



Original Article

Interval between endoscopic surgery and decreased intracranial pressure related to putaminal hemorrhage prognosis

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Received : 05 April 2019
Accepted : 31 March 2020
Published : 25 April 2020

DOI
10.25259/SNI_236_2019

Quick Response Code:



ABSTRACT

Background: Endoscopic evacuation of a putaminal hemorrhage is effective and minimally invasive; however, it may not result in sufficient brain decompression. While monitoring postoperative intracranial pressure (ICP) is likely useful, specific ICP data in patients with a putaminal hemorrhage are limited. The aim of this study was to determine the association between postoperative ICP and the prognosis of patients with putaminal hemorrhage after endoscopic surgery.

Methods: We retrospectively analyzed 24 consecutive patients with a putaminal hemorrhage in whom ICP monitoring after endoscopic surgery was performed. Clinical data regarding hematoma volume, evacuation rate, onset-to-treatment time, operation time, ICP max, ICP peak out time (T peak out), and neurological outcomes on discharge were investigated.

Results: From August 2011 to October 2015, 24 patients with a putaminal hemorrhage were analyzed. Consciousness on admission and hemorrhage volume were associated with poor outcomes after endoscopic surgery for putaminal hemorrhage. The hematoma volume, operation time, and evacuation rate of hemorrhage were correlated to early peak out of ICP. Furthermore, a T peak out ≤ 24 h was significantly associated with good neurological outcomes on discharge.

Conclusions: Our data suggest that early peak out (≤ 24 h) of ICP after endoscopic surgery is predictive of a good prognosis following putaminal hemorrhage. Operation time and evacuation rate of hemorrhage could hasten peak out of ICP and improve outcomes in patients with a putaminal hemorrhage after endoscopic surgery.

Keywords: Endoscopic surgery, Intracranial pressure, Putaminal hemorrhage

INTRODUCTION

A putaminal hemorrhage is the most frequent subtype of spontaneous cerebral hemorrhage and accounts for approximately 40% of cerebral hemorrhages. Putaminal hemorrhage often requires the surgical evacuation of a hematoma, which is performed using various surgical procedures, such as conventional craniotomy, stereotactic aspiration, and endoscopic surgery.

The advantages of surgical treatment for putaminal hemorrhage have previously been reported.^[3,7,12] Endoscopic hematoma evacuation is an established option for patients with intracerebral hemorrhage and is a minimally invasive and effective treatment.^[2,3,9,11,15] However, in terms of decompression, endoscopic evacuation might be potentially insufficient because of the use of only one burr hole during the operation, which is less thorough than a craniotomy. Therefore, postoperative intracranial pressure (ICP) monitoring is likely useful, but specific data of ICP in patients with a putaminal hemorrhage are limited. ICP monitoring in patients with traumatic brain injury is a common and well-established method for perioperative intensive care.^[1,4,6] Since continuous intracranial hypertension is an unsuitable condition for the nervous tissue that comprises the brain, we speculated that appropriate control and an early peak out of ICP would be related to a good prognosis in patients with cerebral hemorrhage. We investigated the association between ICP parameters (maximum and peak out time [T peak out]) and neurological outcomes to determine whether postoperative ICP monitoring can predict the prognosis of a patient with a putaminal hemorrhage after endoscopic surgery.

MATERIALS AND METHODS

Patients

We retrospectively analyzed 25 consecutive patients with putaminal hemorrhage treated by endoscopic surgery in our hospital from August 2011 to September 2015 who underwent postoperative ICP monitoring using the Codman ICP Microsensor (Codman Neuro, USA). Surgical indications were a hematoma volume of greater than 30 mL and impaired consciousness due to a hematoma. Surgical hematoma evacuation was performed within 24 h after onset. ICP was recorded every 1 h in all patients after endoscopic surgery. The following clinical characteristics and parameters were reviewed: sex, age, preoperative Japan Coma Scale (JCS), hematoma volume, evacuation rate of hematoma, onset-to-treatment time, operation time, maximum of ICP, T peak out of ICP (T peak out), and neurological outcome. T peak out was defined as follows; the time from completion of surgery until ICP began to decrease, specifically, it was defined as the time until ICP fell below the ICP max – 2 mmHg and did not become elevated to the same value again. Since T peak out is subjective, it was measured several times by observers who were blinded to parameters and outcomes. Neurological outcomes were evaluated using the JCS [Table 1] and Modified Rankin Scale (mRS) on discharge.

Great efforts were made to obtain written consent from all patients and their families for this study after providing them with general instructions, and our own institutional ethics

Table 1: Japan Coma Scale for grading of impaired consciousness.

Grade	Consciousness level
0	Alert
1-digit code	The patient is awake without any stimuli and is almost fully conscious
1	
2	Unable to recognize time, place, and person
3	Unable to recall name or date of birth
2-digit code	The patient can be aroused (then reverts to the previous state after cessation of stimulation)
10	Easily by being spoken to (or is responsive with purposeful movements, phrases, or words)
20	With loud voice or shaking of shoulders (or is almost always responsive to very simple words like yes or no, or to movements)
30	Only by repeated mechanical stimuli
3-digit code	The patient cannot be aroused with any forceful mechanical stimuli, and
100	Responds with movements to avoid the stimulus
200	Responds with slight movements including decerebrate and decorticate posture
300	Does not respond at all except for change of respiratory rhythm

committee reviewed this study thoroughly and approved it in advance.

Clinical management

Surgical indications were as above. Soon after diagnosis, acute hypertension was treated to achieve systolic blood pressure below 140 mmHg with intravenous infusion of a calcium channel blocker. Endoscopic surgery was performed as soon as possible under general anesthesia in principle, but local anesthesia was considered for comatose patients with brain herniations who were unable to delay treatment for induction of general anesthesia. We used a 2.7 mm rigid endoscope (Olympus Corp., Tokyo) and Neuroport (Olympus Corp.). A linear skin incision and a burr hole were made on the forehead, and the hematoma was evacuated through the burr hole with a trans-frontal lobe approach. An ICP transducer was inserted into the subcortex from the tract of the endoscope. Cerebrospinal fluid drainage was performed if needed after endoscopic surgery. All patients received critical care in the intensive care unit with ICP monitoring. Intracranial hypertension was first treated using a noninvasive procedure, such as head elevation, osmotic diuretics, hyperventilation, or sedation. However, if these methods were not effective, cerebrospinal fluid drainage was performed. If necessary, re-operation or decompressive craniectomy was considered.

Radiological analysis

An initial computed tomography (CT) scan was obtained in all patients, and the diameter and hematoma volume

were assessed. Hematoma volume was calculated from preoperative CT scans using the $a \times b \times c \times 0.5$ method.^[8]

Statistical analysis

Statistical analyses were conducted using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which are a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). More precisely, it is a modified version of R commander designed to add statistical functions that are frequently used in biostatistics. Statistical significance was assumed for $P < 0.05$. Values are presented as the mean \pm standard deviation. We analyzed data using the Mann–Whitney U-test and Spearman's rank correlation coefficient.

RESULTS

One patient died because of acute rebleeding just after surgery and was excluded from this study. Effective ICP monitoring was performed in 24 patients (19 male patients, 5 female patients; mean age: 68.9 years; and age range: 53–87 years) with putaminal hemorrhage treated by endoscopic surgery. The demographic and clinical characteristics of patients included in our study are shown in Table 2. The mean hematoma volume was 101 mL (range: 47–230 mL). Endoscopic surgery was performed as soon as possible; the mean onset-to-treatment time was 440 min (range: 150–1440 min). The hematoma was removed in more than 90% of cases, and the mean evacuation rate was 91.6% (range: 43.2–100%). The mean operation time was 120 min (range: 60–289 min).

The relationship between preoperative parameters and neurological outcomes is shown in Table 3. On discharge, no patient had an mRS of 0–2, 1 (4.2%) patient had an mRS of 3, 11 (45.8%) patients had an mRS of 4, and 12 (50%) patients

had an mRS of 5. JCS on discharge was 0 in 3 (12.5%) patients, 1 in 2 (8.3%) patients, 2 in 2 (8.3%) patients, 3 in 9 (37.5%) patients, 10 in 2 (8.3%) patients, 20 in 1 (4.2%) patients, 100 in 3 (12.5%) patients, and 200 in 2 (8.3%) patients. Preoperative JCS and hematoma volume were significantly associated with the neurological outcome evaluated by mRS and JCS at hospital discharge.

Table 4 shows the correlation between preoperative parameters and ICP variables. Hematoma volume ($r = 0.72$, $P < 0.001$) had a strong correlation with T peak out. The evacuation rate ($r = -0.4$, $P = 0.06$) and operation time ($r = 0.35$, $P = 0.09$) were weakly correlated with T peak out. None of the preoperative parameters correlated with ICP max. Patients with a time to peak out of ICP within 24 h (T peak out \leq 24 h) had a significantly better JCS on discharge ($P = 0.006$) and a better mRS ($P = 0.08$) than those whose time to peak out was later than 24 h. There was no statistically significant difference between the two groups regarding ICP max [Table 5].

DISCUSSION

Hematoma evacuation for putaminal hemorrhage is a well-established surgery, and many cases have been treated in the world. In recent years, endoscopic evacuation of cerebral hematomas has become more common worldwide.^[11,15] Although endoscopic surgery enables effective hematoma removal through only a burr hole, it is significantly less invasive than a conventional craniotomy. However, there are concerns that it might be insufficient in terms of brain decompression postoperatively. Postoperative ICP monitoring is likely useful for detecting and treating elevated ICP immediately, but specific data in patients with a putaminal hemorrhage are limited. Many clinical questions remain unclear, including which preoperative parameters affect ICP variables or which variables are the prognostic factors for ICP. Some reports show a relationship between ICP and outcomes in patients with cerebral hemorrhage.^[5,10,13,14] However, ICP has yet to be studied as a prognostic factor. In this study, we carefully monitored T peak out and the maximum value of postoperative ICP and sought to analyze the relationship between ICP and outcomes.

Among preoperative parameters, hematoma volume is strongly correlated with T peak out. This follows logically from routine clinical observations in which a large cerebral hemorrhage has been shown to inflict broad damage on the brain by prolonging cerebral edema and delaying the time of peak out of ICP. Furthermore, the evacuation rate and operation time were weakly correlated with T peak out. In addition, residual hematoma after operation might stimulate the surrounding brain and lead to prolonged cerebral edema. Meanwhile, an efficient surgery should result in less damage to the surrounding brain. None of the preoperative

Table 2: Patient characteristics.

Characteristic	Value (%)
N	24
Sex	
Male	19 (79.2%)
Female	5 (20.8%)
Age (mean, range)	68.9 \pm 9.7, 53–87
JCS	
10–30	8 (33.3%)
100–300	16 (66.7%)
Hematoma volume, ml (mean, range)	100.7 \pm 55.2, 47–230
Evacuation rate, % (mean, range)	91.7 \pm 13.9, 43.2–100
Onset-to-treatment time, minute (mean, range)	440.4 \pm 366.9, 150–1440
Operation time, minute (mean, range)	120.0 \pm 52.8, 60–289
JCS: Japan Coma Scale	

Table 3: The relationship between preoperative parameters and neurological outcomes on discharge.

Outcome	mRS			JCS		P
	Acceptable (mRS 0-4) n=12	Poor (mRS 5-6) n=12	P	0-3 n=16	10-300 n=8	
Age	66.3±8.7	71.6±10.2	0.2	69.1±10.1	68.6±9.2	0.9
Preoperative JCS			<0.001*			<0.001*
Hematoma volume	77.8±40.2	123.6±60.1	0.04	86.2±44.0	136±66.9	0.04
Evacuation rate	95.8±8.3	87.5±17.2	0.15	95.4±7.3	82.7±21.6	0.2
Onset-to-treatment	579.2±462.6	301.7±159.6	0.07	500.3±407.7	295±195.0	0.2
Operation time	119.4±64.8	120.5±40.5	1	118.6±55.7	123.1±49.0	0.9

JCS: Japan Coma Scale, mRS: Modified Rankin Scale. *Mann-Whitney U-test

Table 4: Correlation between preoperative parameters and ICP variables.

Characteristic	T peak out		ICP max	
	r _s	P	r _s	P
Age	-0.18	0.4	-0.10	0.7
Hematoma volume	0.72	<0.001	0.13	0.5
Evacuation rate	-0.40	0.06	0.044	0.8
Onset-to-treatment	-0.34	0.1	0.28	0.2
Operation time	0.35	0.09	-0.10	0.6

Spearman's rank correlation coefficient

Table 5: The relationship between ICP variables and neurological outcomes on discharge.

Characteristic	JCS at discharge	mRS at discharge
T peak out > 24 h versus ≤ 24 h	0.006	0.08
ICP max < 20 mmHg versus ≥ 20 mmHg	0.4	0.6

ICP: Intracranial pressure, JCS: Japan Coma Scale, mRS: Modified Rankin Scale. Mann-Whitney U-test

parameters were correlated with ICP max. The maximum value of ICP appeared to be less affected by preoperative parameters.

There are some reports demonstrating an association between ICP and mortality or neurological outcomes.^[5,13] Tian *et al.* demonstrated that ICP variability predicts short-term outcomes after intracerebral hemorrhage,^[14] and Sykora *et al.* demonstrated that average ICP, ICP variability, and the frequency of an ICP of >20 mmHg are independently associated with mortality and poor outcomes in patients with intracerebral hematomas.^[13] Moreover, two recent studies have reported a correlation between cerebral perfusion pressure and patient outcomes.^[5,10] In our present study, ICP max was not found to be related to neurological outcomes on discharge. We set the cutoff

value to 20 mmHg, which may be controversial; however, any other cutoff value did not exhibit an association between ICP max and neurological outcomes. The state of intracranial hypertension might be different in each patient, if so, evaluation of ICP by absolute value is possibly inappropriate. As a relative evaluation of ICP, we devised evaluation by T peak out. Contrary to the ICP max, T peak out was well related to neurological outcomes on discharge. Patients with ICP peaked out within 24 h had a significantly better prognosis than others. JCS on discharge was deemed clinically good in a significant number of patients ($P = 0.006$), while mRS on discharge tended to be the same ($P = 0.08$). Although we studied only neurological outcomes at discharge and not long-term prognosis, we found that patients who have an early peak out of ICP can be expected to regain consciousness earlier and experience a speedier recovery. Monitoring ICP focused on peak out for patients with a putaminal hemorrhage after endoscopic surgery may be indicative of short-term prognosis.

There are few limitations to the present study. First, the present study analyzed a small number of cases. In addition, it was a retrospective observational study at a single center. While we found that the early peak out of ICP was reliably predictive of a good prognosis in patients with putaminal hemorrhage who were treated using endoscopic surgery, it remains unclear whether intentional early peak out of ICP by aggressive intracranial hypotension therapy is associated with a good prognosis. At present, it is unknown whether intensive lowering of ICP to achieve early peak out improves prognosis. Further large prospective interventional studies may be needed. Second, the cases included in this study include only those patients with a putaminal hemorrhage who were treated using endoscopic surgery. Therefore, generalizing our findings requires further research. Nevertheless, our study demonstrates that ICP monitoring and T peak out analysis may be helpful for other types of cerebral hemorrhage. Third, neurological outcomes were only measured at the time of discharge, and it is possible that only short-term prognosis is shown. It is necessary to investigate the long-term prognosis after 3 months or 1 year.

In addition, we did not use detailed neurological outcomes, such as the Glasgow Coma Scale or National Institute of Health Stroke Scale. Finally, as described above, the T peak out tends to be subjective; however, this measurement was performed several times by investigators who were blinded to any parameters or outcomes.

The results of this study suggested that monitoring postoperative ICP after endoscopic surgery is useful for predicting prognosis in patients with a putaminal hemorrhage. Early peak out of ICP might contribute to a good prognosis in patients with a putaminal hemorrhage after endoscopic surgery. Although additional studies that validate our findings are needed, ICP monitoring for patients with cerebral hemorrhage after surgery can be a promising supplementary method in the future.

CONCLUSION

The results of this study suggested that monitoring postoperative ICP after endoscopic surgery is useful for predicting prognosis in patients with a putaminal hemorrhage. Early peak out of ICP might contribute to a good prognosis in patients with a putaminal hemorrhage after endoscopic surgery. Although additional studies that validate our findings are needed, ICP monitoring for patients with cerebral hemorrhage after surgery can be a promising supplementary method in the future.

Acknowledgments

We would like to thank Editage (www.editage.jp) for English language editing.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. For this type of study formal consent is not required.

Declaration of patient consent

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

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Uchikawa H, Yamashiro S, Hitoshi Y, Yoshikawa M, Yoshida A, Yano S. Interval between endoscopic surgery and decreased intracranial pressure related to putaminal hemorrhage prognosis. *Surg Neurol Int* 2020;11:78.