR
16	81	M	Colon disease	20			$G_2 D_3 U_2$	$G_1 D_3 U_1$	R
17	86	F	HD, cancer	20 → 15 → 12			$G_2 D_3 U_3$	$G_1 D_3 U_1$	R
18	84	M	HD	20			$G_3 D_2 U_2$	$G_1 D_1 U_0$	R
19	81	F	HLD	20 → 18 → 15		+	$G_2 D_2 U_3$	$G_1 D_2 U_1$	R
20	78	M	HT	20			$G_3 D_3 U_4$	$G_2 D_2 U_1$	R
21	77	M	DM	20			$G_2 D_3 U_1$	$G_1 D_3 U_0$	R
22	80	M	Abdominal disease	20 → 15			$G_4 D_3 U_3$	$G_3 D_3 U_1$	R
23	84	M	COPD	20			$G_4 D_4 U_4$	$G_3 D_3 U_2$	R
24	70	F	HLD, HT	20			$G_2 D_2 U_2$	$G_1 D_2 U_1$	R*
25	89	M	DM	20			$G_3 D_3 U_2$	$G_2 D_3 U_1$	R
26	69	M	Cancer	20 → 15			$G_3 D_2 U_4$	$G_3 D_2 U_1$	R*
27	73	M	HD	20			$G_3 D_2 U_2$	$G_1 D_2 U_0$	R
28	75	F	HT	20 → 15 → 10	+		$G_3 D_3 U_2$	$G_3 D_3 U_2$	NR
29	71	F	HD	20 → 15 → 10 → 5		+	$G_4 D_3 U_3$	$G_2 D_2 U_1$	R

*Symptom worsened during the follow-up period. COPD: chronic obstructive pulmonary disease, D: dementia, DM: diabetes mellitus, F: female, G: gait disturbance, HD: heart disease, HTN: hypertension, HLD: hyperlipidosis, JNPHGS-R: Japanese Normal Pressure Hydrocephalus Grading Scale-Revised,[3] M: male, NR: shunt nonresponder, R: shunt responder, RD: renal disease, SCC: subcutaneous cerebrospinal fluid collection, U: urinary incontinence.

Table 2 Surgical indications of Lumbosubarachnoid-Lumboepidural (L-L) shunting

1. Probable iNPH
2. Advanced age (almost more than 80 years.)
3. Condition of patients
   A. The cases who are considered to be at high risk from general or lumbar anesthesia to the presence of serious systemic complications (diseases of lung, heart, liver, kidney etc,) and/or
   B. The cases where it is not possible to insert the catheter into abdominal cavity because of the existence of severe abdominal disease (abdominal cyst, colon disease, abdominal operation in past disease etc.)
4. No operation of spinal canal stenosis in past history.
5. The cases who are requested L-L shunting by patients and/or family.

iNPH: idiopathic normal pressure hydrocephalus.

said performance, we acquired the consent of all patients themselves and/or of their families.

Decision of initial pressure setting could not use quick reference table[4] reason why no influence of abdominal cavity pressure in L-L shunting.[2] At the time of performing the present L-L shunting methods, pressure setting was 8 cmH_2O in Patients 1–7, with gradual change to higher pressure thereafter; from Patients 11 onward, the pressure setting was 20 cmH_2O.

(1) The operative results of these patients were immediately determined after surgery and in the follow-up period (5–81 months; mean, 25.1 months), and pumping was performed while injecting 2-ml Omnipaque (Daiichi-Sankyo, Tokyo, Japan) into the value pump portion during the lumbar epidural space CSF absorption tests. Immediately after surgery and 48 h after surgery, computed tomography (CT) sagittal images were taken, and pump clearance test was performed with the injection of 0.5-ml Omnipaque® into the valve pump portion. Immediately after surgery and 12 and 48 h after surgery, CT axial images were taken for the temporal measurements of pump-portion CT numbers. (2) Investigation of shunt efficacy rates 3 months after surgery and cases of symptom exacerbation in shunt responders (R) during the follow-up period. (3) Postsurgical complications were investigated. The Japan Normal Pressure Hydrocephalus Grading Scale-Revised (JNPHGS-R)[3,4] was used for postsurgical symptom assessments, and in patients with symptom improvement of 1 point or above, L-L shunting was considered effective, while in patients without symptom improvement, L-L shunting was considered ineffective [shunt nonresponders (NR)]. For the lumbar epidural space CSF absorption tests, patients with contrast medium disappearing in the CT images 48 h after injection were considered as CSF absorption positive (+), while patients with contrast medium still appearing in the CT images were considered as CSF absorption negative (–) (Fig. 2). As regards the pump clearance test evaluations, patients with reduced CT numbers 12 hours after contrast medium injection were considered as clearance positive (+), while patients with no reduced CT numbers were considered as clearance negative (–) (Fig. 3).

Results

Results for lumbar epidural space CSF absorption tests and for pump clearance tests

For all patients, immediately after surgery and during the follow-up period, contrast medium had disappeared in lumbar epidural space CSF absorption tests 48 h after contrast medium injection, and all patients were considered as lumbar epidural space CSF absorption positive (+).

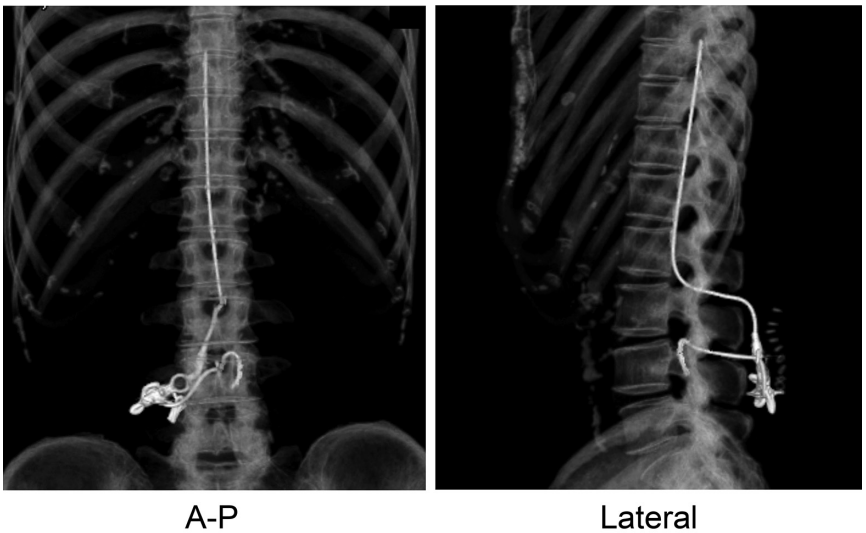

Fig. 1 Lumbosubarachnoid-lumboepidural (L-L) shunting on three-dimensional computed tomography image (Patient 7: left, anterior-posterior view; right, lateral view).

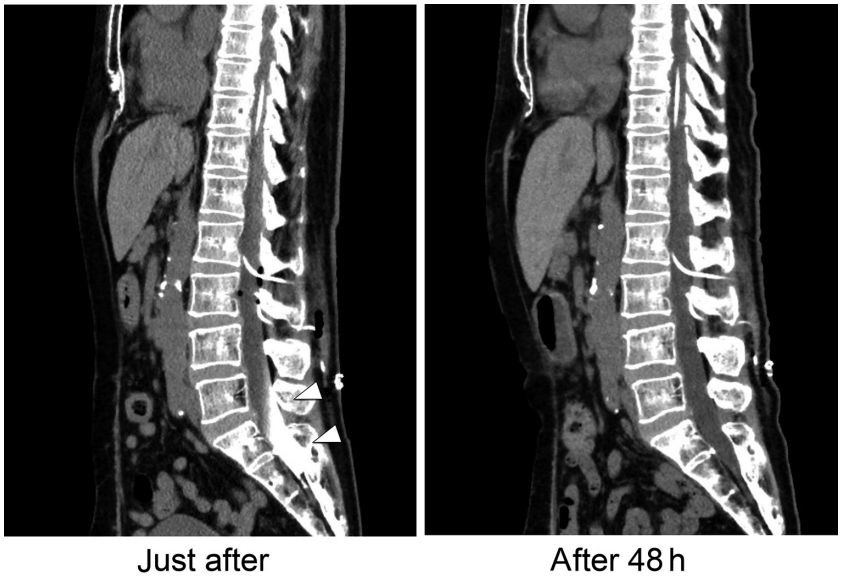

Fig. 2 Lumbar epidural space cerebrospinal fluid absorption test on sagittal computed tomography image (Patient 16: *arrows*, contrast media in lumbar epidural space; just after, just after injection; after 48 h, 48 h after injection).

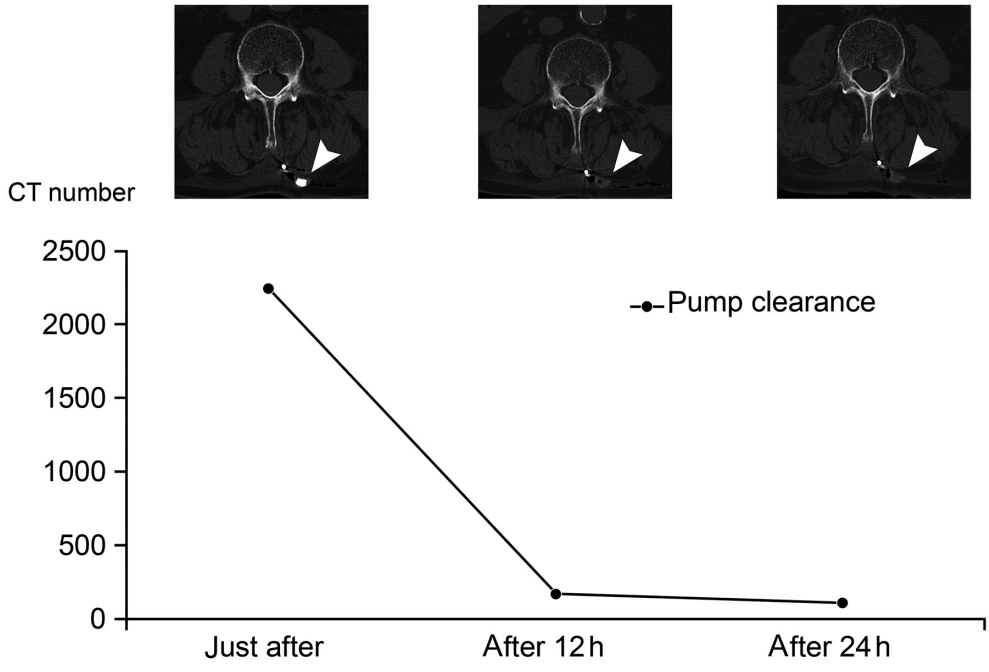

Fig. 3 Pump clearance test on axial computed tomography image (Patient 24: *arrows*, contrast media in pump; just after, just after injection; after 12 h, 12 h after injection; after 24 h, 24 h after injection).

Moreover, for all patients, immediately after surgery and during the follow-up period, remarkable reduction of CT numbers at the pump portion was confirmed 12 and 24 h after contrast medium injection, and all patients were considered as clearance positive (+).

Shunt efficacy rates 3 months after surgery and cases of symptom exacerbation in shunt-effective cases during the follow-up period

Three months after surgery, in 25 of the 29 patients (86.2%), confirmation about symptom improvement of 1 point or above was made using JNPHGS-R,[3,4] and these 25 patients were considered as R. In four patients (Patients 3, 6, 15, 28), no postsurgical symptom improvement was observed, and these patients were considered as NR. Shunt functions were maintained in all four NR cases. Even after changing the pressure settings and with additional ventriculoperitoneal (V-P) shunting performed in two patients who were requested L-L shunting initially and bearable to general anesthesia (Patients 3 and 28), symptom improvements were not observed; instead, gradual exacerbation of dementia was observed. For patients with systemic complications, chronic obstructive pulmonary disease (Patient 3), heart

disease (Patient 6), diabetes mellitus (Patient 15), and physical dysfunction (Patient 28) were noted; it was possibly considered that Patients 3 and 28 had simultaneous co-occurring cerebral parenchymal lesions (either brain degeneration or cerebral ischemic lesion) during the presurgical period.

During the follow-up period, three patients (12%; Patients 3, 24, 26) who were considered R had symptom exacerbation, which means that at the end of the follow-up period, the shunt efficacy rate had decreased to 22 of the 29 patients (75.9%). Moreover, in these three patients, shunt functions were maintained. Even after changing the pressure settings and with additional V-P shunting performed in one patient who was requested L-L shunting initially and bearable to general anesthesia (Patient 26), there were no symptom improvements; instead, gradual exacerbation of dementia was noted. For patients with systemic complications, renal disease (Patient 13), hypertension (Patient 24), and lung cancer (Patient 26) were observed; it was possibly considered that Patients 24 and 26 had simultaneous co-occurring cerebral parenchymal lesions (either brain degeneration or cerebral ischemic lesion) during the presurgical period.

Postsurgical complications

In five patients (17.2%; Patients 5, 7, 9, 10, 28), subcutaneous cerebral spinal fluid collection (SCC) was noted postsurgical days 2–5. SCC was noted in four R patients and one NR patient, characterized by abdominal distension in sitting position. Initial pressure settings were <15 cmH_2O in four patients and 20 cmH_2O in one patient. In shunt system leak tests (injection of contrast fluid into the pump portion under fluoroscopic guidance), in all patients, absence of leakage outside the catheter was noted, and SCC was not noted in all patients with resetting to higher pressure (four patients) and with temporal observation (one patient). In eight of the 18 patients with initial pressure setting of 20 cmH_2O, postsurgical settings were gradually reset to lower pressures, with SCC complication occurring in only one patient.

Epidural catheter displacement was found in three patients (10.3%; Patients 5, 19, 29), and catheter reinsertion was performed postsurgical day 2 in all patients. No recurrence was found after secure fixation of the catheter at the fascia insertion portion 2 days postsurgical bed rest.

Discussion

Inasmuch as L-L shunting can be performed under local anesthesia, it can also be performed in cases where V-P shunting[5,6] and lumbo-peritoneal shunting[7–9] are difficult to perform under general anesthesia or lumbar anesthesia due to old age, systemic complications, and/or intra-abdominal lesions. From the postsurgical follow-up results of the 29 patients who underwent L-L shunting in the present study, the following facts became clear.

According to the results of the lumbar epidural space CSF absorption tests and shunt clearance tests, all patients were considered CSF absorption positive (+) and shunt clearance positive (+). With these facts, it is considered that with L-L shunting, a secure and certain flow of CSF within the shunt system was observed, with absorption within the lumbar epidural space.

As for shunt efficacy rates, this was 86.2% 3 months after surgery and 78.9% in the follow-up period. The shunt efficacy rates of conventional shunt surgery were 50–90% in V-P shunting[5,6] and 51–86% in L-P shunting[7–9] although each judgment basis be different.

As for the four NR patients and the three R patients with symptom exacerbation during the follow-up period, shunt functions were maintained, with no improvement and gradual exacerbation of symptoms even with pressure setting changes and with additional V-P shunting. These were considered neither an exacerbation of the pathological conditions of iNPH itself nor a shunt system dysfunction; instead, these were due to intracranial and extracranial diseases. A fact worthy to be noted is that, in addition to coincidently occurring systemic disease, it is possibly considered that in four of the seven patients, there was worsening of presurgery-existing coincidental cerebral parenchymal lesions (either brain degeneration or cerebral ischemic lesion). Previous reports had stated that there are cases of coincidental brain degenerative disease in iNPH,[3,4] which means that the presurgical diagnosis of brain degenerative disease is extremely important. Currently, when a lumbar tap test is performed,[3,4] investigation about a variety of cerebrospinal fluid biomarkers for brain degenerative disease[3,4] and planned Study of Idiopathic Normal Pressure Hydrocephalus on Neurological Improvement-3 in Japan, a joint research that is to be performed with outside facilities led by Japan, are conducted.

Postsurgical complications of L-L shunting were only observed in five SCC patients and three patients of epidural catheter displacement. Among the patients with SCC, four patients had initial pressure settings of <15 cmH_2O, and with changing of the pressure settings to higher pressure and with temporal observation, SCC was already not observed in all patients. We believe that initial pressure settings have an

extremely strong relationship with the pathological conditions of SCC complication. When the initial pressure setting is set at a low pressure, since the amount of CSF absorption in the epidural space is low compared with CSF flow amount, the balance between CSF outflow and CSF absorption was unstable, resulting in SCC complication. However, it is extremely important that the CSF outflow–CSF absorption balance be stabilized by setting a high pressure (20 cmH_2O) as the initial pressure setting. Thereafter, even though there was gradual resetting to lower pressures, SCC complication was not naturally observed in just one patient. As for epidural catheter displacement, no recurrence was observed after secure fixation at the epidural catheter fascia insertion portion, fibrinogen application, and 2-day bed rest after surgery. Thus, it was possible to develop a response to both complication types. From the investigations conducted in this study, we believe that, in terms of shunt efficacy rates and postsurgical complications, L-L shunting under local anesthesia is a surgical method that is not inferior to conventional shunt surgical methods as regards shunt efficacy ratio and complications after surgery.

Conclusion

The following results were obtained in patients with possible iNPH who underwent L-L shunting under local anesthesia after determining that conventional shunting methods are difficult to be performed in these patients:

1. CSF flowed securely within the shunt system and was absorbed within the lumbar epidural space.
2. For NR and R patients with symptom exacerbation, these were due neither to exacerbation of the pathological conditions of the iNPH itself nor to shunt system dysfunction but rather to due to complicated intracranial and extracranial diseases.
3. L-L shunting is an effective treatment method for probable iNPH.

Acknowledgments

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Conflicts of Interest Disclosure

All authors declare that there are no conflicts of interest regarding this article according to the criteria of the Japan Neurosurgical Society.

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