

## Comparison of Clinical Outcomes of Intraventricular Hematoma Between Neuroendoscopic Removal and Extraventricular Drainage

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### Abstract

The efficacy of treatment for intraventricular hematoma by neuroendoscopic surgery and extraventricular drainage was compared in 10 patients with intraventricular hematoma and hydrocephalus who underwent neuroendoscopic surgery (endoscopic group), and eight patients with intraventricular hematoma and hydrocephalus treated with extraventricular drainage (EVD group). The outcomes in each group were assessed retrospectively using the Graeb scores on the pre- and postoperative computed tomography (CT), duration of extraventricular drainage, requirement for a shunt operation, and modified Rankin scale score at 12 months. The Graeb scores on the preoperative CT were not significantly different between the two groups, but the duration of catheter placement was significantly shorter (69.3%) in the endoscopic group (2.7 days) than in the EVD group (8.8 days). None of the patients in either group required a shunt procedure for communicating hydrocephalus 12 months after surgery. Neuroendoscopic removal is a safe and effective procedure for intraventricular hematoma. Advantages include rapid removal of hematoma in the ventricular systems and reliable improvement of non-communicating hydrocephalus in the acute phase. The procedure resulted in faster removal of the catheter in the postoperative period and earlier patient ambulation.

Key words: neuroendoscopy, extraventricular drainage, intraventricular hematoma, hydrocephalus, clinical outcome

### Introduction

Intraventricular hematoma (IVH) is considered to be a risk factor for poor prognosis and is characterized by a relatively high mortality rate.<sup>5)</sup> Extraventricular drainage (EVD) is generally used to treat IVH, but is sometimes complicated by infection or catheter blockage, unresolved hematoma and protracted hydrocephalus, and problems may persist, ultimately requiring ventriculoperitoneal shunting.<sup>1)</sup> Recent progress in neuroendoscopy allows minimally invasive surgery for patients with cerebral hemorrhage, and use of this technique for IVH can safely achieve reliable decompression and improvement of non-communicating hydrocephalus in the acute phase.<sup>4,8,9,14)</sup>

The present study describes our surgical technique of endoscopic evacuation for IVH, using both rigid and flexible endoscopes for aggressive treatment of hyperacute IVHs, compares the outcomes

achieved by endoscopic removal and by EVD at our hospital, and discusses the usefulness of endoscopic removal.

### Patients and Methods

Ten patients with IVH and acute non-communicating hydrocephalus underwent neuroendoscopic removal between April 2007 and September 2008 (endoscopic group), and eight patients with IVH and acute non-communicating hydrocephalus were treated with EVD from January 2005 to March 2007 (EVD group) at Fukuoka University Hospital.

Neuroendoscopy was performed using a 4-mm 30° rigid endoscope (Olympus Corp., Tokyo, Japan) and a flexible endoscope (VEF-II; Olympus Corp.). The procedure was performed under general anesthesia during the hyperacute phase within 6 hours of onset. A 3-cm longitudinal incision was made to drill an elliptical burr hole (2-cm major axis) using an air drill at a location 2.5 cm lateral and 4 cm anterior to the bregma, on the same side as the

source of bleeding. The approach involved puncture via the anterior horn using a transparent sheath (Neuroport; Olympus Corp.) (outside diameter 10 mm). Removal of the hematoma in the anterior horn of the lateral ventricle using the rigid endoscope was followed by identification of the caudate nucleus, septum pellucidum, choroid plexus, thalamostriate vein, and foramen of Monro. Rigid endoscope procedures were performed in a dry field, resulting in collapse of the ventricles, which hampers observation inside the third ventricle from the foramen of Monro. In the presence of intraparenchymal hemorrhage, the sheath was oriented outward to evacuate as much intracerebral hematoma as possible, and hemostasis was achieved in the small vessels at the source of the bleeding by monopolar electrocoagulation with an aspiration tube. In the presence of hematoma in the lateral ventricle contralateral to the puncture, septostomy was performed posterior to the anterior septal vein while electrocoagulation was performed using an aspiration tube with the rigid endoscope. The rigid endoscope was then replaced with the flexible endoscope, the ventricle was filled with artificial cerebrospinal fluid,<sup>13)</sup> and the foramen of Monro was checked before aspiration of the hematoma in the third ventricle. The hematoma 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 structure of the third ventricle floor was checked before removal of hematoma in the mesencephalic aqueduct and fourth ventricle. The anterior positioning of the burr hole allowed the flexible endoscope to reach nearly linearly to the orifice of the mesencephalic aqueduct and to be advanced as far as the fourth ventricle with a little flexion. Third ventriculostomy was not performed in all cases, because intracerebral hemorrhage often involves midline shift, which means that the normal structure may have shifted close to the midline, and, unlike chronic hydrocephalus, it is nearly always impossible to see through to the basilar artery from the third ventricle floor. Removal of hematoma in the fourth ventricle was followed by removal of hematoma in the main part and trigone of the ipsilateral lateral ventricle on the return to the lateral ventricle, and by removal of hematoma in the contralateral lateral ventricle from the septostomy stoma, as needed. The inferior horn of the lateral ventricle cannot be reached by approaching from the anterior horn, even with the assistance of a flexible endoscope, so any hematoma present was left behind. Removal was followed by catheter placement in the lateral ventricle. Cranial computed tomography (CT) was performed on the day follow-

**Table 1 Grading system for intraventricular hematoma reported by Graeb et al.<sup>2)</sup>**

Lateral ventricle score\*:

- 1 = trace of blood or mild bleeding
- 2 = less than half of the ventricle filled with blood
- 3 = more than half of the ventricle filled with blood
- 4 = ventricle filled with blood and expanded

Third and fourth ventricle score:

- 1 = blood present, ventricle size normal
- 2 = ventricle filled with blood and expanded

Total score (maximum = 12). \*Each lateral ventricle is scored separately.

ing neuroendoscopic removal, and the pre- and postoperative hematoma volumes were assessed using the Graeb score (Table 1).<sup>2)</sup>

EVD used a catheter placed in the anterior horn via precoronal perforation on the same side as the source of bleeding. Bilateral catheters were used for hematoma in the bilateral lateral ventricles. The hematoma volumes were assessed using the Graeb scores on CT preoperatively and after catheter removal.

The duration of drainage was compared between the two groups, and clinical outcomes were assessed 12 months postoperatively based on the need for a shunt procedure and the modified Rankin scale (mRS) score. Statistical analysis was conducted using Student's *t*-test. All statistical results were considered significant if *p* < 0.05.

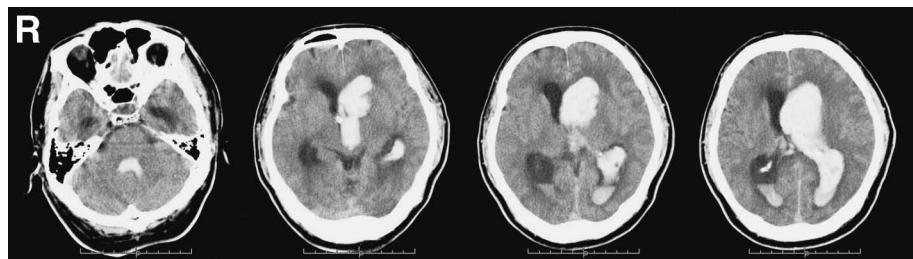
## Results

The 10 cases treated with neuroendoscopic removal are summarized in Table 2. An illustrative case is shown in Figs. 1 to 3. The patients ranged in age from 36 to 83 years (mean 58.9 years), and the male to female ratio was 7:3. The site of bleeding included the thalamus (*n* = 5), caudate nucleus (*n* = 4), and putamen (*n* = 1). The cause of hemorrhage was hypertensive cerebral hemorrhage in 8 cases, moyamoya disease in 1 case, and unknown in 1 case. Most cases were severe, with a preoperative Glasgow Coma Scale (GCS) score of 3 to 8 (mean 5.4) and a mean Graeb score of 8.9 on CT. CT on the day after neuroendoscopic removal revealed improvement in the mean Graeb score to 2.2. The mean duration of catheter placement was 2.7 days. None of the patients developed postoperative recurrent bleeding or meningitis. No patient required a shunt procedure after 12 months, and the mean mRS score was 3.7. No permanent morbidity and no mortality were associated with any endoscopic procedure. However, one patient who had chronic obstructive

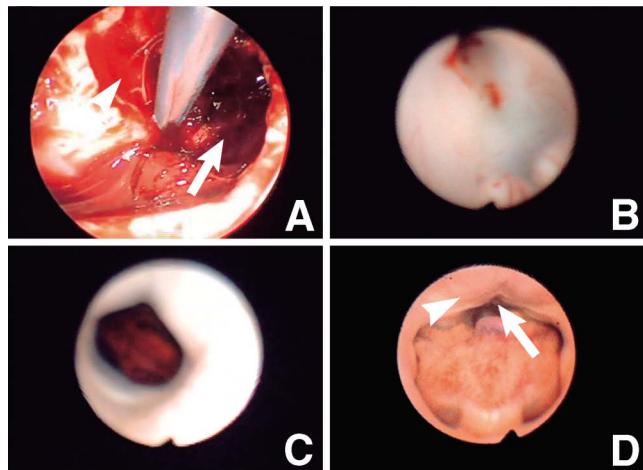
**Table 2 Comparison of clinical outcomes for patients treated by neuroendoscopy and extraventricular drainage (EVD)**

	Mean GCS score on admission	Mean Graeb score on		Mean duration of EVD (days)	VP shunt required	mRS score at 12 mos	
		Preoperative CT	Postoperative CT			6	0-2
Endoscopic group (n = 10)	5.4	8.9	2.2	2.7	0	1 (10%)	3 (30%)
EVD group (n = 8)	7.5	8.1	3.8	8.8	0	2 (25%)	0 (0%)
p Value	0.044*	0.290	0.107	0.001*	—	0.426	0.100

\*p < 0.05. GCS: Glasgow Coma Scale, mRS: modified Rankin scale, VP: ventriculoperitoneal.



**Fig. 1 Preoperative computed tomography scans showing hydrocephalus caused by left caudate nucleus hemorrhage with intraventricular hematomas in the left lateral, third, and fourth ventricles.**



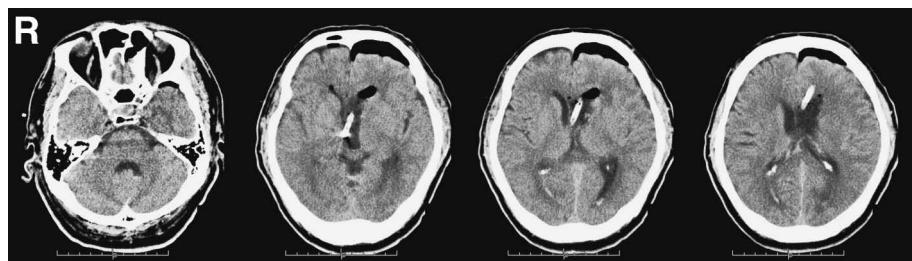
**Fig. 2 Intraoperative photographs showing (A) hematomas in the left caudate nucleus (arrowhead) and anterior horn (arrow) removed by a rigid endoscope, (B) floor of the third ventricle observed with a flexible endoscope, (C) aqueduct filled with hematoma, and (D) overview of the fourth ventricle from the aqueduct after removal of hematoma using a flexible endoscope showing the foramen of Magendie (arrow), and the floor of the fourth ventricle (arrowhead).**

pulmonary disease died of pneumonia.

The 8 cases treated with EVD are shown in Table 2. Patients were aged from 47 to 73 years (mean 64.3

years), and the male to female ratio was 3:1. The site of bleeding was the thalamus in all cases. The cause of hemorrhage was hypertensive cerebral hemorrhage in all cases, the preoperative GCS score was 4 to 13 (mean 7.5), and the mean Graeb score on CT was 8.1. EVD was continued for a mean of 8.8 days, and the mean Graeb score on CT at catheter removal was 3.8. None of the patients developed postoperative recurrent bleeding or meningitis. Two patients in the EVD group died: one of pneumonia and one of uncontrollable high intracranial pressure. No patient required a shunt procedure after 12 months, and the mean mRS score was 4.6.

The outcomes of the endoscopic group and the EVD group are summarized in Table 2. The preoperative ( $p = 0.290$ ) and postoperative ( $p = 0.107$ ) Graeb scores showed no significant differences between the two groups, but the duration of catheter placement was significantly different between the two groups ( $p = 0.001$ ). The duration of the catheter placement was 6.1 days shorter in the endoscopic group than in the EVD group, or a 69.3% reduction in the catheter placement period. There was no significant difference in mortality between the two groups ( $p = 0.426$ ). Ultimately, 3 patients (30%) in the endoscopic group and none of the patients (0%) in the EVD group were able to live independently, with an mRS score of 2 or lower, but this difference was not significant ( $p = 0.100$ ).



**Fig. 3 Postoperative computed tomography scans revealing resolving hydrocephalus and absence of most of the intraventricular hematoma.**

## Discussion

The use of a flexible endoscope for neuroendoscopic removal of IVH has been widely reported.<sup>3,8,9,14)</sup> Good results have been reported with the use of only a flexible endoscope, but we have been performing IVH removal with both a rigid endoscope and a flexible endoscope. Rigid endoscopes afford higher image resolution than flexible endoscopes, and the use of a transparent sheath and aspiration tubes permits rapid hematoma removal.<sup>11)</sup> Rigid endoscopes also permit electrocoagulation to be performed, but the fundamentally linear operation limits the range of access. The curved operation of flexible endoscopes permits a broader range of access, but hematoma can be removed from the working channel only in small portions, and the hemostatic capability is also inferior to that achieved by rigid endoscope procedures. Therefore, in patients with massive intraventricular inundation immediately upon intracranial rupture, rapid removal of hematoma in the anterior horn by rigid endoscope aspiration and easy orientation of the device are achieved. Intraventricular removal and perforator (source of bleeding) hemostasis can also be achieved, and septostomy is easier than with a flexible endoscope. A flexible endoscope can access areas that a rigid endoscope cannot and so can be used to remove hematomas in the latter portion of the third ventricle, inside the fourth ventricle, and inside the posterior horn of the lateral ventricle, contributing greatly to hydrocephalus improvement. The various advantages of rigid and flexible endoscopes can be combined for more efficient and simpler hematoma removal.

Previous reports have indicated that neuroendoscopic hematoma removal in the acute phase can result in decompression and improve non-communicating hydrocephalus, but provide no comparisons with non-endoscopic procedures, such as only EVD. Therefore, there is little evidence to support the conclusion that neuroendoscopic removal of IVH is more useful than EVD. The present compari-

son of the two groups suggests that the use of neuroendoscopy for rapid removal of hematoma in the ventricular systems and reliable improvement of acute non-communicating hydrocephalus allowed removal of the catheter 6.1 days (69.3%) sooner and facilitated earlier ambulation. Assessment of quality of life and mortality 12 months after surgery in the present series of cases revealed no significant differences between the two groups. However, the locations of the intracerebral hematomas differed between the two groups, so further studies are needed to assess if the rapid removal of the hematoma contributes to the functional prognosis.

The need for a shunt procedure to treat communicating hydrocephalus in the chronic phase is one of the factors used to assess long-term outcome. Communicating hydrocephalus after IVH may be caused by dysfunction of the cerebrospinal fluid-reabsorbing Pacchioni granulations of the arachnoidea, so endoscopic removal of IVH in the acute phase may reduce the incidence of communicating hydrocephalus in the chronic phase.<sup>12)</sup> A shunt procedure is required in 0% to 17% of cases after neuroendoscopy,<sup>3,8,9,14)</sup> compared to 13.9% to 33% of cases after EVD.<sup>6,7,10)</sup> However, whether neuroendoscopic surgery significantly reduces the incidence of communicating hydrocephalus remains unclear. In the present study, no patients required a shunt procedure after either endoscopic or non-endoscopic procedures, and no conclusions could be reached.

The significant advantages of neuroendoscopy include shorter duration of drainage and earlier patient ambulation. More studies are needed to clarify the long-term improvement in neurological signs and the effect on the incidence of communicating hydrocephalus.

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