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Navigation-assisted Aspiration and Thrombolysis of Deep Intracerebral Hemorrhage

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ABSTRACT

Objective : Frame-based stereotatic catheter placement and subsequent thrombolysis is one treatment option for the management of a deep intracerebral hemorrhage. Recently, frameless stereotactic surgery with a navigation system has been introduced to reduce the hematoma volume. This study was designed to evaluate the effectiveness of frameless stereotactic ICH catheterization using a navigation system. **Methods** : From January 2006 to November 2006, we identified 27 patients who were diagnosed with deep ICH and underwent navigation-assisted frameless stereotactic catheter insertion with/without thrombolysis by urokinase irrigation. **Results** : The mean length between the center of the hematoma and the tip of the catheter was 6.8 mm (range between0 and 15 mm). The catheter tip and target matched in 8 patients (29.6%). In cases of an inappropriately located catheter tip (70.4%), most of the hematomas were thalamic in location due to the long trajectory (9 of 10 thalamic locations). The preoperative hematoma volume showed a statistically significant correlation with the final hematoma volume. There was no mortality reported. Multiple regression analysis showed a statistically significant correlation between the initial Glasgow coma scale score and the outcome. **Conclusions** :Navigation-assisted frameless stereotactic ICH catheterization has limited accuracy but is effective in reducing the ICH volume reduction. **(Kor J Cerebrovascular Surgery 9(3):172-6, 2007)**

KEY WORDS : Intracerebral hemorrhage · Navigation · Stereotactic aspiration · Thrombolysis

Introduction

Deep intracerebral hemorrhage (ICH) is critical disease because it has higher morbidity and mortality. There is controversy in management of deep ICH, medical conservative care and surgical intervention.[7] Surgical evacuation of hematoma is effective in reduction of hematoma volume, lowering intracranial pressure, and recovery of perfusion in cerebral hemisphere.[2][4][11] But open craniotomy causes additional damage to overlying brain parenchyma. Catheter insertion into the deep ICH is less invasive and cause little damage to brain parenchyma. This method has been assisted by stereotaxy, such as frame based stereotactic technique and its accuracy has been improved.[10] In recent years, frameless stereotactic method has been introduced and used world widely. However its accuracy has been questioned. The aim of this study is to evaluate accuracy of frameless stereotactic technique for deep ICH catheterization and its result.

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Patients and Methods

Patients

From January 2006 to November 2006, we identified 27 patients who were diagnosed as deep ICH and underwent navigation-assisted frameless stereotactic catheter insertion with/without thrombolysis by urokinase irrigation. Clinical and radiologic data included the following: age, sex, initial Glasgow coma scale (GCS), preoperative hematoma location and volume, coexistence of intraventricular hemorrhage (IVH).

Hematoma volume measurement

Hematoma volume was calculated according to the ABC method had been described by Kothari et al.[6] Digitalized CT image was measured on GE PACS system.

Techniques of navigation-assisted frameless stereotatic catheter insertion

Fiducial markers were patched around the entry point, usually Kocher's point or above the subcortical hematoma. 1 mm slice non-contrast CT scan was taken for navigation system. The images were reconstructed in the system (CART-II, Stryker Instuments, Kalamazoo, MI) and matched its points to fiducial markers on scalp of the patients. Target point was created at the center of hematoma. Catheter insertion was done under general anesthesia, with head fixation by the Mayfield head rest. After aseptic preparation, scalp was incised straightly. Small hole was drilled and dura was opened. The hole was usually located at Kocher's point or the closest one to the target point. A catheter was inserted toward target using the guiding instruments. Hematoma was aspirated with low tension by syringe about 5 to 10 ml due to target confirmation and acute decompression of mass effect.

Post operative care and outcome assessment

All patients underwent CT study immediately after operation. It was compared with preoperative image, and catheter tip location was calculated by Euclidean x-y-z method.

Subsequent thrombolysis and clot aspiration were

Table 1. Summary of patients with deep intracerebral hemorrhage treated by navigation-assisted aspiration and thrombolysis

Patient	Sex/Age, yr	Initial GCS Score	Initial ICH volume, ml	ICH location	IVH	Number of target	Distance from target center of ICH, mm	Urokinase Instillations, number	% of ICH removed	GOS Score 6months postsurgery
1	M/45	10	30	Thalamic	Yes	2	0	6	90	3
2	M/42	13	48	Basal ganglia	No	1	15	7	100	4
3	M/56	14	30	Subcortical	No	1	0	0	100	5
4	M/42	13	25	Basal ganglia	No	1	8	7	90	4
5	M/67	14	25	Subcortical	No	1	0	0	100	5
6	M/51	12	20	Thalamic	No	1	15	0	90	3
7	M/48	11	44	Subcortical	No	1	0	0	80	3
8	M/55	13	32	Basal ganglia	No	1	0	0	100	4
9	F/64	13	35	Subcortical	No	1	0	0	100	4
10	F/77	11	30	Thalamus	No	1	10	1	80	3
11	F/79	10	34	Thalamus	Yes	1	10	0	80	3
12	F/72	11	46	Basal ganglia	Yes	1	5	1	80	3
13	M/67	12	45	Subcortical	No	2	10	1	90	3
14	M/55	10	35	Thalamus	Yes	1	15	0	80	3
15	F/63	9	22	Thalamus	Yes	1	15	3	70	3
16	M/58	11	28	Thalamus	Yes	1	10	5	40	3
17	M/53	13	35	Subcortical	No	1	10	0	50	3
18	M/40	13	25	Subcortical	No	1	3	0	90	4
19	M/76	13	25	Subcortical	No	1	3	0	90	
20	M/50	10	40	Thalamus	Yes	1	10	5	80	3
21	M/70	7	48	Thalamus	Yes	1	15	4	70	3
22	M/63	11	50	Basal ganglia	No	1	0	6	80	3
23	M/46	9	32	Thalamus	Yes	2	10	2	80	3
24	M/44	12	40	Basal ganglia	No	1	10	6	80	3
25	M/44	11	36	Basal ganglia	No	1	5	6	80	3
26	F/56	12	30	Basal ganglia	No	1	5	4	80	4
27	F/90	12	35	Subcortical	No	1	0	2	90	4

GCS: Glasgow Coma Scale, ICH: intracerebral hemorrhage, IVH: intraventricular hemorrhage, GOS: Glasgow Outcome Sacle.

performed at the bedside using sterile technique. Urokinase 3000 IU in 1 ml of preservative-free saline was injected into the catheter. After 6 to 8 hours, manual aspiration of lysed clot was attempted at the bedside, and the aspirated volume was recorded. Catheter was preserved until drainage below 10cc/day or CSF drained through a catheter due to communication between ventricle and hematoma. In patients whose catheter was located deeper than hematoma center, it has been withdrawn. 7 days later from catheter removal, CT scan was followed.

Final outcome of patient was scaled by Glasgow outcome scale (GOS) at 6 month after the operation.

Statistical analysis

Independent T-test, ANOVA test, and univariate analysis were used for comparison between target accuracy and hematoma location and size. Paired T-test was used for comparison between preoperative hematoma volume and final hematoma volume. Multivariate regression analysis was performed to analyze the prognostic impact of the following parameters on GOS: gender, age, preoperative clinical status, hematoma volume before and after treatment, localization, ventricular extension. For that purpose, the GOS was dichotomized into favorable (GOS>3) and unfavorable outcome (GOS≤3). The level of significance was set at 0.05.

Results

Clinical characteristics and treatment of patients with deep ICH treated by navigation-assisted aspiration and thrombolysis was summarized in Table 1.

There were 20 men and 7 women, and the age ranged between 40 and 90 years (mean, 58.3±13.2 years). The initial GCS score ranged between 7 and 14 with a mean of 11.5. Hematoma volume ranged 20 ml and 50 ml (mean 34 ml). ICH was located in basal ganglia with 8 patients, thalamus with 10 patients, and subcortical with 9 patients. Nine patients had IVH simultaneously. Rebleeding before operation occurred in one patient (patient 18). Navigation CT showed the increased ICH volume when compared one in the initial CT scan.

Technical purpose of surgery was that catheter tip was located to the center of ICH. The length between center of hematoma and tip of catheter was calculated. Its mean length was 6.8 mm (range between 0 and 15 mm). Catheter tip and target matched in 8 patients (29.6%). In cases of inappropriately located catheter tip (70.4%), most of hematomas were thalamic in location due to long trajectory (9 of 10 thalamic locations), which were statistically significant ($p<0.05$). However, hematoma size was not significantly correlated with accuracy. Also, univariate analysis showed no statistical significance between these two factors and accuracy.

There were no postoperative complications in all patients. Postoperative urokinase irrigation was done in 16 patients. Bleeding that occurred after urokinase irrigation was not developed in any cases.

Remnant ICH was measured in final CT scan before removal of catheter. They were taken almost 3rd post operative day. The remnant ICH was detected in 22 patients. Initial ICH

Table 2. Multivariate regression analysis for Glasgow outcome scale in patients who underwent navigation-assisted aspiration and thrombolysis

Variable	Regression coefficient	Standard error	β	p
Sex	−0.074	0.277	−0.051	0.861
Age	0.006	0.010	0.132	0.510
Initial GCS score	0.243	0.100	0.636	0.026*
Initial ICH volume	−0.015	0.019	−0.197	0.451
ICH location	0.020	0.125	0.025	0.877
IVH	−0.280	0.304	−0.210	0.369
Distance from target center of ICH	−0.013	0.019	−0.115	0.505
% of ICH removed	0.023	0.035	0.505	0.525
Final ICH volume	0.021	0.108	0.156	0.852

GCS: Glasgow Coma Scale, ICH: intracerebral hemorrhage, IVH: intraventricular hemorrhage.
*: statistically significant ($p < 0.05$).

volume was reduced by an average of 83% (range 40 to 100%) and average final hematoma volume was 5.9 ml (range 0 to 18 ml). Preoperative hematoma volume had statistically significant correlation with final hematoma volume ($p<0.05$).

Mean GOS points was 3.4. No mortality was reported. In multiple regression analysis, initial GCS score was statistically significant (Table 2, $p<0.05$). However, the preoperative hematoma volume, final hematoma volume, and hematoma location were not significant.

Discussion

This report with the preliminary results showed that navigation-assisted frameless stereotactic ICH catheterization has limited accuracy but effectiveness for management choice of ICH volume reduction.

ICH catheterization and thromobolysis had been studied by several investigators.[9)10)14)15)17)] However they were failed to prove ICH aspiration and thrombolysis is superior to medical treatment, so it still remains controversial. Catheter insertion is suggested as one of several treatment modality of ICH. In recent years, several studies were processed with the frameless stereotactic navigation, because of its advantages superior to the frame based.[13)16)]

Frameless navigation operation does not need to frame fixation before anesthesia, so patient does not suffer from head fixation. Rebleeding was less frequently occurred in the frameless. Thiex et al. reported that rebleeding rate of frameless stereotaxy was 10.7%, frame based stereotaxy was 17%.[16)] Only one case underwent rebleeding event in our study, it was occurred in preoperative period. Stereotactic frame appliance is more complicated and painful than fiducial markers setting on scalp. It can increase blood pressure, and finally cause rebleeding.

Accuracy of the frameless stereotaxy had been proved also in brain biopsy.[12)] However, frame based stereotaxy is more accurate than frameless. In frameless stereotaxy, fiducial markers are patched on the scalp, so it is movable by stretching of scalp. Even though some study reported that head position during preoperative imaging did not affect on error of navigation procedure,[12)] markers on the scalp could be displaced during CT scanning or fixation of skull, and finally it serves increasing error. Dorward et al. reported that error of CT image based frameless stereotactic biopsy is 4.8 mm.[3)] In our study, mean error was 6.8 mm. This difference may be due to usage of locking instrument holder. For more accurate result, holding device should be needed during catheter advancement toward target.[5)] Malposition can be detected during operation by blood clot drainage. If fiducial markers preserved during operation, postoperative image could be used for re-operation data. It is also possible in frame based surgery. Thiex et al. reported other complication of catherization by both methods, there was no significant difference in infection rate.[16)]

Frame-based stereotaxy is time consuming.[1)] Even if we did not assess the time it takes to utilize frameless stereotaxy in the management of ICH, we assume that this technique is less time-consuming. After performing CT scan, we could transfer the patient directly to the operating room for frameless stereotactic catheter placement. The required time for frameless stereotaxy is further reduced by direct 3-dimensional visualization of possible trajectories without previous target point selection and data processing. If comparing frame-based and frameless stereotaxy for deep ICH management, the duration of each procedure should be taken into account, because at least in animal models, the degree of secondary tissue damage in the vicinity of the ICH was related to the quickness of hematoma evacuation.[16)]

There have been a small series of frameless stereotaxy in the management of ICH,[13)16)] but data of frame-based stereotaxy for hematoma puncture and subsequent thrombolysis are available.[10)15)] Increasing age, and greater severity either measured clinically (GCS, limb paresis) or by imaging (hematoma volume, intraventricular extension) are usually indicated as poor prognostic factors.[8)] Residual volume of ICH after therapy or percent change of ICH volume from baseline is also important for functional outcome.[10)] In our study, the only significant factor affecting the prognosis was the preoperative neurologic status. The present study is limited due to small number of patients and various hematoma location. Further investigations are required of larger number of patients and controlled design for validating frameless stereotactic catheter insertion and subsequent thrombolysis.

Conclusion

Navigation-assisted frameless stereotactic ICH catheterization has limited accuracy but effectiveness for management choice of ICH volume reduction. There were no postoperative complications in all patients. The only significant factor affecting the prognosis was the preoperative neurologic status.

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