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Original Article

Optimizing shunt integrity during acute subdural hematoma evacuation

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ABSTRACT

Background: Even mild head trauma can cause severe intracranial hemorrhage in patients with cerebrospinal fluid (CSF) shunts for hydrocephalus. CSF shunts are considered a risk factor for subdural hematoma (SDH). The management of acute SDH (ASDH) in shunted patients with normal pressure hydrocephalus can be challenging. Addressing the hematoma and the draining function of the shunt is important. To preserve the shunt, we set the shunt valve pressure to the highest and perform hematoma evacuation for ASDH. In this study, we report the surgical cases of ASDH in patients with shunts.

Methods: Between 2013 and 2019, five patients with ASDH and CSF shunts underwent hematoma evacuation at our hospital. We retrospectively analyzed data regarding their clinical and radiological presentation, hospitalization course, the use of antithrombotic medications, and response to different treatment regimens.

Results: The patients presented with scores of 5–14 in the Glasgow coma scale and severe neurological signs, consciousness disturbance, and hemiparesis. Most patients were elderly, taking antithrombotic medications (four of five cases), and had experienced falls (4 of 5 cases). All patients underwent hematoma evacuation following resetting their programmable shunt valves to their maximal pressure setting and shunt preservation. ASDH enlargement was observed in only one patient who underwent burr-hole drainage. Glasgow outcome scale scores at discharge were 1 and 3, respectively.

Conclusion: In hematoma evacuation, increasing the valve pressure may reduce the bleeding recurrence. To preserve the shunt, setting the shunt valve pressure to the highest level and performing endoscopic hematoma evacuation with a small craniotomy could be useful.

Keywords: Acute subdural hematoma, Intracranial pressure, Normal pressure hydrocephalus, Shunt, Traumatic brain injury

INTRODUCTION

Even mild head trauma can cause severe intracranial hemorrhage in patients with cerebrospinal fluid (CSF) shunts for hydrocephalus. CSF shunts are considered a risk factor for subdural hematoma (SDH), which can occur in 2–17% of patients with CSF shunts.[3-5,12,17] Factors associated with SDH in patients with CSF shunts include the valve type of the shunt system and the use of antiplatelet or anticoagulant medications.[3,5,14] Lower valve settings can result in overdrainage, increasing the risk of subdural hygromas and hematomas.[12]

The management of acute SDH (ASDH) in patients with shunted normal pressure hydrocephalus (NPH) can be challenging. If the hematoma volume is small, treating the shunt by increasing the valve pressure or ligating the shunt could reduce recurrent bleeding.[2,6] If the hematoma is large, managing the drainage function of the shunt and removing the hematoma is important.

To preserve the shunt, we set the shunt valve pressure to the highest and perform hematoma evacuation for ASDH. In this study, we report a series of surgical cases of five patients with ASDH occurring in shunt patients.

MATERIALS AND METHODS

We retrospectively reviewed the hospitalization records of patients with ASDH and CSF shunts who underwent hematoma evacuation surgery between 2013 and 2019.

Five patients with ASDH were identified and analyzed for the following details: age, sex, modified Ranking scale (mRS) score before onset, cause of hydrocephalus, pressure level of the shunt valve at the time of head trauma, and use of antiplatelet medications or anticoagulant medications before injury.

The interval until ASDH from CSF shunt, cause of head injury, Glasgow coma scale (GCS) score on admission, and neurological deficits were documented. The maximal width of the hematomas and midline shift were measured.

Treatments and their timing during hospitalization were recorded, including changes in the shunt valve pressure setting, shunt ligation or externalization, addition of shunt assist devices, surgical procedures for evacuation of the hematomas, operation duration, and measurement of intracranial pressure (ICP).

Outcomes included the length of hospitalization, and Glasgow outcome scale (GOS) scores at discharge. Furthermore, chronic SDH (CSDH) after the procedure and outcome-affecting complications were recorded.

RESULTS

The results are summarized in Table 1.

Patient background

The average age at presentation was 84.4 years (range, 77–95 years). Of the patients, three were male, and two were female. Pre-trauma mRS scores were four in four patients and three in one patient. During their injuries, two were hospitalized, and three were in nursing homes.

All patients had ventriculoperitoneal shunt (VPS) or lumboperitoneal shunt inserted for 26.6 months (range, 5–96 months) before their current presentation. The cause of hydrocephalus was secondary in four cases and idiopathic in one case. Three types of shunt valves were used: Codman-Hakim programmable valves with SiphonGuard (Codman, Raynham, Massachusetts) programed to 200 mmH_2O (two cases), Polaris programmable valve (Sophysa Ltd, Orsay, France) programed to 110–150 mmH_2O (two cases), and Strata valve (Medtronic Inc., Minneapolis, MN, USA) programed at 2.5 (one case).

Four patients received pretreatment with antiplatelet or anticoagulant medications. This included one patient on aspirin, one on clopidogrel, one on warfarin, and one on a combination of aspirin and warfarin.

Presentation on admission

Initial head computed tomography (CT) revealed ASDH in all cases. The hematomas were located on the left side in two cases, on the right side in two cases, and bilateral in one case. The causes of ASDH included falls in four patients and unknown in one patient. The patients' preoperative GCS scores ranged from 5 to 14 (average, 9.8), and the symptoms included headache, vomiting, hemiparesis, and consciousness disturbances.

Hematomas were located on the shunt side in two patients. The average maximal hematoma width was 23.6 mm, ranging from 19 mm to 30 mm, and the average midline shift was 10.2 mm, ranging from 0 mm to 17 mm.

Treatment

All urgent surgeries for ASDH were performed with the shunt preserved. The pressure setting on the shunt valve was set to its maximal pressure before the evacuation of the hematoma. Two patients underwent small craniotomy and endoscopic hematoma evacuation for ASDH, one patient underwent craniotomy, another patient underwent large decompressive craniectomy, and the remaining patient underwent burr-hole evacuation followed by craniotomy on day 4. A drainage tube and an ICP sensor were inserted into the subdural space. The operation time was 32–202 min (average, 91.2 min). No increased ICP (<25 mmHg) was observed. One patient had clinical deterioration due to CSDH under conservative treatment and, thus, had the hematoma drained.

Outcome

The mean hospitalization period was 30–119 days (median, 38 days; average, 55.6 days). The GOS scores at discharge were three in four patients and one in one patient. Four patients were discharged to a rehabilitation hospital. Three patients presented with symptomatic cerebral infarction at the ASDH side, and one patient had a lower extremity embolism.

Illustrative cases

An 85-year-old female presented to our hospital with consciousness disorder after a fall at a nursing home. On admission, the patient's level of consciousness was 9 points on the GCS. Initial head CT revealed an inserted VPS and a right ASDH without contusion or other intracranial hematomas [Figure 1a]. The patient's medical history included cerebral infarction, myocardial infarction, and NPH. The patient was taking oral aspirin.

Therefore, the shunt valve pressure was set to the maximum valve pressure of 200 mmH_2O. To preserve the shunt catheter, a small craniotomy with endoscopy for ASDH was performed. A 10-cm linear skin incision was made parallel to the shunt catheter, and a small craniotomy with a diameter of 7 × 4 cm was performed [Figure 1b]. The hematoma was easily removed using a suction cannula. The culprit vessel for ASDH on the cerebral surface was identified, and bipolar electrocautery was used to stop the bleeding. The postoperative CT revealed complete removal of the hematoma [Figure 1c]. After surgery, the patient became alert, and the patient's aphasia and right hemiparesis improved. At discharge, on postoperative day 38, the patient's GOS score was 3. No recurrence was observed 3 months after surgery, and the patient returned to normal activities of daily life.

DISCUSSION

Therapy for SDH in patients with shunts is extremely challenging due to heterogeneous treatment options, such as programmable shunt valve function restriction, shunt ligation, hematoma evacuation, and a combination of these techniques.

This study reports on five cases of ASDH in patients shunted for NPH. The typical patient is elderly, taking antithrombotic medication caused by a fall. The pressure of the shunt valve was consistently set to the highest level in all cases, and the patients with symptoms related to mass effect underwent urgent hematoma evacuation with a craniotomy.

In the literature, 12 cases have been reported regarding urgent surgical treatment of CSF shunt patients presenting with ASDH.[1,7,10,13,16,18] The findings are presented in Table 2. The mean age was 67 years (44–88 years), the cause was often a fall (nine of 12 cases), and shunt ligation was performed in four of eight cases.[1,7,10,13,16,18] Three of the five cases without shunt treatment developed re-enlargement of hematoma, and a craniotomy was performed. Five of the 12 cases died.[1,7,10,13,16,18]

Shunt management

Programmable shunt valves include a nonoperative treatment option for conservative management of ASDH in patients with ventricular shunts.[2,6] It is speculated that raising the valve pressure setting elevates ICP just enough to prevent hematoma expansion but not too severe to induce high ICP signs.[7] The assumption is that in cases of communicating hydrocephalus, as in patients with NPH, decreasing ventricular shunt drainage would force CSF to spread into alternative routes, such as the basal cisterns, thus decreasing the buildup of intraventricular pressure.[20] Most chronic hygromas or SDH cases in patients with adjustable valves were managed conservatively by readjusting the opening pressures. Removing the shunt and ligating the shunt catheter can result in the formation of hydrocephalus and clinical deterioration in shunt-dependent patients. This approach necessitates a secondary operation and poses a risk of infection.

This report suggests that increasing the shunt pressure settings prevents hematoma expansion even in ASDH, which requires emergency surgery. Thus, we recommend preserving the shunt function by increasing the shunt pressure settings.

ASDH treatment

The first choice of treatment for ASDH is a large craniotomy under general anesthesia. However, increasing age or the comorbid burden of patients may render invasive treatment strategies inappropriate. There have been increasing reports of the use of endoscopic hematoma evacuation for ASDH in the elderly.[9,11,15,19] This technique should be applied to elderly patients who have brain atrophy and a relatively thick hematoma because endoscopic manipulation favors a wider subdural space. Tanaka *et al*. reported that endoscopic hematoma evacuation of ASDH and postoperative management using ICP sensors in elderly patients are safe and effective approaches.[19] However, it should be noted that in patients with patent shunts, the drainage of CSF may mask increases in ICP, potentially leading to unnoticed hematoma enlargement. Careful monitoring and frequent imaging follow-ups are essential in such cases. Hematoma removals with shunt preservation, such as burr holes, small craniotomy, endoscopic procedures, and twist drill craniotomy, have been reported.[8,13,19] In our case, we could preserve the shunt by making the skin incision parallel to the shunt catheter during endoscopic small craniotomy hematoma removal.

Treatment strategy for ASDH in shunt patients

Whenever possible, we recommend preserving the shunt function during ASDH treatment in patients with CSF shunts [Figure 2]. For these patients, the shunt valve pressure should be set to the highest level. In elderly patients without severe cerebral contusions, shunt-preserving small craniotomy with endoscopic hematoma evacuation should be performed. In

Table 1: Clinical characteristics of the five patients with ASDH in shunted NPH.

Case	Age/Sex	Side	mRS before onset	The period between shunt placement and ASDH	Cause of NPH	Shunt type/valve type/setting	Cause of injury	GCS on admission	Symptom	Hematoma width/ midline shift at presentation	Use of antithrombotic medication	Intervention for shunt	Anesthesia	Intervention for ASDH/ operative time	Enlargement of ASDH	ICP	Complications of CSDH	Other complication	Length of hospitalization	GOS on discharge
1	86/M	Left	4	6 months	CH	LPS/Codman Hakim/200	Fall	14	Right hemiparesis→Consciousness disturbance	19.0 mm/7.8 mm→ 26.4 mm/10.7 mm	Warfarin	No (maximal pressure)	Local→General	Burr hole drainage/32 min→Craniotomy/202 min	Yes	<25 mmHg	Yes	acute limb ischemia, cerebral infarction	119 days	1
2	95/F	Right	4	5 months	iNPH	LPS/Codman Hakim/200	Fall	7	Consciousness disturbance	21.4 mm/16.0 mm	Warfarin, Aspirin	No (maximal pressure)	General	Decompressive craniectomy/80 min	No	<25 mmHg	No	cerebral infarction	57 days	3
3	79/M	Bilateral	4	96 months	Brain tumor	VPS/Medtro/2.5	Fall	14	Right hemiparesis	Right 30.0 mm, Left 30.4 mm/0 mm	Clopidogrel	No (maximal pressure)	General	Small craniotomy/99 min	No	<25 mmHg	No		34 days	3
4	85/F	Right	4	10 months	CI	VPS/Polaris/110	Fall	9	Consciousness disturbance	23.6 mm/10.1 mm	Aspirin	110→200 (maximal pressure)	General	Small craniotomy with endoscopy/73 min	No	<25 mmHg	No		38 days	3
5	77/M	Left	3	16 months	TBI	VPS/Polaris/150	Unknown	5	Consciousness disturbance	23.8 mm/17.1 mm	No	70→200 (maximal pressure)	General	small craniotomy with endoscopy/61 min	No	<25 mmHg	No	cerebral infarction	30 days	3

M: Male, F: Female, mRS: Modified Rankin scale, ASDH: Acute subdural hematoma, NPH: Normal pressure hydrocephalus, iNPH: Idiopathic normal pressure hydrocephalus, CH: Cerebral hemorrhage, CI: Cerebral infarction, TBI: Traumatic brain injury, VPS: Ventriculoperitoneal shunt, LPS: Lumboperitoneal shunt, GCS: Glasgow coma scale, CSDH: Chronic subdural hematoma, GOS: Glasgow outcome scale

Table 2: Summarized cases of acute subdural hematoma in shunted normal pressure hydrocephalus performed urgent surgery.

Case	Author/Year	Age/Sex	Side	The period between shunt placement and ASDH	Cause of NPH	Shunt type/valve type/setting	Cause of injury	GCS	Symptom	Use of antithrombotic medication	Intervention for shunt	Intervention for ASDH	Enlargement of ASDH	Length of hospitalization	GOS on discharge
1	Tamaki *et al.*/1987	74/F	Left	28 days	NA	VPS/NA/75 mmH2O	Unknown	NA	Consciousness disturbance	NA	NA	Decompressive craniectomy	No	48 h	1
2	Tamaki *et al.*/1987	68/F	Right	6 months	NA	VPS/NA/4.5 mmH2O	Fall	NA	Consciousness disturbance	NA	NA	Craniotomy	No	1 month	1
3	Aoki/1987	44/F	Right	23 days	Brain tumor	LPS/NA/NA	Fall	NA	Consciousness disturbance left hemiparesis	NA	NA	Craniotomy	No		5
4	Kamiryo *et al.*/2003	58/M	NA	11 months	iNPH	LPS/Distal slit valve/NA	Fall	NA	Consciousness disturbance	NA	Ligation	Craniotomy	No	NA	2 (3 months later)
5	Kamiryo *et al.*/2003	66/F	NA	1 month	iNPH	LPS/Distal slit valve/NA	Fall	NA	Consciousness disturbance	NA	Ligation	Craniotomy	No	NA	1 (3 months later)
6	Hoya *et al.*/2012	58/M	NA	NA	SAH	VPS/Codman Hakim/80	Fall	14	NA	No	No	Craniotomy 4 case, Burr hole drainage 1 case	Yes	NA	1
7	Hoya *et al.*/2012	64/F	NA	NA	SAH	VPS/Delta/0.5	Fall	5	Pupillary dilatation	No	No		Yes	NA	3
8	Hoya *et al.*/2012	64/M	NA	NA	SAH	VPS/Dual switch valve/100 mmH2O	Traffic accident	6	Pupillary dilatation	No	No		Yes	NA	1
9	Hoya *et al.*/2012	88/F	NA	NA	iNPH	LPS/Strata/0.5	Fall	11	NA	No	No		No	NA	3
10	Hoya *et al.*/2012	67/M	NA	NA	CH	VPS/Delta/0.5	Fall	10	Pupillary dilatation	No	No		No	NA	3
11	Kon *et al.*/2013	87/F	Left	5 years	SAH	VPS/NA/NA	Fall	8	Consciousness disturbance, right hemiparesis	No	NA	Burr hole with endoscopy	No	30 days	5
12	Sila *et al.*/2021	66/F	Bilateral	NA	NA	VPS/CERTAS/2	Fall from a ladder	3	Seizure	No	Ligation	Craniotomy	No	26 days	NA

M: Male, F: Female, NA: Not available, mRS: Modified Rankin scale, ASDH: Acute subdural hematoma, NPH: Normal pressure hydrocephalus, iNPH: Idiopathic normal pressure hydrocephalus, SAH: Subarachnoid hemorrhage, CH: Cerebral hemorrhage, VPS: Ventriculoperitoneal shunt, LPS: Lumboperitoneal shunt, GCS: Glasgow coma scale, CSDH: Chronic subdural hematoma, GOS: Glasgow outcome scale

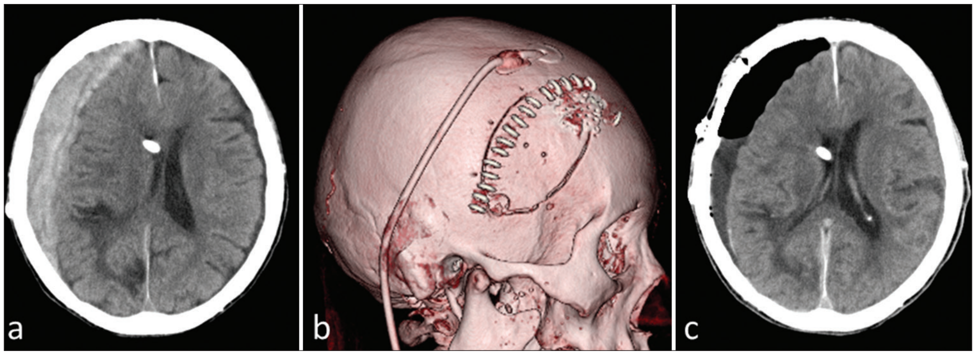

Figure 1: (a) Computed tomography (CT) on arrival showing acute subdural hematoma and shunt catheter. (b) Three-dimensional CT showing a skin incision parallel to the shunt catheter and a small craniotomy. (c) Postoperative CT revealed the removal of the hematoma.

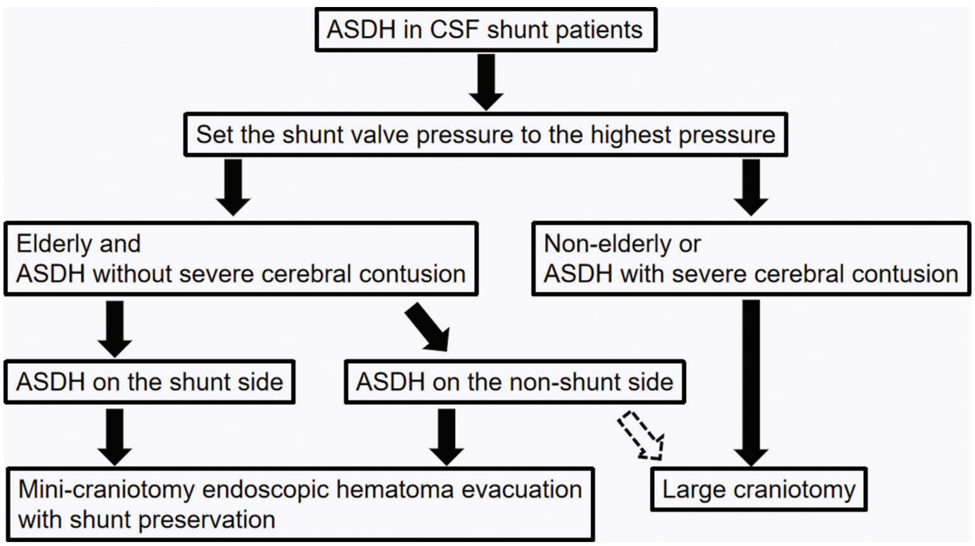

Figure 2: Treatment strategy for acute subdural hematoma in shunt patients. ASDH: Acute subdural hematoma, CSF: Cerebrospinal fluid.

non-elderly patients or those with severe brain contusion, craniotomy should be performed.

Limitation

The limitations of this study include the small number of cases and its retrospective design conducted at a single institution. Further, research with larger sample sizes and prospective randomized trials is necessary to establish the safety and efficacy of our treatment strategy.

CONCLUSION

ASDH in CSF shunt patients who required hematoma removal was common in the elderly, in those taking antithrombotic medications, and in those that were caused by falls.

To preserve the shunt, it may be useful to set the shunt valve pressure to the highest level and perform endoscopic hematoma evacuation with a small craniotomy.

Ethical approval

The authors declare that this work complies the guidelines for human studies, and the research was conducted ethicallly in accordance with the World Medical Association Declaration of Helsinki.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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