

Clinical Article

Even in Patients with a Small Hemorrhagic Volume, Stereotactic-Guided Evacuation of Spontaneous Intracerebral Hemorrhage Improves Functional Outcome

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Objective : The decision to adopt a conservative or surgical modality for a relatively small volume of spontaneous intracerebral hemorrhage (SICH) is difficult and often controversial, especially when consciousness is tolerable. The authors examined the results of stereotactic-guided evacuation of SICH for relatively small volumes with respect to functional outcome.

Methods : This prospective study was performed on 387 patients with SICH who underwent stereotactic-guided evacuation (n = 204, group A) or conservative treatment (n = 183, group B) during the past 8 years. The primary end-point was recovery of functional status, which was estimated using the Modified Barthel Index (MBI) and the modified Rankin Scale (mRS).

Results : All patients had a Glasgow coma scale (GCS) score of ≥ 13 and unilateral hemiparesis of less than motor power grade 3. Group demographic characteristics and initial neurological statuses were similar. In all cases, the volume of SICH involved was $< 30 \text{ cm}^3$ and location was limited to basal ganglia and thalamus. At 6-month follow-ups, MBI was 90.9 in group A and 62.4 in group B ($p < 0.05$), and MRS was 1.2 in group A and 3.0 in group B ($p < 0.05$). Better motor function and stereotactic-guided evacuation had a significant effect on a functional recovery in regression analyses.

Conclusion : Even in patients with a small volume of SICH, stereotactic-guided evacuation improved functional recovery in activities in daily life than conservative treatment did.

KEY WORDS : Cerebral hemorrhage · Treatment efficacy · Neurosurgery · Stereotaxy · Recovery of function.

INTRODUCTION

Spontaneous intracerebral hemorrhage (SICH) causes 10% to 15% of first-ever strokes, with 30-day mortality rate of 35% to 52%. Furthermore, half of all deaths occur in the first 2 days^{2,7,12}. SICH produces serious neurological sequelae that require long-term medical and social care^{6,14-17}. Of the estimated 67,000 individuals who experienced SICH in the United States during 2002, only 20% were expected to be functionally independent 6 months later¹².

Despite many studies conducted to date, no consensus

has been reached on the treatment of patients with SICH, largely because no randomized study has demonstrated an improvement in functional outcome or mortality rate following surgical intervention as compared with medical treatment. Of the available surgical intervention modalities, stereotactic-guided evacuation has been reported to reduce mortality and improve functional outcomes in patients with SICH^{3,4,8,13}. However, the stereotactic evacuation of hematomas is not widely accepted as a standard therapy for treating SICH, because its effect on functional outcome is regarded as marginal and no randomized trial has been performed. Furthermore, especially in patient who has a small volume of SICH, no comprehensive study has been conducted on the effect of stereotactic evacuation on functional outcome. In 1998, a Wide Regional Emergency Center was established in our institute and has been practicing as a main and official referral emergency center of Gyeongangnam-do Province for about ten years. Through

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this center, we have experienced over 2,500 cases of patients with SICH during same periods. Our interests were focused on patients who had a relatively small volume of SICH, in terms of functional outcome according to the different treatment modalities.

Therefore, we conducted this randomized and controlled trial in patients with SICH to evaluate its ability to improve functional outcome versus conservative treatment, in patients with a relatively small hemorrhagic volume. The primary end-point of this study was functional outcome, which was estimated using Modified Barthel Indices (MBI) and the modified Rankin Scale (MRS). The second end-points were 30-day mortality and 6-month mortality rates.

MATERIALS AND METHODS

In this presenting study, we examined 387 patients with SICH that had been treated over the previous 8 years at our institute, and who met the inclusion criteria. The following inclusion criteria were used: 1) an age was between 30 and 80 years; 2) a Glasgow coma scale (GCS) at presentation between 13 and 15; 3) moderate and severe unilateral motor weakness of muscle power grade between 0 to 2; 4) a radiographically estimated SICH volume of $\geq 30 \text{ cm}^3$ by computed tomography (CT); 5) a SICH location limited to the basal ganglia and thalamus. Patients with traumatic ICH, hemorrhagic cerebral infarction, ICH due to the aneurysmal rupture of an arteriovenous malformation, brain tumor bleeding, any coagulopathy, or a malignant neoplasm were excluded.

Patients' collection and randomization

Patients with a GCS between 13 and 15, and a motor power grade between 0 and 2 who fulfilled the inclusion criteria were admitted into this study. We provided relevant information regarding surgical intervention and conservative treatment to patients and their families during admission, and explained that there was no firm evidence of any difference between stereotactic-guided evacuation and conservative treatment, especially in patients with a small hemorrhagic volume. To avoid selection bias, randomization was accomplished using sealed, opaque envelopes with equal treatment allocation probabilities. Group A was defined as the stereotactic-guided evacuation group, and group B as the conservative treatment group. If any patient or family member requested a specific treatment protocol, the such patient was excluded from this study. A patient who had any sign or symptom of cerebral herniation was not enrolled for the study. Local ethical committees at our institute approved the protocol used this study.

Neurological estimation

Neurological states were estimated according using the GCS designed by Teasdale et al.²³. Muscle powers of extremities contralateral to affected sides are expressed according to the classification of the British Medical Research Council (muscle power scores: 0 = no contraction; 1 = a trace of contraction; 2 = active movement with gravity eliminated; 3 = active movement against gravity; 4 = active movement against gravity with resistance; 5 = normal power)²².

Motor deficits were assessed using Modified Motor Assessment Scale (MMAS), which is a modification of the motor assessment scale described by Carr et al.⁹. MMAS is composed of 9 items, which are each scored from 0 to 6 (6 = "most difficult"), which pertain to upper extremity motor recovery, balance, and function. Specifically, these 9 items are; 1) supine to side lying, 2) supine to sitting over the side of a bed, 3) balanced sitting, 4) sitting to standing, 5) walking, 6) upper arm function, 7) hand movement, 8) advanced hand activities, and 9) general tonus.

Evaluations of functional outcomes

Functional outcomes were estimated by using MBIs and the mRS scale. The MBI involves an assessment of level of independence in terms of the activities of daily living (ADL), and is scored in increments of 5 points (highest possible total score = 100). The 10 items assessed in MBI are; 1) bowel control, 2) bladder control, 3) personal hygiene, 4) toilet transfer, 5) bathtub transfer, 6) feeding, 7) dressing, 8) wheelchair transfer to and from bed, 9) walking (wheelchair management if patient is non-ambulatory), 10) ascending and descending stairs²⁰.

MRS scores were applied as follows⁵: 0 = no symptoms; 1 = minor symptoms that do not interfere with lifestyle; 2 = minor handicap that restrict lifestyle, but which does not interfere with the capacity to look after oneself; 3 = moderate disability that significantly restricts lifestyle and prevents a totally independent existence; 4 = moderately severe disability that clearly prevents an independent existence, although constant attention is not needed; 5 = severe disability requiring constant attention night and day; 6 = death.

Treatment modalities

In group A, a burr hole was created at the Kocher point under a Leksell frame (Stockholm, Sweden). In each case, the hematoma was aspirated using an Archimedes aspirator (Stockholm, Sweden) after determining the localization point using Leksell Surgiplan software (Stockholm, Sweden), usually, 1-2 aspiration points were used during the evacuation procedure. According to the postoperative CT scanning, when a residual clot above 10 cm^3 was left, we considered

the instillation of urokinase into the bed of the hematoma. The time interval from ictus to stereotactic-guided evacuation was calculated from the time of ictus to the exact time to start surgery.

In group B, we used medication to control blood pressure. Mean arterial pressure was maintained in a range of 100-140 mmHg using anti-hypertension medication (labetalol, amlodipine, etc.). In addition, we also administered a hypertonic agent (glycerol, mannitol, etc.) when a CT scan indicated a mass effect or when clinical symptoms indicated an elevated intracranial pressure. The time interval from ictus to medication was calculated and recorded.

Follow-up

All patients were followed for at least 6 months (mean follow-up period of 11.6 months).

Motor power, GCS score, MMAS, MBI, and mRS were regularly documented at admission and at 7 days, 1 month, and 6 months after ictus or brain surgery. Brain CT scans were performed at admission, 2 weeks later, and then at 1 or 2 month intervals. Hematoma volume is expressed in cubic centimeters and was derived using the formula of " $\pi \times \text{width} \times \text{length} \times \text{height (cm)} / 6$ " based on hematoma radius estimated by CT.

Statistical analysis

The t-test was used to compare group variables. Pearson's Chi-square test was used to compare group mortality rates and ages, and the logistic regression analysis was used to examine the likelihood of a better MBI score at 6 month after ictus. Univariate analysis was used to determine the effects of age, gender, hypertension, diabetes mellitus, hypercholesterolemia, smoking status, alcoholism, initial MMAS, initial GCS, hematoma volume, and treatment modalities on MBI scores at 6 months after ictus. Variables that were found to be significantly associated with a better MBI score by univariate analyses were subjected to multivariate analyses. Differences were regarded significant if their probability values were < 0.05 . Statistical analyses were performed using SPSS version 12.0 (SPSS Institute, Inc., Chicago, IL, USA).

RESULTS

Among 2,144 patients with SICHD for 8 years, we enrolled 410 patients in this study, initially. But, 23 patients were excluded because of rebleeding during treatment, which we had to change the therapeutic modalities. Therefore, 387 patients could be examined. Table 1 summarizes the demographic characteristics in the two groups. There were 289 men and 98 women of overall mean age 65.8 years. Two-hundred-and-four of these patients underwent stereotactic-guided hematoma evacuation (group A) and 183 were treated conservatively (group B).

Three-hundred-and-fifty-three patients (91.2%) had history of hypertension, 200 (51.7%) had diabetes mellitus, 245 (63.3%) had hypercholesterolemia, and 298 (77.0%) were smokers. GCS scores were; 15 in 189 patients (48.8%), 14 in 111 (28.7%), 13 in 87 (22.5%). Muscle power grades in affected side were; 0 in 25 patients (6.5%), 1 in 65 patients (16.8%), and 2 in 297 patients (76.7%). Mean MMAS at admission was 15.8 and ranged from 5 to 27. Mean hematoma volume was 23.1 cm^3 and ranged from

Table 1. Demographic characteristics of patients

Characteristics	Total (n = 387)	Group A (n = 204)	Group B (n = 183)	p-value
Age				
Mean (year)	65.8	64.3	67.1	$> 0.05^*$
Range (year)	30-80	30-80	33-79	
Gender				
Male	289 (74.7%)	157 (76.9%)	132 (72.1%)	> 0.05
Female	98 (25.3%)	47 (23.1%)	51 (27.9%)	
Underlying conditions				
Hypertension	353 (91.2%)	189 (92.6%)	164 (89.6%)	> 0.05
Diabetes mellitus	200 (51.7%)	102 (50.0%)	98 (53.6%)	> 0.05
Hypercholesterolemia	245 (63.3%)	132 (64.7%)	113 (61.7%)	> 0.05
Previous stroke	17 (4.4%)	13 (6.4%)	4 (2.2%)	> 0.05
Smoking	298 (77.0%)	154 (75.5%)	144 (78.9%)	> 0.05
Chronic alcoholism	116 (30.0%)	65 (31.9%)	51 (27.9%)	> 0.05
Glasgow coma scale				
15	189 (48.8%)	91 (44.6%)	98 (53.6%)	> 0.05
14	111 (28.7%)	59 (28.9%)	52 (28.4%)	> 0.05
13	87 (22.5%)	54 (26.5%)	33 (18.0%)	> 0.05
Muscle power grade				
0	25 (6.5%)	14 (6.9%)	11 (6.0%)	> 0.05
1	65 (16.8%)	37 (18.1%)	28 (15.3%)	> 0.05
2	297 (76.7%)	153 (75.0%)	144 (78.9%)	> 0.05
Modified Motor Assessment Scale				
Mean	15.8	17.4	14.1	$> 0.05^*$
Range	5-27	5-27	5-20	
Volume of hemorrhage (cm^3)				
Mean	23.1	24.3	21.0	$> 0.05^*$
Range	10.4-30.0	14.4-30.0	10.4-30.0	

*t-test and all of the other factors are analyzed by Pearson Chi-square test

10.4 to 30.0 cm³. No significant differences were found between the two groups with regard to age, gender, underlying medical condition, GCS score, muscle power grade, MMAS, and hematoma volume.

Morbidity and mortalities

There were 23 patients who were discarded from this study because of rebleeding which led to change therapeutic modality from medical treatment to surgical intervention, or from stereotactic-guided evacuation to open craniotomy or craniectomy to remove increased hematoma. Among them, 14 patients were included in group A, and 9 patients were included in group B.

In group A, total of 57 patients (26.1%) received thrombolytic therapy using urokinase with stereotactic instillation into the bed of clot. They received 5,000 IU of urokinase every 6 hours for a maximum of 48 hours. Among 57 patients, 8 patients (14.0%) experienced rebleeding. And, among 14 patients who had rebleeding after stereotactic-guided evacuation, 5 patients had medically intractable hypertension.

In group B, among 9 patients, 6 patients had poorly controlled hypertension, and 5 patients had a medical history of anti-coagulant or anti-platelet medication.

During follow-up, pulmonary complications, such as pneumonia etc., occurred in 44 patients (11.4%), cardiologic complications, such as angina pectoris, myocardial infarction etc., in 37 patients (9.6%), hepatic insufficiency in 28 patients (7.2%), renal insufficiency in 21 patients (5.4%), and stroke in 16 patients (2.4%).

In terms of mortality, 4 patients (1.0%) died within 30 days after evacuation or ictus, and 18 patients (4.7%) died within 6 months of evacuation or ictus. Thirty-day mortality rates were 1.0% in group A and 1.1% in group B, and 6-

month mortality rates were 5.4% in group A and 3.9% in group B. Accordingly, no significant difference was observed between the two groups in terms of mortality rates (Table 2).

Functional outcome according to time interval from ictus to treatment

In group A, all patients underwent stereotactic-guided evacuation of SICH within 5 days. Among 204 patients, 19 patients (9.3%) underwent surgical intervention within 12 hours, 133 patients (65.2%) between 12 hours and 24 hours, 46 patients (22.5%) between 24 hours and 48 hours, and 6 patients (2.9%) between 48 hours to 5 days. In patients who underwent surgery within 24 hours, a mean MBI score was 19.0, 77.2, and 89.6, at 7 days, 1 month, and 6 months, respectively. And, in patients who underwent surgical treatment after 24 hours, a mean MBI score of 21.4, 80.7, and 93.1, at the same period respectively. However, there was no statistical difference in the functional outcome between patients who underwent stereotactic-guided evacuation within 24 hours and after 24 hours ($p > 0.05$).

In group B, we started medical treatment for the patients within 7 days after ictus. Among 183 patients, 22 patients (12.0%) were treated medically within 12 hours, 102 patients (55.7%) between 12 hours and 24 hours, 19 patients (10.4%) patients between 24 hours and 48 hours, 17 patients (5.5%) between 48 hours and 72 hours, and 23 patients (12.6%) between 72 hours and 7 days. Patients who were treated medically within 24 hours had a mean MBI score of 19.2 at 7 days, 49.8 at 1 month, and 66.7 at 6 months respectively. And patients who received medical treatment after 24 hours had a mean MBI score of 18.0 at 7 days, 53.6 at 1 month, and 59.8 at 6 months, respectively. However, there was no statistical difference in the functional

outcome between patients who started to receive medical treatment within 24 hours and after 24 hours ($p > 0.05$).

Functional outcomes according to follow-up duration

Table 2 summarizes MBI and mRS scores expressing functional outcome. Mean MBI score for all patients was 17.0 (range; 3-33) at time of admission. In group A, mean MBI was 18.3 (range; 3-33) at admission, 19.6 (range; 3-48) at 7 days after evacuation, 78.1 (range; 25-94) at 1 month after evacuation, and 90.9 (range; 25-100) at 6

Table 2. Comparison of outcome between two groups

Outcome	Total (n=387)	Group A (n=204)	Group B (n=183)	p-value
Mortality				
30-days*	4 (1.0%)	2 (1.0%)	2 (1.1%)	0.917
6-months†	18 (4.7%)	11 (5.4%)	7 (3.9%)	0.893
Mean Modified Barthel Index (MBI)‡				
At admission	17.0 (3-33)	18.3 (3-33)	16.4 (3-28)	0.721
7 days	19.1 (3-48)	19.6 (3-48)	18.7 (3-42)	0.906
1 month	67.5 (18-94)	78.1 (25-94)	50.3 (18-72)	0.048
6 months	80.2 (25-100)	90.9 (25-100)	62.4 (25-81)	0.011
Mean modified Rankin Scale (mRS)‡				
At admission	4.6 (3-5)	4.2 (3-5)	4.4 (3-5)	0.886
7 days	3.7 (2-5)	4.1 (2-5)	3.7 (2-5)	0.143
1 month	2.9 (1-4)	1.8 (1-3)	3.1 (1-4)	0.009
6 months	2.1 (0-4)	1.2 (0-3)	3.0 (1-4)	0.017

*Fisher's exact test, †Pearson Chi-square test, ‡t-test

months after evacuation. In group B, mean MBI was 16.4 (range; 3-28) at admission, 18.7 (3-42) at 7 days after ictus, 50.3 (range; 18-72) at 1 month after ictus, 62.4 (range; 25-81) at 6 months after ictus.

Overall mean MRS was 4.6 (range; 3-5) at admission. In group A, mean MRS was 4.2 (range; 3-5) at admission, 4.1 (range; 2-5) at 7 days after evacuation, 1.8 (range; 1-3) at 1 month after evacuation, and 1.2 (range; 0-3) at 6 months after evacuation. In group B, mean MRS was 4.4 (range; 3-5) at admission, 3.1 (2-5) at 7 days after ictus, 3.7 (range; 1-4) at 1 month after ictus, and 3.0 (range; 1-4) at 6 months after ictus. No significant difference in MBI or MRS scores was observed between the two groups until 7 days after evacuation or ictus. However, the two groups had significantly different MBI and MRS scores at 1 month and 6 months after evacuation or ictus ($p < 0.05$).

Regression analyses for Modified Barthel Index

Four factors including age, initial MMAS, initial GCS, and stereotactic-guided hematoma evacuation, had a positive association with MBI in univariate analysis (Table 3). The

odds ratio of age of < 60 years for a better MBI was 2.45 (95% confidence Interval, 0.88-3.57; $p = 0.017$) in univariate analysis and 2.07 (95% confidence interval, 0.88-2.38; $p = 0.155$) in multivariate analysis. The odds ratio of initial MMAS of < 15 for a better MBI was 3.88 (95% confidence interval; $p = 0.020$) in univariate analysis and 5.21 (95% confidence interval, 1.56-8.32; $p = 0.008$) in multivariate analysis. The odds ratio of initial GCS score of 15 for a better MBI was 3.41 (95% confidence interval, 1.65-4.83; $p = 0.041$) in univariate analysis and 2.96 (95% confidence interval, 1.25-3.55; $p = 0.065$) in multivariate analysis. The odds ratio of the factor of stereotactic-guided evacuation of hematoma for a better MBI was 4.84 (95% confidence interval, 2.34-6.57; $p = 0.011$) in univariate analysis and 4.26 (95% Confidence Interval, 2.12-7.10; $p = 0.032$) in multivariate analysis. Although the factor of age of < 60 years and initial GCS of 15 had significant effect on MBI in univariate analysis, after multi-factor adjustment, they had no significant effect on a better MBI. Therefore, initial MMAS and stereotactic-guided hematoma evacuation were meaningful factors that had a significant positive effect on a better MBI, even in multivariate analysis.

At the same time, regression analyses for MBI in patients who underwent stereotactic-guided evacuation were performed (Table 4). The odds ratio of initial MMAS of ≥ 15 for a better MBI was 2.71 (95% confidence interval, 1.96-3.87; $p = 0.027$) in univariate analysis and 2.83 (95% confidence interval, 2.00-4.12; $p = 0.022$) in multivariate analysis. The odds ratio of initial GCS score of 15 for a better MBI was 2.96 (95% confidence interval, 1.73-3.66; $p = 0.045$) in univariate analysis and 3.17 (95% confidence interval, 1.72-3.93; $p = 0.155$) in multivariate analysis. As a result, in patients who underwent stereotactic-guided evacuation, both univariate and multivariate analyses showed significant positive effect of initial MMAS and GCS score on a better MBI.

DISCUSSION

No consensus has been reached regarding whether surgical therapy produces a better outcome than its

Table 3. Regression analyses of functional outcomes which are estimated by modified Barthel Index according to the factor, in all the enrolled patients

Factors	Mean MBI (6 mo)	Univariate analysis (p-value)	Odds ratio (95% CI)	Multivariate analysis (p-value)	Odds ratio (95% CI)	
Age	< 60 years	88.7	0.017	2.45	0.055	2.07
	≥ 60 years	70.4		(0.88-3.57)		(0.88-2.38)
Gender	Male	80.1	0.924	1.02	NA	
	Female	80.5		(0.51-1.22)		
Hypertension	Yes	84.6	0.098	2.11	NA	
	No	75.4		(0.90-3.12)		
Diabetes mellitus	Yes	81.5	0.241	1.84	NA	
	No	78.8		(0.83-2.51)		
Serum cholesterol	Normal	76.3	0.192	2.46	NA	
	Abnormal	83.7		(0.69-3.04)		
Smoker	Yes	82.3	0.223	1.91	NA	
	No	76.4		(0.67-2.33)		
Initial MMAS	< 15	68.5	0.020	3.88	0.008	5.21
	≥ 15	87.8		(1.87-5.42)		(1.56-8.32)
Initial GCS	13	73.3	Reference			
	14	79.8	0.304	2.12	NA	
	15	84.7	0.041	3.41	0.065	2.96
						(1.65-4.83)
						(1.25-3.55)
Volume of hemorrhage	< 20 cm ³	84.5	0.058	2.81	NA	
	20-30 cm ³	76.3		(1.37-3.54)		
Time interval of treatment	< 24 hours	82.4	0.188	2.09	NA	
	≥ 24 hours	79.0		(1.05-2.80)		
Treatment modality	Stereotactic	90.9	0.011	4.84	0.032	4.26
	Conservative	62.4		(2.34-6.57)		(2.12-7.10)

CI : confidence interval, GCS : Glasgow coma scale, MBI : modified Barthel Index, MMAS : Modified Motor Assessment Scale, NA : not assessed

alternatives in patients with SICH. Nevertheless, SICH volume and GCS score on admission are known to be the most powerful predictors of death within 30 days of onset⁸). Therefore, those with a large SICH and a low GCS score are generally believed to be critical candidates for surgical treatment¹⁰). However, although many studies have been conducted on the survival and mortality of patients with SICH, no comprehensive study has been conducted on functional outcome, especially in a small volume of SICH. Accordingly, patients with a good GCS score and a small hematoma but with severe motor weakness present neurosurgeons with a dilemma regarding whether to opt for surgical or conservative treatment.

One large retrospective study conducted by Matsumoto et al.²¹) demonstrated that stereotactic-guided hematoma evacuation improves functional outcome in cases with a mild or moderate hemorrhage. Furthermore, according to a report by Cho et al.¹⁰), for patients with a GCS score of 15-12 and a SICH volume of < 30 mL, 30-day mortality rates for conservative and surgical treatment are 1.85% and 5.4%, respectively. In addition, they reported an MBI score of 36.9 ± 17.3 at a mean follow-up of 2 year after stereotactic aspiration for SICH. In the present study, for patients with a GCS score of 13-15 and a SICH volume of < 30 cm³, 30-day mortality rates for patients that underwent stereotactic-guided evacuation or conservative treatment were 1.0% and 1.1%, respectively. Furthermore, mean MBI scores after 6-month follow-up in surgically and conservatively treated patients were 90.9 and 62.4, respectively. Although the present study and Cho's study had a great difference in terms of MBI score, our higher MBI score than Cho's was thought to be originated from the different volume of SICH in two different studies. Cho's report included patients regardless volume of SICH, but our study included a patient who had a SICH volume of < 30cm³.

With regards to the effect of different surgical modality, stereotactic-guided evacuation of SICH showed as a good result as craniotomy or craniectomy does. According to a report by Ahn et al.¹), ADL recovered to the independent

Table 4. Regression analyses of functional outcomes which are estimated by modified Barthel Index according to the factor, in patients who underwent stereotactic-guided evacuation of a relatively small volume of spontaneous intracerebral hematoma

Factors	Mean MBI (6 mo)	Univariate analysis (p-value)	Odds ratio (95% CI)	Multivariate analysis (p-value)	Odds ratio (95% CI)
Age	< 60 years	92.7	0.617	1.24	NA
	≥ 60 years	89.0			
Gender	Male	90.4	0.889	1.21	NA
	Female	91.2			
Hypertension	Yes	89.7	0.765	1.33	NA
	No	91.9			
Diabetes mellitus	Yes	90.6	0.892	1.13	NA
	No	91.2			
Serum cholesterol	Normal	88.7	0.601	1.52	NA
	Abnormal	92.1			
Smoker	Yes	90.0	0.904	1.05	NA
	No	91.8			
Initial MMAS	< 15	75.6	0.027	2.71	0.022
	≥ 15	94.8			
Initial GCS	13	76.3	Reference	1.55	NA
	14	89.4			
	15	93.8			
Volume of hemorrhage	< 20 cm ³	92.1	0.741	1.12	NA
	20 - 30 cm ³	89.8			
Time interval of surgery	< 24 hours	89.6	0.566	1.43	NA
	≥ 24 hours	93.1			

CI : confidence interval, GCS : Glasgow coma scale, MBI : modified Barthel Index, MMAS : Modified Motor Assessment Scale, NA : not assessed

state in 53.3% patients after craniotomy or decompressive craniectomy for SICH, regardless of GCS score. In this previous study, 30 SICH patients were treated surgically, and 16 patients (53.3%) had an MRS score of 0, 1, or 2 at 1-year follow-up. In the present study, of 204 patients that underwent stereotactic-guided hematoma evacuation, 148 (72.5%) showed an MRS score of ≤ 2 at 6-month follow-ups, whereas only 81 (44.3%) of the 183 patients treated conservatively had an MRS score of ≤ 2 at 6-months of follow-up, despite a small volume hematoma and a good GCS score at admission.

Naoyuki et al.¹⁸) reported that muscle power, volume of hematoma, age, and presence of a previous cerebrovascular accident were contributable factors to ADL score in their study. But, our study shows that initial muscle power and therapeutic modality of stereotactic-guided hematoma evacuation had an influence on ADL. In our study, because SICH volume was < 30 cm³, different result from that of Naoyuki's might be expelled. Moreover, the number of patients who had previous cerebrovascular accident history was too small to be estimated for the effect on functional

outcome in this study.

In this present study, time interval from ictus to stereotactic-guided evacuation did not influence on functional outcome. But, Cho et al.¹¹⁾ suggested that the early surgery within 24 hours after bleeding was correlated with the better outcome. In their study, the ratio of patients who had SICH volume of < 30 cm³ was only 41.3%, and the ratio of patients who had SICH volume of ≥ 30 cm³ was 58.7%. Furthermore, there were no comparative data in patients with a small volume of SICH according to the time interval from bleeding to stereotactic-guided evacuation. On the other hand, Lee et al.¹⁹⁾ reported that the statistical difference between the time interval from hemorrhage to operation and functional outcome was not significant in his clinical analysis of stereotactic aspiration of SICH.

Our study shows good recovery of function after stereotactic-guided evacuation of SICH given the limiting conditions that all patients enrolled had a relatively good GCS score, a relatively small hematoma volume, and a moderate and severe motor deficit that prevented normal activities. We stress that although this study was a randomized, controlled study, our results cannot be applied to all SICH patients. To determine a functional recovery in SICH, a clinical trial of considerably wider scope is required that includes patients with a large volume SICH and relatively poor GCS scores.

CONCLUSION

In this prospective and controlled study, we examined the functional outcome in patients with a spontaneous intracerebral hemorrhage after stereotactic-guided evacuation. Opinions differ regarding treatment modalities in SICH patients. However, the present study shows that despite a relatively small hematoma volume of < 30 cm³ and a relatively good GSC score of ≥ 13, in those with moderate and severe motor weakness preventing independent daily life, stereotactic-guided evacuation can improve functional outcome and allow a patient to perform the activities required for independent daily life.

References

- Ahn CS, Lee SK, Kim HS, Kong MH, Song KY, Kang DS : Surgical outcome of spontaneous intracerebral hemorrhage in less than stuporous mental status. *J Korean Neurosurg Soc* 35 : 290-296, 2004
- Anderson CS, Chakera TM, Stewart-Wynne EG, Jamrozik KD : Spectrum of primary intracerebral haemorrhage in Perth, Western Australia, 1989-90 : incidence and outcome. *J Neurol Neurosurg Psychiatry* 57 : 936-940, 1994
- Auer LM, Deinsberger W, Niederkorn K, Gell G, Kleinert R, Schneider G, et al. : Endoscopic surgery versus medical treatment for spontaneous intracerebral hematoma : a randomized study. *J Neurosurg* 70 : 530-535, 1989
- Batjer HH, Reisch JS, Allen BC, Plaizier LJ, Su CJ : Failure of surgery to improve outcome in hypertensive putaminal hemorrhage. A prospective randomized trial. *Arch Neurol* 47 : 1103-1106, 1990
- Bonita R, Beaglehole R : Recovery of motor function after stroke. *Stroke* 19 : 1497-1500, 1988
- Broderick JP, Adams HP Jr, Barsan W, Feinberg W, Feldmann E, Grotta J, et al. : Guidelines for the management of spontaneous intracerebral hemorrhage : a statement for healthcare professional from a special writing group of the Stroke council. American Heart Association. *Stroke* 30 : 905-915, 1999
- Broderick JP, Brott T, Tomsick T, Miller R, Huster G : Intracerebral hemorrhage more than twice as common as subarachnoid hemorrhage. *J Neurosurg* 78 : 188-191, 1993
- Broderick JP, Brott TG, Duldner JE, Tomsick T, Huster G : Volume of intracerebral hemorrhage. A powerful and easy-to-use predictor of 30-day mortality. *Stroke* 24 : 987-993, 1993
- Carr JH, Shepherd RB, Nordholm L, Lynne D : Investigation of a new motor assessment scale for stroke patients. *Phys Ther* 65 : 175-180, 1985
- Cho DY, Chen CC, Lee HC, Lee WY, Lin HL : Glasgow Coma Scale and hematoma volume as criteria for treatment of putaminal and thalamic intracerebral hemorrhage. *Surg Neurol* 70 : 628-633, 2008
- Cho TG, Nam DH, Cho BM, Lee JI, Kim JS, Hong SC, et al. : Stereotactic evacuation of spontaneous intracerebral hemorrhage. *J Korean Neurosurg Soc* 28 : 237-245, 1999
- Counsell C, Boonyakarnkul S, Dennis M, Sandercock P, Bamford J, Burn J, et al. : Primary intracerebral haemorrhage in the Oxfordshire Community Stroke Project, 2 : prognosis. *Cerebrovasc Dis* 5 : 26-34, 1995
- Doi E, Moriwaki H, Komai N, Iwamoto M : [Stereotactic evacuation of intracerebral hematomas.] *Neurol Med Chir (Tokyo)* 22 : 461-467, 1982
- Evers SM, Ament AJ, Blaauw G : Economic evaluation in stroke research : a systematic review. *Stroke* 31 : 1046-1053, 2000
- Gedders JML, Chamberlain MA, Bonasall M : The leeds family placement scheme : principles, participants and postscript. *Clin Rehab* 5 : 53-64, 1991
- Gladman JRF, Lincoln NB, Barer DH : A randomized controlled trial of domiciliary and hospital-based rehabilitation for stroke patients after discharge from hospital. *J Neurosurg Psychiatry* 56 : 960-966, 1993
- Gladman J, Whyne D, Lincoln N : Cost comparison of domiciliary and hospital-based stroke rehabilitation. DOMINO study group. *Age Ageing* 23 : 241-245, 1994
- Hattori N, Katayama Y, Maya Y, Gatherer A : Impact of stereotactic hematoma evacuation on activities of daily living during the chronic period following spontaneous putaminal hemorrhage : a randomized study. *J Neurosurg* 101 : 417-420, 2004
- Lee JC, Min BK, Park K, Suk JS : The clinical analysis of stereotactic aspiration of spontaneous intracerebral hemorrhage. *J Korean Neurosurg Soc* 26 : 347-353, 1997
- Mahoney FI, Barthel DW : Functional evaluation : the Barthel Index. *Md State Med J* 14 : 61-65, 1965
- Matsumoto K, Hondo H : [Surgical indication for hypertensive brain hemorrhage - update.] *No To Shinke* 46 : 105-117, 1994
- Medical Research Council : **Aids to the examination of the peripheral nervous system.** London : Her Majesty's Stationary Office, 1976
- Teasdale G, Jennet B : Assessment of coma and impaired consciousness. A practical scale. *Lancet* 2 : 81-84, 1974