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Endoscopic surgery via a combined frontal and suboccipital approach for cerebellar hemorrhage

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Abstract

Background: Spontaneous cerebellar hemorrhages (CHs), which frequently require surgical intervention, are life-threatening and can be complicated by intraventricular hemorrhages (IVHs) and obstructive hydrocephalus. Commonly, endoscopic surgery is performed to remove CHs via a suboccipital approach (SA) alone. At our institution, when patients exhibited supratentorial IVH-associated hydrocephalus, we used a combined frontal and suboccipital approach (CA) to evacuate both CHs and supratentorial IVHs. The present study retrospectively evaluated the effectiveness and safety of this CA, as no prior studies examining this approach currently exist.

Methods: Twenty-six patients with spontaneous CH were surgically treated at our hospital from April 2009 to March 2016. Twenty-two patients who could independently perform activities of daily living before the onset underwent endoscopic surgery to evacuate the CHs; among these, 13 patients underwent the SA alone, while nine underwent the CA. We assessed and compared the patients' baseline characteristics, surgical results, and prognosis at 1 month after the intervention between the SA and CA groups.

Results: Patients who underwent the CA had significantly poorer consciousness before the surgery owing to IVH extension and obstructive hydrocephalus. However, the surgical results and prognosis at 1 month were not significantly different between the two approaches. The CH-associated IVHs were successfully removed with the CA and resulted in shorter external ventricular drainage (EVD) placement durations.

Conclusion: Endoscopic surgery performed via the CA appeared to neutralize the deteriorating effects of CH-associated IVHs. Surgical strategies employing the CA may have the potential to improve the prognosis of patients with CH.

Key Words: Cerebellar hemorrhage, endoscopic surgery, intraventricular hemorrhage, hydrocephalus

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INTRODUCTION

Spontaneous cerebellar hemorrhages (CHs) account for approximately 10% of all spontaneous intracerebral hemorrhage (sICH) cases and are commonly attributed to hypertension.[12,14,18] Patients with CH frequently require urgent surgical treatment;[5] however, such patients typically exhibit surgical risk factors, such as old age and a history of stroke, cardiac disease, diabetes mellitus, hypertension, and antithrombotic therapy, among others.[10,18] Therefore, minimally invasive surgical intervention is likely optimal in treating patients with CHs.

Prior studies have shown that CHs are frequently complicated by subsequent obstructive hydrocephalus owing to ventricle compression and intraventricular hematomas (IVHs).[5,7] Such cases require external ventricular drainage (EVD) until the cerebrospinal fluid (CSF) is released from obstruction. A longer duration of external drainage device placement might result in a higher risk of intracranial infection, as well as delayed ambulation and rehabilitation.[6] The long-term presence of a ventricular hematoma may also be associated with chronic communicating hydrocephalus.[11] Although, EVD with intraventricular fibrinolysis (IVF) reportedly improves the treatment outcome, complications associated with the procedure include rebleeding and/or intracranial infection.[7,18]

It has been reported that endoscopic evacuation is effective in providing a favorable prognosis to patients with an sICH or IVH.[7-9] However, literature on the application of this surgery for cases of CH is lacking.[15,16] The early alleviation of hematoma(s) in the cerebellum and/or ventricle may lead to a better prognosis in patients with CH, as has been reported for patients with sICHs.[7-9]

In our institution, CHs and/or CH-associated IVHs are removed using minimally invasive endoscopic surgery. More specifically, we use the suboccipital approach (SA) to remove CHs and/or IVHs in the fourth ventricle, while we employ a combined suboccipital and frontal approach (CA) to endoscopically remove massive IVHs in the supratentorial region. In the present study, we evaluated the efficacy and safety of using the new CA surgical procedure.

MATERIALS AND METHODS

In total, we reviewed the medical records of 41 patients with spontaneous CH who were treated at our hospital from April 2009 to March 2016. The protocol for this retrospective study was approved by the ethics committee at our institution. Patients with traumatic or secondary hematoma associated with aneurysm, vascular malformations, neoplasm, or evident hemorrhagic infarction were not included in this study. Of the 41 patients, 26 were treated surgically. In one patient, the parenchymal CH was not significant but a massive IVH and acute hydrocephalus were present. Therefore, surgery was only performed via a frontal burr hole for the IVH and hydrocephalus but not for the parenchymal CH. The other 25 patients had significant parenchymal CHs, which were surgically removed by endoscopic surgery via an SA or CA. After excluding three patients with moderate to poor pre-hemorrhage activities of daily living [modified Rankin Scale (mRS) score ≥3], the surgical outcomes were compared between the remaining patients treated with the SA or CA. The demographic data and clinical characteristics of the 22 included patients are shown in Table 1.

The surgical indications were a large CH (diameter ≥3 cm), brain stem compression, obstructive hydrocephalus, and/or a reduced level of consciousness. Our operative strategy [reviewed in Figure 1] consisted of endoscopic surgery via an SA or CA. In patients with hydrocephalus, an EVD device was usually placed in the patient until the noncommunicative hydrocephalus improved. When a hematoma was found to have spread

Table 1: Demographics and clinical characteristics of patients with cerebellar hemorrhage (CH)

	SA alone (n=13)	CA (n=9)	P
Age (years)	72.6±9.3	73.2±7.0	0.87
Female gender	5 (38.5%)	2 (22.2%)	0.65
Hypertension	13 (100%)	8 (88.9%)	0.41
Diabetes mellitus	1 (7.7%)	2 (22.2%)	0.54
Smoking	4 (30.8%)	2 (22.2%)	>0.99
Daily alcohol drinkers	4 (30.8%)	3 (33.3%)	>0.99
Dyslipidemia	4 (30.8%)	4 (44.4%)	0.66
Thrombocytopenia	2 (15.4%)	1 (11.1%)	>0.99
Antiplatelet therapy	1 (7.7%)	1 (11.1%)	>0.99
Coagulopathy or anticoagulant therapy	5 (38.5%)	4 (44.4%)	>0.99
Preoperative Glasgow coma scale	14 (8.5-14)	7 (5-12.5)	<0.05
Volume of CH (mL)	21.8±12.4	23.5±11.7	0.75
LeRoux score	0 (0-6)	10 (8-11)	<0.01
Hydrocephalus	4 (30.8%)	9 (100%)	<0.01

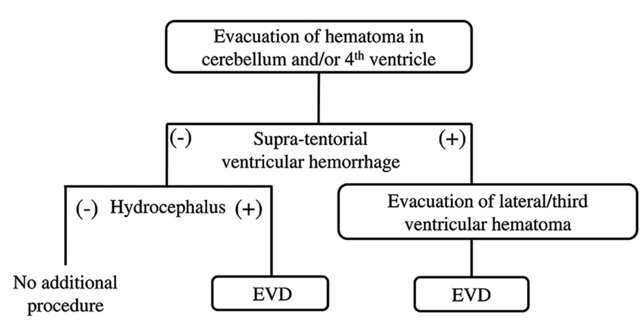

Figure 1: Surgical strategy for treating cerebellar hemorrhage

into the fourth ventricle, it was removed alongside the CH evacuation. In cases where the hydrocephalus was caused by a hematoma extending into the third and/or lateral ventricle, the supratentorial IVH was evacuated by an additional endoscopic procedure performed using the frontal approach, which we classified as the CA [Figure 2a]. This approach was usually performed simultaneously with EVD and through the same tract. To avoid midbrain damage, the supratentorial IVH was not typically removed though the aqueduct. However, if the surgeon suspected that the supratentorial IVH-causing hydrocephalus was effectively removed after the SA, application of the CA was reconsidered following postprocedural computed tomography (CT). The details of our surgical procedure are described below. All surgeries were conducted after acquiring informed consent from the patients.

Endoscopic surgery was performed under general anesthesia in a dry field. Patients were placed in the supine position with their ipsilateral shoulders elevated by a pillow and with their heads mildly flexed and rotated toward the contralateral side. A 3-cm linear incision and 1.4-cm diameter burr hole were made at the point closest to the CH cavity, around the midpoint between the ipsilateral mastoid tip and inion [Figure 2b]. Next, a transparent sheath, with an outside diameter of 10 mm (Neuroport; Olympus Corp., Tokyo, Japan), was inserted into the hematoma cavity. Under a 4-mm, 0^o or 30^o rigid endoscope (Karl Storz Endoscopy Japan K.K., Tokyo, Japan), the hematoma was aspirated via a suction tube. If bleeding was identified, it was treated by monopolar coagulation using electrocoagulation with an aspiration tube. If an IVH was identified in the fourth ventricle, the sheath was advanced into the ventricle, and hematoma was evacuated using the method described above.

The CA was applied for patients exhibiting supratentorial IVH-causing hydrocephalus and is described as follows. After CH evacuation via the SA, patients were repositioned supine with their heads in a neutral position, giving the surgeon good access to the ventricles. A frontal skin incision and burr hole were then made 3 cm lateral and 2 cm anterior to bregma on the side where a larger proportion of the hematoma was located in the lateral ventricle [Figure 2c]. In cases where there was no difference in laterality, the approach was performed in the non-dominant hemisphere. After inserting the transparent sheath into the anterior horn of the lateral ventricle, the hematoma was initially removed using a rigid endoscope. The rigid endoscope was then replaced by a flexible endoscope (VEF-type V; Olympus Corp.) and the ventricle was filled with artificial CSF (Artcereb®; Otsuka Pharma. Factory, Tokushima, Japan). The endoscope was subsequently advanced into the third ventricle through the foramen of Monro, and the IVH in the third ventricle was aspirated by connecting a 10-mL syringe to the working channel of the flexible endoscope and manually applying negative pressure. The IVH occupying and dilating the mesencephalic aqueduct was identified and removed, followed by observation of the fourth ventricle to confirm that the CSF pathway was not obstructed. When a massive IVH was located in the lateral ventricle contralateral to the puncture side, it was evacuated via septostomy at the site posterior to the anterior septal vein. After the IVH removal, a drainage tube was inserted into the lateral ventricle of the approach side, where it remained until the non-communicative hydrocephalus was alleviated.

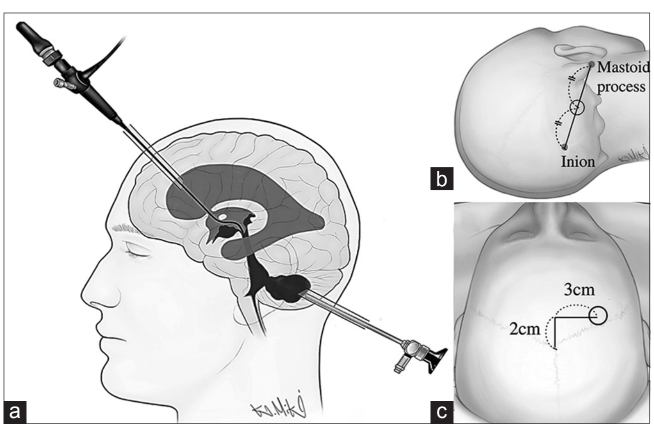

Figure 2: Schema illustrating endoscopic surgery via the combined frontal and suboccipital approach (a); burr holes for the suboccipital (b) and frontal (c) approaches are shown

Patients with hypertension were defined as those with a systolic blood pressure of ≥140 mmHg and/or a diastolic blood pressure of ≥90 mmHg, as well as patients who were on antihypertensive drugs. Patients with dyslipidemia were defined as those with a low-density lipoprotein cholesterol level (≥140 mg/dL) and/or a high-density lipoprotein cholesterol level (<40 mg/dL), as well as patients taking lipid-lowering drugs. Thrombocytopenia was defined as a blood cell count of $80 \times 10^3/\mu L$, and coagulopathy was defined as an activated partial thromboplastin time ≥40 s or a prothrombin time-international normalized ratio >1.4. Patients were classified as diabetic if their level of glycosylated hemoglobin A1C exceeded 6.5% or if they were being treated with insulin and/or oral hypoglycemic drugs. Patients were considered to be current smokers if they had smoked tobacco within the past year and to be daily drinkers if they consumed alcoholic beverages every day. The Glasgow Coma Scale (GCS) score at admission, pre- and postoperative hematoma volumes and extension of the IVH, duration of EVD, surgical complications including bleeding and surgical site infection, and mRS score at 1 month after surgical intervention were all recorded. If the patient transferred to another hospital or clinic, the mRS score was evaluated by interviewing the patient via telephone or based on a report from another institution. The cerebellar hematoma volume was calculated using the simplified equation 1/2A × B × C, where A is the maximum width measured, B is the length, and C is the height.[1] The IVH severity was graded using the LeRoux score,[4] where each ventricle was ranked as follows: 0: no blood, 1: trace blood, 2: less than 50% filled, 3: more than 50% filled, and 4: completely filled and expanded. The sum of these scores (0–16) was the LeRoux score. An EVD device that was in place for more than 5 days was defined as long-duration EVD. All data collection was performed by blinded investigators.

All statistical analyses were performed with SPSS version 24 software (IBM Corp., Tokyo, Japan). For the univariate analyses, we used Fisher's exact tests, Student's *t*-tests, or Mann-Whitney U-tests. Differences were considered significant at $P < 0.05$. Numerical data are expressed as the mean ± standard deviation or median (interquartile range).

RESULTS

In nine of the 22 patients, the CA was applied. Of these, eight patients underwent CA surgeries from the frontal and suboccipital sides immediately, while in one patient, the CA was applied after an initial surgery using the SA because a supratentorial IVH–causing occlusive hydrocephalus was identified on a CT image after CH evacuation. The remaining 13 patients were treated by SA alone. Comparisons of the patients' demographic data and clinical characteristics are shown in Table 1.

Preoperative consciousness was significantly reduced in patients who underwent surgery with the CA compared to those treated by SA alone. In addition, the LeRoux score and frequency of hydrocephalus were significantly higher in the CA-treated patients than in the SA-treated patients. Patient ages and CH volumes were not different between the two treatment groups. The patients treated with the CA were considered to have more severe brain damage neurologically and radiographically.

Table 2: The surgical outcome

	SA alone (n=13)	CA (n=9)	P
Removal rate of CH (%)	90.6±21.1	91.7±19.6	0.91
LeRoux score	0 (0-4)	1 (0-3)	0.26
EVD placement ≥5 days	3 (23.1%)	1 (11.1%)	0.62
Ventriculoperitoneal shunt	1 (7.7%)	0 (0%)	>0.99
Recurrent hemorrhage	1 (7.7%)	1 (11.1%)	>0.99
Death	1 (7.7%)	2 (22.2%)	0.54
directly related to hematoma	1	0	
indirectly related to hematoma	0	2	
mRS ≤3 at 1 month	9 (69.2%)	5 (55.6%)	0.66
mRS at 1 month	3 (1-4)	3 (2-5)	0.39

CH: Cerebellar hemorrhage, EVD: External ventricular drainage, mRS: Modified Rankin Scale

The surgical outcomes are shown in Table 2. We successfully removed the CHs in both groups; indeed, the average removal rate was >90% in each group. Because supratentorial IVHs were evacuated using the CA, the LeRoux scores for these patients remarkably decreased postoperatively and were at the same levels as those for the SA-treated group. The incidences of recurrent hemorrhage were not different between the groups.

Owing to non-communicative hydrocephalus, an EVD device was placed in four of the 13 patients (30.8%) treated by SA alone and in all nine patients who underwent treatment via the CA. Although all patients who underwent the CA had remarkable IVH and hydrocephalus, long-duration EVD (≥5 days) was only needed in one patient who had a recurrent CH postoperatively. In the other eight patients, EVD was only required for a few days, as the IVH was successfully removed via the CA. In three of the patients who underwent the SA alone, long-duration EVD was required for the following reasons: high preoperative LeRoux score (8 and 14) and IVH-associated third ventricle occlusion in two patients, and fourth ventricle compression due to an insufficiently removed CH in one patient. Of the three patients who underwent long-duration EVD, one received a ventriculoperitoneal shunt (VPS) for hydrocephalus owing to an IVH-induced wall adhesion in the third ventricle.

Although the data for patients who underwent CA showed that this group had an increased preoperative rate of poorer consciousness, severe IVHs, and frequent hydrocephalus, no remarkable differences in prognosis were noted between this group of patients and the patients who underwent treatment via the SA alone. More specifically, no significant differences in modified Rankin Scale (mRS) scores were identified between the SA-treated and CA-treated groups. Nine (69.2%) of the 13 patients who underwent the SA alone and five (55.6%) of the nine patients who underwent the CA were almost able to independently perform activities of daily living (mRS ≤3).

Illustrative case

A 78-year-old female presented with sudden deterioration of consciousness (GCS scores: E1V2M6). Brain CT showed a CH, which extended through the fourth ventricle to the supratentorial ventricle, resulting in non-communicating acute hydrocephalus [Figure 3a]. The patient underwent endoscopic surgery via the CA and gross-total removal of the CH and IVH, which improved the hydrocephalus [Figure 3b].

DISCUSSION

The present findings showed that endoscopic evacuation of IVHs by the CA is effective for immediately improving CH-associated obstructive hydrocephalus. Moreover, the

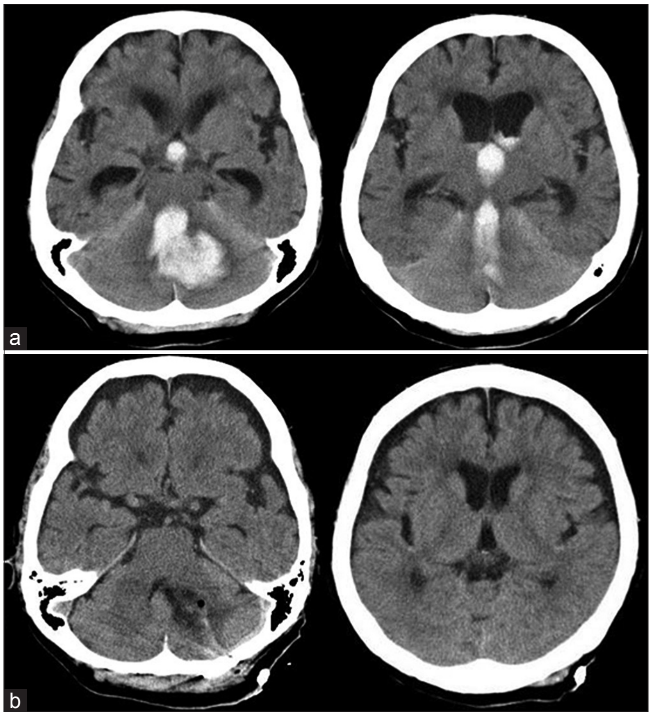

Figure 3: Preoperative (a) and postoperative (b) computed tomography scans. Cerebellar and intraventricular hematomas were totally removed by endoscopic surgery via the combined frontal and suboccipital approach

CA was associated with a shorter duration of EVD device placement, and thus may have the potential to reduce frequency of intracranial infection or VPS dependency and to facilitate early ambulation.

As previously mentioned, CHs are often accompanied by IVHs, which are associated with ventricular dysfunction, intracranial hypertension, reduced cerebral perfusion, and secondary cerebral injuries.[4,7] In the meta-analysis reported by Graberel *et al.*,[3] the risk of death is higher in sICH associated with IVH (51.2%) than with no IVH (19.5%), with an odds ratio of 6.01. Additionally, Young *et al.*[17] reported that in IVH associated with supratentorial ICH, IVH volume of >20 mL is directly related to poor outcome. Finally, Hwang *et al.* showed that assessment of IVH severity using IVH grading scales, such as IVH, Graeb and LeRoux scores, could predict the patient's prognosis, respectively.[4] The degree of IVH severity may significantly influence ventricular dysfunction and VPS dependency.[6,11] Chronic communicating hydrocephalus may be caused by IVH-induced dysfunction of the CSF-reabsorbing system. Therefore, removing IVHs in the acute phase may reduce the incidence of chronic hydrocephalus.[6] In addition, long-duration EVD and IVH-induced ventricular wall adhesions may be associated with VPS dependency, as was observed in our patients.

The most preferred treatment method for controlling obstructive hydrocephalus is EVD, and the application of EVD devices often results in a decreased IVH-related mortality rate.[3] However, in the systematic review by Li *et al.*,[7] EVD alone did not effectively improve the functional outcome of patients with IVHs in comparison with endoscopic surgery with EVD and could not prevent the development of hydrocephalus. Furthermore, EVD catheters are often obstructed by blood clots. Because the circadian blood clot dissolution rate is only 10.8%,[2,6,7] sufficient drainage of an IVH using EVD alone requires the placement of long-duration EVD devices (9–16 days). As such long-duration EVD device placements can result in EVD-related infections (10–20%) and VPS dependency,[2,6,7] this approach is not an optimal treatment strategy. Komatsu *et al.*[6] reported that endoscopic surgery effectively shortened the duration of EVD (2.7 days) compared with EVD alone (8.8 days). Thus, endoscopic removal of IVH is associated with fewer complications and prevents IVH-associated hydrocephalus more effectively than do EVD and/or IVF.[6,7] In contrast, endoscopic removal of CH-associated IVH has not been studied.

Based on our findings, endoscopic surgery by CA is useful to treat CH patients with supratentorially extended IVHs. Removal of an IVH associated with a CH was found to shorten the duration of EVD, thereby inhibiting VPS dependence and EVD-related infections. Although all nine patients who underwent the CA had IVH-associated obstructive hydrocephalus, only one patient needed long-duration EVD owing to recurrent bleeding. Moreover, none of the patients in the CA group were VPS-dependent. In contrast, three patients that underwent SA alone needed long-duration EVD and one case resulted in VPS dependence. In our retrospective assessments of the preoperative CT scans of the three abovementioned patients, the CA may have been a better strategy for two of the patients because of the presence of supratentorial IVHs.

In terms of prognostic factors and outcomes, previous studies have used the following parameters to evaluate CH prognosis: hematoma size, location of the hematoma relative to the midline, presence of IVH or hydrocephalus, decreased level of consciousness, and neuroradiological or clinical signs of brainstem damage.[5,13,14] In the present study, the patients who had these poor prognostic factors were successfully treated by CA, and their clinical outcomes were equivalent to the SA-treated patients. Therefore, we suggest that evacuating supratentorially extended IVHs via the CA minimizes the harmful effects of IVH and improve the patients' prognosis. This study was limited by the varying backgrounds of the available patient population, which differed between the SA and CA groups, and prevented a direct demonstration of the efficacy of CA. This study was further limited by its relatively small sample size, which was due to the small number of patients who had undergone the relevant surgical treatments. Finally, this study incurred a selection bias because the decision of which surgical approach to use was made by the surgeon. To confirm efficacy and safety of CA, a randomized study with a large sample size is needed.

CONCLUSION

Our results support that endoscopic evacuation via a CA might be useful for treating patients with IVH associated–hydrocephalus. Surgical strategies employing this CA have the potential to improve the prognosis of patients with CHs. However, further prospective studies are needed to confirm our findings.

Declaration of patient consent

The authors certify that they have obtained an appropriate consent form of the presented patient. In the form the patient has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

Dr. K. Yagi received grant support from the Japan Society for the Promotion of Science and AOSpine. Dr. T. Morishita received grant support from the Japan Society for the Promotion of Science, St. Luke Life Science Institute, Nakatomi Foundation, Takeda Science Foundation, Uehara Memorial Foundation, and Central Research Institute of Fukuoka University. He also received honoraria from Boston Scientific and Medtronic as a consultant. Dr. T. Inoue received grant support from the Clinical Research Promotion Foundation Japan and Japan Agency for Medical Research and Development.

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