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Original Article

Endoscopic hematoma evacuation for acute subdural hematoma with improvement of the visibility of the subdural space and postoperative management using an intracranial pressure sensor

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ABSTRACT

Background: The first choice to treat acute subdural hematoma (ASDH) is large craniotomy under general anesthesia. However, increasing age or the comorbid burden of patients may render invasive treatment strategy inappropriate. These medically frail patients with ASDH may benefit from a combination of small craniotomy and endoscopic hematoma removal, which is less invasive. We proposed covering with protective sheets to prevent brain injury due to contact with the endoscope and suction cannula and improve visualization of the subdural space. Moreover, we placed an intracranial pressure (ICP) sensor after endoscopic hematoma removal. In this article, we attempted to clarify the use of small craniotomy evacuation with endoscopy for ASDH.

Methods: Between January 2015 and December 2019, nine patients with ASDH underwent hematoma evacuation with endoscopy at our hospital. ASDH was removed using a suction tube with the aid of a rigid endoscope through the small craniotomy (5–6 cm). Improvement of the clinical symptoms and procedure-related complications was evaluated.

Results: No procedure-related hemorrhagic complications were observed. The outcomes of our endoscopic surgery were satisfactory without complications or rebleeding. The outcomes were not inferior to those of other reported endoscopic surgeries.

Conclusion: The results suggest that small craniotomy evacuation with endoscopy and postoperative management using an ICP sensor is a safe, effective, and minimally invasive treatment approach for ASDH in appropriately selected cases.

Keywords: Acute subdural hematoma, Endoscopic hematoma evacuation, Intracranial pressure, Minimally invasive, Small craniotomy, Surgical technique, Traumatic brain injury

INTRODUCTION

Traumatic acute subdural hematoma (ASDH) is a major clinical entity among traumatic brain injuries. Its operative management usually includes cranioplastic craniotomy, large decompressive craniectomy, trephination/craniectomy, or a combination of these procedures under general anesthesia. However, craniotomy or decompressive craniectomy has risks of blood loss and infection, making these procedures inappropriate in some cases, particularly the elderly or patients with comorbidities. Recently, reports on endoscopic hematoma removal with small craniotomy for ASDH have been increasing.[1-5,7-14] This minimally invasive surgery could compensate for the disadvantages of craniotomy and craniectomy. In this study, we report a case series of nine patients with ASDH who underwent endoscopic hematoma removal with small craniotomy under general anesthesia.

MATERIALS AND METHODS

Between 2015 and 2019, nine patients with ASDH (defined as a hematoma that develops within 3 days from the time of injury) who underwent endoscopic hematoma evacuation surgery were analyzed. The patients' baseline characteristics, including age, sex, comorbidities, preoperative use of antiplatelet or anticoagulant agents, and initial neurological state as assessed using the Glasgow Coma Scale (GCS), were retrieved from the medical records. The duration of the procedure and the type of anesthesia (general or local) were reviewed in the surgical records and videos.

The clinical characteristics of these patients are shown in Table 1. Four patients were male and five were female, with an average age of 82 years (range, 61–93 years). Initial head computed tomography (CT) demonstrated ASDH in all cases. The hematomas were located on the left side in three cases and on the right side in six cases. The causes of ASDH included falls in three patients, burr hole surgery in two patients, and unknown in the remaining four patients. The patients' preoperative GCS scores ranged from 3 to 9 (average, 6). An antithrombotic drug was used before the procedure in three patients.

Large craniotomy or craniectomy is typically the first-choice treatment for acute and subacute ASDH. Endoscopic hematoma evacuation was performed for ASDH in carefully selected patients. The indications for endoscopic surgery were as follows: (1) the presence of symptoms and (2) the absence of moderate or massive brain contusion/hematoma.

Endoscopic procedure

We performed endoscopic ASDH removal under general anesthesia for patients meeting the aforementioned criteria. However, we also prepared for conversion to craniotomy under general anesthesia in case the brain expanded rapidly or hemostasis was endoscopically difficult.

The patients' head was rotated contralateral to the hematoma side and placed on a horseshoe headrest. An approximately 8–10-cm linear skin incision was made parallel to the coronal suture, and small craniotomy of 5–6 cm in diameter was made on the point under which the hematoma thickness was the largest [Figure 1]. After a cruciate dural incision was made, the hematoma just below and around the craniotomy was removed in direct view. The brain surface was covered with protective sheets to prevent brain injury due to contact with the endoscope and suction cannula and improve visualization of the subdural space [Figure 2]. Next, we introduced a rigid endoscope (2.7 mm, 0° angle; Olympus, Tokyo) and a suction cannula into the subdural space to observe the hematoma. The rigid endoscope was held by the left hand, while the suction cannula was held by the right hand, and the suction cannula was exchanged for bipolar forceps as needed. The hematoma was removed with the suction cannula under the vision of the rigid endoscope as much as possible.

When bleeding from a vessel on the brain surface was observed, the suction cannula was placed at the bleeding point, and the bleeding vessel was coagulated using bipolar forceps. Figure 3 shows the schema of our procedure. A drainage tube and an intracranial pressure (ICP) sensor were inserted into the subdural space. After hematoma evacuation and hemostatic treatment, the dura mater was closed and the bone flap was replaced with a titanium plate. The head skin was closed using 2-0 vicryl sutures (Ethicon, Johnson and Johnson) and a skin stapler.

Hematoma evacuation success was evaluated using head CT.

Postoperative management

All patients underwent follow-up CT imaging immediately and 1 week after the operation. If required, craniotomy was performed on the occurrence of ICP >25 mmHg, despite drug treatment. Although antiplatelet or anticoagulant medications were discontinued before surgery in all cases, they were restarted 1 week after the surgery, depending on the patient's condition and comorbidities.

Outcome measures

Neurological outcomes represented by GCS and modified Rankin Scale (mRS) scores at discharge, procedure-related complications, and the recurrence of the hematoma were analyzed to evaluate the safety and efficacy of the proposed procedure.

RESULTS

The results are summarized in Table 2. The reasons for choosing less invasive small craniotomy in these nine patients were severe cognitive dysfunction, cardiopulmonary complications, and coagulopathy. Endoscopic surgery was performed under general anesthesia in all patients. No

Table 1: Clinical characteristics of the nine patients with acute subdural hematoma who underwent endoscopic surgery.

Case	Age	Sex	Side	mRS before onset	Comorbidities	Cause of ASDH	Preoperative GCS	Symptom	Use of antithrombotic medication
1	61	M	L	0	CSDH	After burr hole surgery	8	Disturbance of consciousness, hemiparesis	-
2	83	F	R	5	AD, epilepsy	Unknown	6	Disturbance of consciousness, hemiparesis	-
3	86	F	R	3	myelodysplasia, CSDH, CHF	After burr hole surgery	3	Disturbance of consciousness	-
4	85	M	R	3	AD, CI	Fall	8	Disturbance of consciousness	Ticlopidine
5	93	F	R	4	AD, AMI, CHF	Fall	7	Disturbance of consciousness, hemiparesis	Aspirin
6	86	F	R	0	Myelofibrosis	Unknown	4	Disturbance of consciousness	-
7	82	M	L	3	AD, depression, asthma	Unknown	4	Disturbance of consciousness	-
8	77	M	L	4	CH, TBI, hydrocephalus, epilepsy	Unknown	5	Disturbance of consciousness	-
9	85	F	R	4	CI, AMI, hydrocephalus	Fall	9	Disturbance of consciousness	Aspirin

M: Male, F: Female, L: Left, R: Right, mRS: Modified rankin scale, CSDH: Chronic subdural hematoma, AD: Alzheimer's disease, CI: Cerebral infarction, CHF: Chronic heart failure, AMI: Acute myocardial infarction, CH: Cerebral hemorrhage, TBI: Traumatic brain injury, ASDH: Acute subdural hematoma, and GCS: Glasgow coma scale

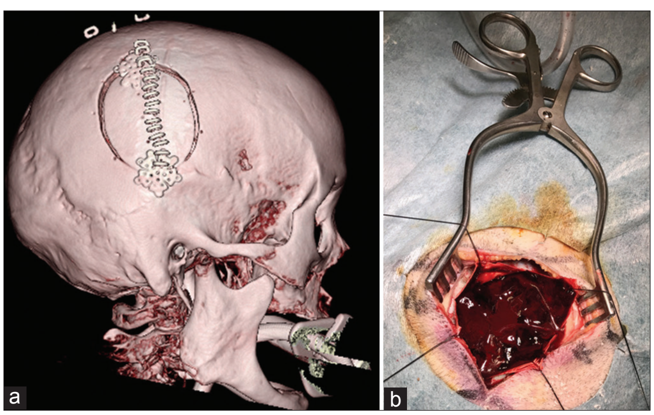

Figure 1: (a) Three-dimensional computed tomography shows the cranial bone after the procedure. An approximately 8-cm linear skin incision was made parallel to the coronal suture, and small craniotomy of 5–6 cm in diameter was made on the point under which the hematoma thickness was largest. (b) Small craniotomy was performed at the thickest point of the hematoma to insert the endoscope.

surgery-related mortality occurred and no rebleeding was observed. Three patients received antithrombotic therapy at admission; however, no rebleeding after endoscopic surgery was observed in these patients. The mean operation time was from 61 to 143 min (median, 97 min; average, 98.5 min). Two patients had increased ICP; however, decompressive craniectomy was not required in these patients. One patient presented with symptomatic ASDH at the contralateral side 1 day after surgery. Another patient presented with brain swelling due to cerebral infarction. The mean hospitalization period was from 5 to 250 days (median, 34 days; average, 56 days). Favorable outcomes at discharge were attained in two patients (22.2%); however, two patients (22.2%) died.

Illustrative cases

A 93-year-old female presented to our hospital with vomiting, aphasia, and left hemiparesis after a fall at home. On admission, the patient's level of consciousness was E1V1M5 on the GCS. Initial head CT revealed a right ASDH without contusion or another intracranial hematoma. The ASDH was approximately 1-cm thick [Figure 4a]. Her medical history included Alzheimer's disease, myocardial infarction, and chronic heart failure. The patient was taking aspirin orally. Therefore, endoscopic evacuation of the hematoma was performed. The hematoma was removed easily using a suction cannula. We could identify the culprit vessel for

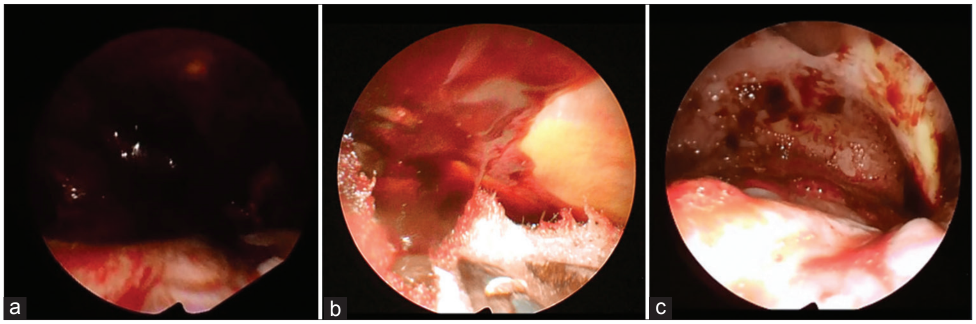

Figure 2: Intraoperative photograph showing a solid clot located between the dura mater and brain surface (a). The brain surface was covered with protective sheets to improve the visualization of the subdural space (b). Intraoperative photograph showing the area after hematoma evacuation (c).

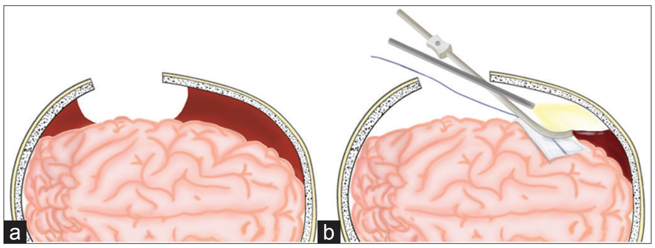

Figure 3: Illustrative schema of our procedure. (a) After a small 5-cm-diameter craniotomy and dural incision were made, a subdural hematoma just below and around the craniotomy is evacuated. (b) The brain surface is covered with protective sheets. A rigid endoscope and surgical instruments, such as a bipolar coagulator, suction cannula, or forceps, are inserted into the subdural space to evacuate the remaining subdural hematoma and stop bleeding.

the ASDH on the cerebral surface, and the bleeding from the culprit vessel was stopped with bipolar electrocautery. Postoperative CT demonstrated complete hematoma removal [Figure 4b]. After surgery, the patient became alert, and the aphasia and right hemiparesis were improved. At discharge, on postoperative day 14, the patient's mRS score was 4. Recurrence was not observed 3 months after surgery, and the patient returned to normal activities of daily living.

DISCUSSION

Surgical evacuation of ASDH in the elderly remains a point of contention because of the significant associated mortality. There have been increasing reports of the use of endoscopic hematoma evacuation for ASDH in the elderly.[1-5,7-14] In a recent scoping review, mortality rates ranged between 0% and 40%, whereas the rate of favorable outcomes ranged between 26.7% and 96.4%.[13] Rebleeding was the most commonly reported complication, with a prevalence ranging between 0% and 13%.[13] In this case series, the patients' mean age was 82.6 years, the mortality rate was 22.2%, and the proportion of patients with a favorable prognosis was 33.3%.

The reported craniotomy size ranged between 2 and 5 cm in diameter.[4,12,15] In this case series, the craniotomy size was 5–6 cm in diameter for rapid hematoma removal and reliable hemostasis. It is often caused by ruptured bridging veins in the elderly and it is difficult to stop bleeding in this area with endoscopy techniques through a burr hole. In our study related to small craniotomy procedure of 5–6 cm in diameter, venous bleeding could be stopped by compression with oxidized cellulose and fibrin glue, if necessary. If decompression was sufficient, the parietal hematoma was not removed more than necessary.

Another important consideration is the improved visualization of the subdural space. Hematomas are black; therefore, they absorb light. Therefore, the visibility of the subdural space becomes poor under an endoscope. We improved the visibility of the subdural space by covering the brain surface with a white protective sheet, which reflects light.

In this case series, all surgical procedures were performed under general anesthesia. The primary initial treatment of severe trauma is to secure the airway and stabilize respiratory and circulatory conditions. Endotracheal intubation was initiated in the emergency department for eight of nine patients with severe (GCS score ≤8) ASDH. The option of performing endoscopic hematoma evacuation under local anesthesia is one of its major advantages, as this provides a surgical alternative for patients who cannot tolerate general anesthesia. Suitability for local anesthesia implies that the patient can maintain their airway. Another consideration is the risk of excessive patient movement intraoperatively following ASDH evacuation, which may necessitate sedation or conversion to general anesthesia. Essentially, a sufficiently experienced neuroanesthetist must be immediately available to consider sedation or conversion to general anesthesia.

The median operative duration was reported to vary between 65 and 111 min.[11,12] In this case series, the median operative duration was 97 min, with an average of 98.5 min.

Table 2: Results of neuro-endoscopic hematoma removal with small craniotomy.

Case	Anesthesia	Operative duration (minutes)	Rebleeding	ICP (mmHg)	Length of hospital stay (days)	mRS at discharge	CSDH after the procedure
1	General	143	None	<25	34	2	None
2	General	89	None	<25	53	5	None
3	General	97	None	25<	12	6	None
4	General	111	None	<25	68	5	None
5	General	105	None	<25	14	4	None
6	General	125	None	25<	5	6	None
7	General	83	None	<25	250	5	None
8	General	61	None	<25	30	5	None
9	General	73	None	<25	38	5	None

ICP: Intracranial pressure, mRS: Modified rankin scale, CSDH: Chronic subdural hematoma

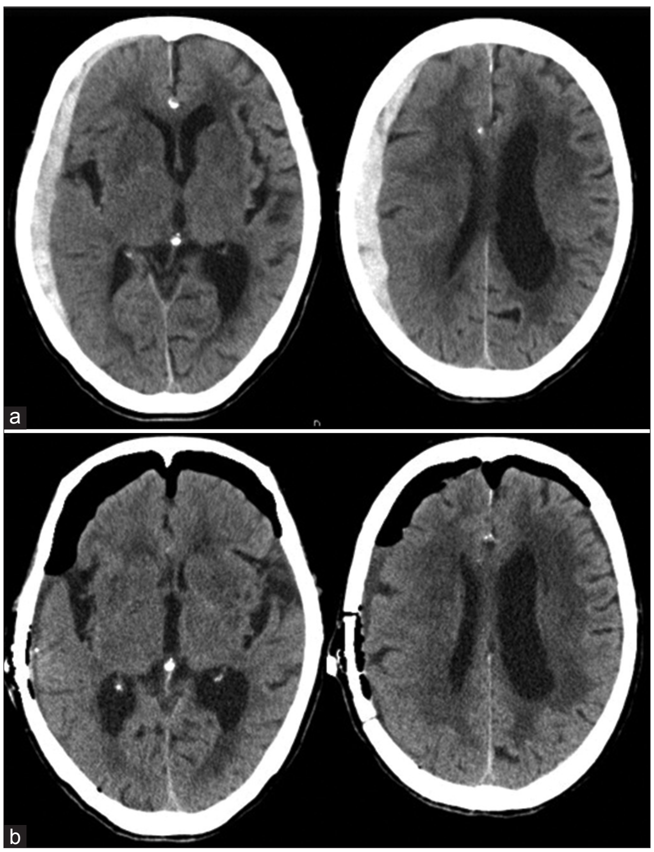

Figure 4: (a) Head computed tomography (CT) showing a thick acute subdural hematoma and mild midline shift at the time of admission in case 5. (b) Follow-up head CT showed sufficient hematoma removal and improved midline shift after the procedure.

Therefore, it is thought that endoscopic surgery is useful for ASDH.

Kiyohira *et al*. suggest the value of burr hole surgery, followed by ICP monitoring, in patients with ASDH.[6] In this case series, two patients had increased ICP. The elderly with brain atrophy were less likely to have an elevated ICP than the younger. However, this technique may be difficult to use in severe cases with massive cerebral edema, such as severe cerebral contusions. ICP monitoring allows for safe postoperative management and may improve outcomes.

However, this case series involved a small number of patients and was a retrospective study. Thus, conducting a study that involves more cases and examines long-term outcomes will be necessary.

CONCLUSION

Endoscopic hematoma evacuation of ASDH and postoperative management using an ICP sensor for appropriately selected patients are a safe and effective approach. We believe that this technique may be a less invasive surgical approach for treating patients with ASDH.

Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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