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Clinical Article

Open Surgical Evacuation of Spontaneous Putaminal Hematomas: Prognostic Factors and Comparison of Outcomes between Transsylvian and Transcortical Approaches

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Objective : The purpose of this study was to investigate the factors affecting the surgical outcome and to compare the surgical results between transsylvian and transcortical approaches in patients with putaminal hematomas.
Methods : Retrospective review of charts and CT scan images was conducted in 45 patients (20 transsylvian and 25 transcortical approaches) who underwent open surgical evacuation of putaminal hematomas. Mean Glasgow coma scale (GCS) score and hematoma volume were 7.5 ± 3.2 and 78.1 ± 29.3 cc, respectively. The factors affecting the functional mortality were investigated using a multivariate logistic regression analysis. In addition, surgical results between transsylvian and transcortical approaches were compared.
Results : None of the patients had a good recovery after the surgery. Overall functional survival rate and mortality were 37.7% and 31%, respectively. The only risk factor for functional mortality was GCS motor score after controlling age, history of hypertension, side of hematoma, hematoma amount, midline shift, presence of intraventricular hemorrhage and surgical approach (p=0.005). Even though a transcortical approach was shorter in operative time (4.4 versus 5.1 hour) and showed a higher mortality rate (40% versus 20%) and lower functional survival (45% versus 35%) compared to the transsylvian approach, the differences were not statistically significant between the two groups.
Conclusion : In patients who have large amounts of hematoma and require open surgical evacuation, the only significant risk factor for functional survival is the preoperative GCS score. Cortical incision methods such as transsylvian and transcortical approaches have no influence on the surgical outcome. To decompress the swollen brain rapidly, transcortical approach seems to be more suitable than transsylvian approach.

KEY WORDS : Putaminal hemorrhage · Craniotomy · Glasgow coma scale · Mortality.

INTRODUCTION

Putamen is the most common location of a spontaneous intracerebral hemorrhage (ICH), which constitutes 48-67% of all spontaneous hypertensive ICH[16,11]. A large number of patients could be managed conservatively, but in a selected patient who had a significant amount of ICH, surgical evacuation of hematoma could be beneficial by volume reduction and lowering intracranial pressure (ICP). Even though stereotactic guided aspiration of hematoma is a preferred treatment modality to open craniotomy, hematoma evacuation through open craniotomy still deserves to be done in a large number of ICH patients with significant mass effect to control ICP effectively[5]. There have been two methods to access the putaminal hematoma through open craniotomy, ie, transsylvian and transcortical approaches. Transsylvian transinsular approach has an advantage of minimal disruption of a normal cerebral cortex, even though it requires a small insular cortex incision, which is known not to have any neurologic deficit in most cases[15,22,23]. However, it has some disadvantages such as increased risk of surgically induced trauma to the frontal and temporal lobe due to retraction and of vasospasm due to manipulation of perisylvian vessels, as well as the time consuming in such cases as difficult sylvian dissection[22]. On the contrary, the transcortical approach requires a small cortical incision at the thinnest cortex to hematoma, through which the hematoma can be evacuated effectively with minimal brain retraction.

To the authors' knowledge, there has been no report regarding the surgical outcome of transsylvian and trans-

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cortical approaches in patients with spontaneous putaminal hematoma. The purpose of this study was to evaluate the open surgical results of putaminal hematoma and compare the outcome between transsylvian and transcortical approach groups.

MATERIALS AND METHODS

Patient population

Of the 1106 patients who were treated in our hospital due to spontaneous ICH between May 2003 and December 2007, 342 patients had ICH in putamen. Among these, hematoma evacuation using open craniotomy was performed in 48 patients and stereotactic guided aspiration of hematoma in 51 patients. Open surgical evacuation of hematoma in our hospital was usually performed in patients who had more than 50 cc in hematoma volume and in stupor patients who had a hematoma volume of 30-50 cc. All patients underwent emergency open surgery within 24 hours including 5 cases whose consciousness deteriorated before surgery due to increase in volume of hematoma. To evaluate the clinical results based on the patients who underwent the hematoma evacuation using open craniotomy, 45 were recruited in this retrospective study. Three of the 48 patients were excluded from this study due to incomplete clinical records and unavailable CT scans. We collected the data regarding age, sex, medical history of hypertension and diabetes, preoperative GCS score, hemorrhage side, presence of intraventricular hemorrhage, amount of ICH, degree of midline shift and obliteration of basal cistern on preoperative CT scans, time delay from admission to operation, operative time which was defined as an elapsed time to evacuate ICH from skin incision to skin closure, surgical approach for hematoma evacuation, decompressive craniectomy or craniotomy, GCS score at 24 hours after hematoma evacuation, degree of midline shift and hematoma volume remained on immediate postoperative CT scans, period of hospital stay and outcome at discharge. Surgical outcome was assessed by Glasgow outcome scale at discharge.

To investigate the factors affecting functional survival, univariate analysis using the above collected variables was performed in these 45 patients who were treated by open craniotomy. Functional survival indicates the patients who remained good to severe disabilities except the functional mortality which was defined as both persistent vegetative state and death. After the statistically significant factors on functional survival were selected using univariate analysis, logistic regression analysis was performed to determine the independent prognostic factors.

Twenty patients underwent hematoma evacuation through a transsylvian approach and the remaining 25 underwent a transcortical approach. After comparing the preoperative clinical and radiological severities between the two groups, the following variables were compared as the surgical results : operative time elapsed to evacuate ICH; decompressive craniectomy or craniotomy; GCS score and GCS motor score at 24 hours after hematoma evacuation; degree of midline shift and hematoma volume remained on immediate postoperative CT scans; period of hospital stay; and

Table 1. Preoperative clinical and radiological differences between transsylvian and transcortical groups

Variables	Transsylvain group (%)	Transcortical group (%)	Total
No. of patients	20	25	45
Age in years	58.5±12.5	54.2±11.6	56.1±12.1
Sex (M/F)	12/8	21/4	33/12
Hypertension	9 (45)	15 (60)	24 (53.3)
Diabetes mellitus	2 (10)	4 (16)	6 (13.3)
Preoperative GCS score	7.3±2.5	7.6±3.6	7.5±3.6
3–5	4 (20)	11 (44)	15 (33.3)
6–8	12 (60)	5 (20)	17 (37.8)
9–12	3 (15)	6 (24)	9 (20.0)
13–15	1 (5)	3 (12)	4 (16.0)
Preoperative GCS motor score	4.5±1.2	4.0±1.6	4.2±1.4
Left putaminal ICH	12 (60)	15 (60)	27 (60.0)
IVH	13 (65)	14 (56)	27 (60.0)
Preoperative midline shifting (mm)	10.7±2.8	10.5±3.9	10.6±3.4
Preoperative ICH amount (mL)	79.3±29.7	77.1±30.7	78.1±29.9
30–60	5 (25)	11 (44)	16 (35.6)
61–90	11 (55)	7 (28)	18 (40.0)
>90	4 (20)	7 (28)	11 (24.4)
Cisternal status on CT scan			
Normal	1 (5)	3 (12)	4 (8.9)
Partially obliterated	12 (60)	7 (28)	19 (42.2)
Completely obliterated	7 (35)	15 (60)	22 (48.9)
Onset to Operation (hr)	7.6±8.6	10.2±10.8	9.0±9.9
Time delay from ER to OR (hr)	4.9±6.6	4.0±4.8	4.4±5.6

Differences were not statistically significant between two groups in all preoperative variables. M : male, F : female, GCS : Glasgow coma scale, ICH : intracerebral hemorrhage, IVH : intraventricular hemorrhage, ER : emergency room, OR : operation room, DEC : decompressive, Postop. : postoperative outcome at discharge.

The mean age of the 45 patients were 56.1 ± 12.1 years old (range 39-79). The preoperative mean GCS score and GCS motor score were 7.5 and 4.2, respectively. Preoperative mean ICH amount and midline shifting were 78.1 cc (range : 30-159 cc) and 10.6 mm (range : 0-17 mm), respectively. Mean preoperative delay from symptom onset to operation was 9.0 hours. Table 1 showed baseline demographic characteristics in detail.

Surgical technique

In a transsylvian approach, distal sylvian fissure was opened from lateral to medial direction, using the microsurgical technique. Early identification of M3 branches within the fissure provided reference for further proximal dissection to M2 divisions and insular cortex. A small insular cortex incision was made parallel to sylvian fissure. Splitting the insular cortex resulted in the exposure of hematoma on putamen. Hematoma evacuation was performed using suction and bipolar cautery. If the hematoma was extended to the cerebral convexity region, it was hard to evacuate due to the limited visual access. Gentle manual compression of parietal or frontal convexity inferiorly resulted in hematoma displacement into the operative field, which facilitated complete evacuation of hematoma even though it was very large. A minimal amount of hematoma remained untouched near the hematoma margin to avoid further injury of adjacent normal brain. Hematoma cavity was covered with Surgicell and wet Gelform. Glue was then applied to the hematoma cavity after confirming the complete hemostasis using the Valsalva maneuver. Dura was closed with or without an artificial dura graft depending on the brain condition. Replacement of skull bone was determined based on the brain condition after evacuation of ICH.

In the transcortical approach, about a 2 cm cortical incision was made along the thinnest cortex to hematoma. Hematoma evacuation was done in a similar manner to that of the transsylvian approach.

Demonstrative case 1

A 42-year-old male patient Presented with a sudden semicomatose consciousness. Initial GCS score was 6. A CT scan showed large amount of right putaminal ICH with 10 mm midline shifting. Emergent craniotomy and evacuation of hematoma was performed using the transsylvian approach 3 hours after admission. Postoperative CT scan showed total removal of ICH and a shrunken brain (Fig. 1A, B). The patient survived with mild disability.

Demonstrative case 2

A 41-year-old man Presented with stuporous consciousness 20 minutes prior to admission. He showed pupillary anisocoria. Initial GCS score was 6T. A CT scan showed 110 cc of ICH on left putamen with 11 mm midline shifting. Decompressive craniectomy and hematoma evacuation was performed using a transcortical approach. Even though a near complete hematoma evacuation was done, the patient died of brain swelling at 4 days postoperatively (Fig. 2A, B).

Postoperative patient management

After hematoma evacuation, all patients were managed in the neurosurgical intensive care unit. Postoperative medical treatment included blood pressure control, intravenous fluids, antibiotics, anticonvulsant, hyperosmolar agents, H2 blockers, maintenance of normoglycemia, early nutritional support, and physical therapy.

Statistical analysis

Statistical analysis was done using SPSS 12.0 statistical package (SPSS Inc, Chicago, IL). Significance of intergroup differences was assessed by Fisher's exact test for

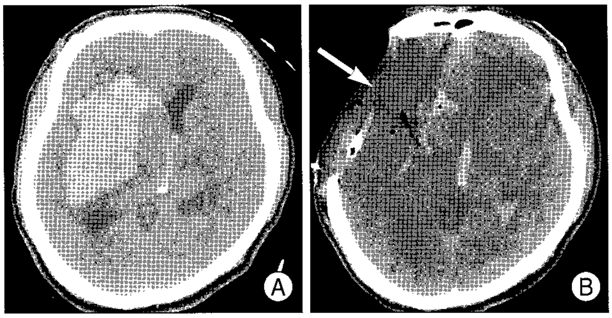

Fig. 1. Preoperative brain computed tomography (CT) (A) showing large putaminal hematoma with midline shifting and immediate postoperative brain CT (B) showing complete evacuation of hematoma and cranial bone defect. The arrow indicates a corridor of transsylvian approach.

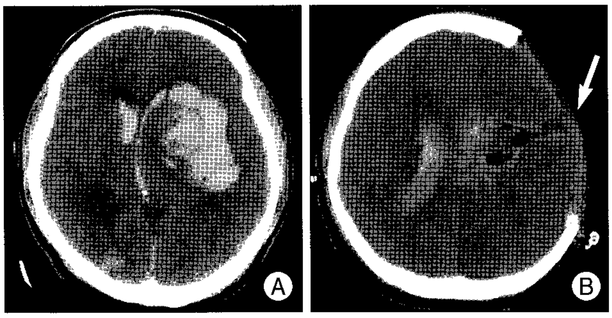

Fig. 2. Preoperative brain computed tomography (CT) (A) showing large putaminal hematoma with midline shifting and immediate postoperative brain CT (B) showing subtotal evacuation of hematoma and cranial bone defect. The arrow indicates a corridor of transcortical approach.

categorical variables and non-parametric Mann-Whitney U test for continuous variables. To determine the prognostic factors for functional survival, logistic regression analysis was employed. A p-value of <0.05 was considered statistically significant.

RESULTS

No patient achieved a good recovery after the evacuation of hematoma using craniotomy in patients with spontaneous putaminal ICH. Overall functional survival rate, vegetative survival and overall mortality rate were 37.8%, 31.1% and 31.1%, respectively (Table 2).

According to GCS score, only one patient (6.7%) survived functionally at discharge in a subgroup analysis of GCS score less than 6, whereas 75% (3/4) of the patients who had GCS score of 13-15, functionally survived at dis-charge. This difference was statistically significant. Preoperative clinical status measured by GCS score was influenced on the final surgical outcome ($p<0.05$) (Fig. 3).

Regarding the relationship between ICH amount and surgical outcome, functional survival rate in patients who had ICH of 30-60 ml, 61-90 ml and more than 90 ml were 31.3% (5/16), 55.5% (10/18) and 18.2% (2/11), respectively. The absolute amount of ICH did not affect on the final surgical outcome ($p>0.05$) (Fig. 4).

Mean operative time was 4.7 hours. Mean ICH amount remained after surgery was 11.0 cc. Median hospital stay was 26.5 days. Mean postoperative GCS score at 24 hours and midline shift were 7.1 and 7.7 mm, respectively (Table 2).

Table 2. Postoperative comparison of clinical and radiological results between transsylvain and transcortial approaches

	No. of patients (%)		
	Transylvian group	Transcortical group	Total
Operative time (hr)*	5.1±1.2	4.4±1.4	4.7±1.4
DEC craniectomy	9 (45)	14 (56)	23 (51.1)
Postop. GCS score	7.1±2.3	7.2±3.1	7.1±2.7
Postop. GCS motor score	4.2±1.0	4.0±1.5	4.1±1.3
Postop. midline shift (mm)	7.3±3.95	8.1±4.4	7.7±4.2
ICH remained (mL)	10.8±11.2	11.16±17.3	11±14.7
Hospital stay, median (days)	49.8±39.5, 45	34.5±38.4, 18	41.4±39.2, 26.5
Outcome			
Good recovery	0 (0)	0 (0)	0 (0)
Moderate disability	3 (15.0)	2 (8.0)	5 (11.1)
Severe disability	6 (30.0)	6 (24.0)	12 (26.7)
Vegetative state	7 (35.0)	7 (28.0)	14 (31.1)
Death	4 (20.0)	10 (40.0)	14 (31.1)
Total	20 (100)	25 (100)	45 (100)

Differences were not statistically significant between two groups in all postoperative variables. *p=0.082. DEC : decompressive, Postop : postoperative, GCS : Glasgow coma scale, ICH : intracerebral hemorrhage

Complications related to surgery occurred in 3 patients (6.7%) including 1 case of epidural hematoma requiring evacuation, 1 case of recurrent bleeding resulted in death, and 1 case of brain abscess.

Functional survival

Factors affecting functional survival is summarized in Table 3. Age, sex, history of hypertension, diabetes, left side ICH, ICH volume and presence of intraventricular extension of ICH did not affect the functional survival. Preoperative GCS score and GCS motor score significantly affected the functional survival ($p<0.05$). Basal

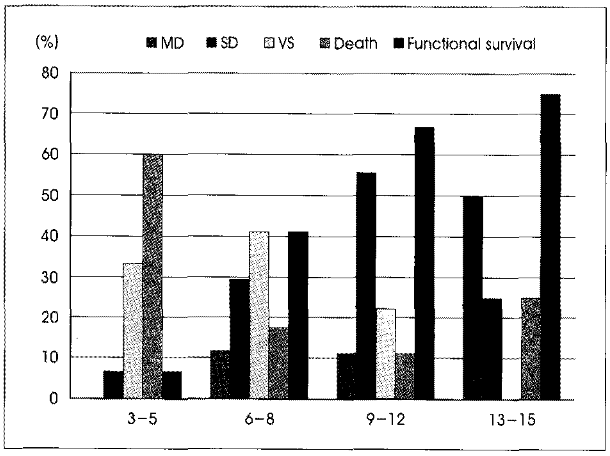

Fig. 3. Surgical outcome according to preoperative Glasgow coma scale score (p=0.012). MD : moderate disability, SD : severe disability, VS : vegetative state.

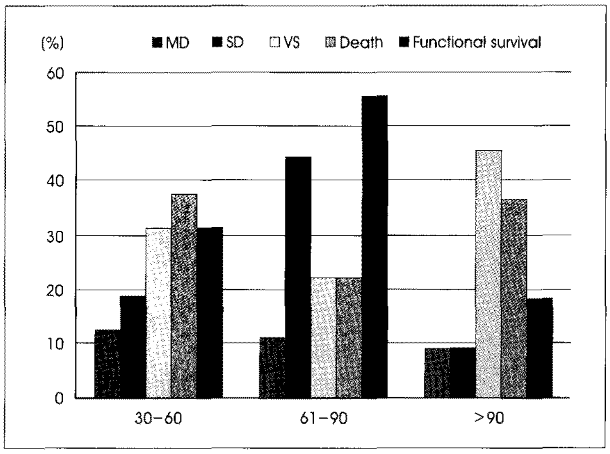

Fig. 4. Surgical outcome according to intracerebral hematoma amount (p>0.05, MD : moderate disability, SD : severe disability, VS : vegetative state.

cistern status also significantly affected the functional survival ($p<0.05$). The midline shifting was more severe in functional death group compared to functional survival group (mean : 11.3 mm versus 9.4 mm), but the difference did not reach a statistical significance (p=0.068). Functional survival was achieved in 52. 9% of transsylvian and 47.1% of transcortical approach group. But, the difference was not statistically significant ($p>0.05$). Decompressive craniectomy was performed more frequently in the functional death group (64.3% versus 29.4%), which reflected on a poor brain condition in the functional death group ($p<0.05$) (Table 3).

Comparison of outcomes between transsylvian and transcortical approaches

Mean operative time was 5.1 and 4.4 hours in transylvian and transcortical group, respectively. Transcortical approach showed a tendency of a shorter time requirement than transsylvian approach. But, the difference was not statistically significant (p=0.082). Postoperative GCS score, remained ICH amount, hospital stay were similar between the two groups (Table 2).

The transcortical approach was associated with a higher mortality rate than the transsylvian approach (40% versus 20%). However, the difference was not statistically significant between two groups ($p>0.05$). Functional survival rate was higher in the transsylvian group than the transcortical group (45% versus 32%), but the difference did not reach statistical significance ($p>0.05$) (Table 2).

Logistic regression analysis

After controlling the multiple variables such as age, history of hypertension, side of ICH, ICH amount, midline shift, IVH and surgical approach, the only risk factor for functional mortality was GCS score (GCS motor score had a stronger impact) (p=0.005) (Table 4).

Table 3. Factors for functional survival by univariate analysis

Variables	Functional survival (%)	Functional death (%)	p-value
No of patients	17	28	
Age in years (mean±SD)	57.0±12.3	55.6±12.2	0.732
Male sex	13 (76.5)	20 (71.4)	0.745
Hypertension	10 (58.8)	14 (50.0)	0.795
Diabetes mellitus	2 (11.8)	4 (14.3)	1
Lt. putaminal ICH	8 (47.1)	19 (67.9)	0.216
GCS score	9.5±3.2	6.3±2.5	0.001
GCS motor score	5.1±1.0	3.6±1.3	0.000
ICH amount (mL)	70.8±25.7	82.5±31.9	0.439
IVH	8 (47.1)	19 (67.9)	0.216
Midline shift (mm)	9.4±3.1	11.3±3.4	0.068
Basal cistern status			0.003
Normal	4 (23.5)	0	
partially obliterated	9 (52.9)	10 (35.7)	
completely obliterated	4 (23.5)	18 (64.3)	
ER to OR (hr)	5.1±7.2	3.9±3.5	0.977
Onset to operation (hr)	9.9±9.6	8.5±10.2	0.662
Approach			0.537
transsylvian approach	9 (52.9)	11 (39.3)	
transcortical approach	8 (47.1)	17 (60.7)	
Operative time (hr)	4.7±1.4	4.8±1.4	0.493
DEC craniectomy	5 (29.4)	18 (64.3)	0.033
ICH remained (mL)	8.6±8.9	12.4±17.4	0.929
Postop. midline shift (mm)	6.4±4.1	8.6±4.1	0.076
Postop. GCS motor score	9.1±3.0	5.9±1.7	0.000

Functional death was defined as death and persistent vegetative state following open surgery. ICH : intracerebral hemorrhage, GCS : Glasgow coma scale, IVH : intraventricular hemorrhage, ER : emergency room, OR : operation room, DEC : decompressive, Postop. : postoperative

Table 4. Risk factors for functional mortality by logistic regression analysis

Variables	β	Significance	Odd ratio (95% CI)
Age	0.017	0.660	1.017 (0.943-1.097)
Hx of hypertension	0.938	0.317	2.556 (0.407-16.052)
GCS motor score	-1.096	0.005	0.334 (0.157-0.713)*
Left side ICH	-0.773	0.407	0.462 (0.074-2.873)
ICH amount	0.008	0.613	1.008 (0.978-1.039)
Midline shift	0.117	0.476	1.124 (0.816-1.548)
IVH	0.230	0.811	1.258 (0.191-8.308)
Transcortical approach	0.616	0.459	1.852 (0.363-9.462)†

*indicates p-value of less than 0.05, † The risk of functional mortality in transcortical approach is not different statistically compared that of the transsylvian approach. Hx : history, GCS: Glasgow coma scale, ICH : intracerebral hemorrhage, IVH : intraventricular hemorrhage, CI : confidence interval

DISCUSSION

The short term outcome of ICH is determined by the severity of bleeding as measured by clinical conditions, the hematoma size, and the presence of intraventricular hematoma and the long term outcome depends mainly on age[6,7,13,21,24]. Other independent prognostic factors of ICH include alcohol consumption, hematoma growth, presence of hydrocephalus, baseline D-dimer level and maintenance of high blood pressure[8-10,12].

In our study, initial GCS score, more specifically GCS motor score, basal cisternal status on preoperative CT and decompressive craniectomy influenced the functional survival in univariate analysis. But, the only independent prognostic factor for functional mortality was preoperative GCS motor score by logistic regression analysis. Other factors, such as age, history of hypertension, side of ICH, midline shift, ICH amount, presence of IVH, time delay to operation and operative approaches did not influence the functional mortality.

The results of this study were quite different to those of other studies, which include the patients who underwent conservative treatment or stereotatic guided aspiration for small amount ICH[6,7,13,21,24]. But, this study only included the patients who underwent open craniotomy as a life saving procedure. Their brains were severely destructed already due to large amounts of hematoma and severe midline shifting. Thus, they had little chance of recovery as compared to other studies.

The only independent prognostic factor for functional mortality was GCS motor score. This could be explained by the reservoir capacity of the brain. If the ICH began to enlarge after bleeding, the sulci were effaced first. As the compensatory mechanism of the brain is exhausted, the midline shift begins to occur. If the ICH enlargement continues, severe midline shifting and deterioration of consciousness occurs. The compensatory reservoir capacity of the brain is, however. Quite different on an individual basis mainly due to the degree of brain atrophy. Therefore, the amount of ICH does not always correlate with the GCS score. In this study, the ICH amount did not correlate with the GCS score (not shown in the Table).

Despite recent improvements in the surgical treatment of ICH, it is still unclear whether surgical evacuation of an ICH will improve the outcome[2-4,14,18,19]. Of the four randomized clinical trials of surgical treatment, three showed that surgical treatment had little advantage over conservative treatment[3,17,18]. Broderick et al.[5] recommended that; 1) no clear evidence at present indicates that ultraearly craniotomy improves functional outcome or mortality rate, 2) operative removal within 12 hours, particularly when performed by less invasive methods, has the most supportive evidence, and 3) very early craniotomy may be associated with an increased risk of recurrent bleeding. Another study indicated that endoscopic guided evacuation of the hemorrhage was superior to conservative treatment[2,5].

Surgical intervention increases the chance of survival or prolonged the surviving period, despite remaining severe neurological deficits. However, because the ICHs were significantly more severe in patients who received surgery than in those who did not, the lack of a statistically significant difference in outcome might indirectly indicate that evacuation of the hematoma is effective in reducing the mortality rate[17]. Another author reported that the mortality rate of semicomatose or stuporous patients (GCS score 7 to 10) was significantly lower in the surgical treatment group than in the conservative treatment group, but all surviving patients in this subgroup were severely disabled[18].

In our study, overall mortality rate was 31.1%. But, among the patients with GCS score less than 6 (15 patients), only one patient (6.7%) survived functionally (severely disabled) and 33.3% survived persistent vegetative state, whereas sixteen of thirty patients (53%) functionally survived in GCS score more than 5. This result suggests that open surgery merely increases vegetative survival in this subgroup of patients with a GCS score less than 6. Open surgery and hematoma evacuation should not be attempted in this subgroup of spontaneous putaminal ICH unless special permission from the patient's family is obtained after giving enough information regarding the poor surgical results after surgery.

Decompressive craniectomy was performed less frequently in the functional survival group than the functional mortality group. This could be explained by more severe brain swelling or anticipated brain swelling after the evacuation of hematoma in the functional mortality group, which required bone decompression.

Transsylvian transinsular and transcortical approaches are standard surgical approaches to evacuate putaminal hematoma. In particular, transsylvian approach can be considered "minimally invasive" because it doesn't invade pia matter of frontal and temporal lobes. Neurosurgeons specialized in vascular surgery, frequently use this approach to clip the intracranial aneurysms[22]. But, sylvian fissure dissection can be a difficult job for other neurosurgeons and neurosurgeons in beginner stage. The transcortical approach, in this respect, can be easily performed by any neurosurgeon.

Disadvantages of the transsylvian approach are hemodynamic change due to major vessel injury, sacrifice of cortical and sylvian veins, manipulative transgression of the thin arachnoid membrane and vasospasm due to mechanical damage to the vessel walls, continuous seepage of small amounts of blood into basal cisterns and damage to the hypothalamus[1,22,23].

In contrast to transsylvian approach to clip the aneurysm, which requires wide sylvian dissection, transsylvian transinsular approach to evacuate putaminal hematoma often requires a small distal sylvian fissure dissection to expose insular cortex. Thus, the chance of cerebral vasospasm in putaminal hematoma might be minimal compared to aneurysm surgery.

Martin et al.[20] compared outcome after selective amygdalohippocamectomy with transsylvian versus transcortcial approach. The result showed that cognitive outcomes were essentially the same after both approaches.

In our study, surgical approach didn't influence the functional mortality. Furthermore, transsylvian approach showed a tendency of longer operation time than transcortical approach. An additional 43 minutes were required for the transsylvian approach. Based on this result, the authors suggest that the transcortical approach might be a suitable approach to evacuate large putaminal hematoma because it could decompress the swollen brain more rapidly than the transsylvian approach.

CONCLUSION

In patients who have large amounts of hematoma and require open surgical evacuation, the only significant risk factor for functional survival is the preoperative GCS score. Cortical incision methods such as the transsylvian transinsular or transcortical approaches have no influence on the surgical outcome. To decompress the swollen brain rapidly, transcortical approach seems to be more suitable than transsylvian approach.

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