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Original Article

Comparison of the clinical effects of stereotactic aspiration and craniotomies in the treatment of hypertensive intracerebral hemorrhages

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Abstract: Objective: The aim of this study was to explore the value of stereotactic aspiration by comparing surgical outcomes of stereotactic aspiration and craniotomies in the treatment of hypertensive intracerebral hemorrhages (HICH). Methods: A total of 60 HICH patients, admitted to Affiliated Zoucheng Hospital of Ji'ning Medical College, from January 2015 to January 2018, were recruited for the study. They were randomized into two groups, group A (n=30) undergoing stereotactic aspiration and group B (n=30) undergoing craniotomies. Operative times, incidence of rebleeding, and length of stays were recorded and compared between the two groups. Hematoma volumes of two groups were measured and compared at day 1, day 3, and day 5 after surgery. Impairment in neurological function was evaluated before and 2 weeks after surgery, using the National Institute of Health Stroke Scale (NIHSS). Activities of daily living (ADL) scores were rated before surgery and at month 3 after surgery. These indicators were compared for differences between preoperative and postoperative levels. Times to awakening and postoperative complications were also recorded and compared. Results: Operative times and length of stays in group A were significantly shorter than those in group B (both $P<0.05$). There were no significant differences in incidence of rebleeding between the two groups ($P=0.742$). However, hematoma volumes in group A were significantly lower than those in group B at day 1 ($P<0.05$), but were not significantly different from those in group B at day 3 and day 5 after surgery (both $P>0.05$). There were significant differences between the two groups in differences between preoperative hematoma volume and hematoma volume at day 1 after surgery ($P<0.05$). There were no significant differences between the groups in differences between preoperative hematoma volume and hematoma volume at day 3 and day 5 after surgery, respectively (both $P>0.05$). Regarding NIHSS scores and ADL scores, there were no significant differences between the two groups before surgery (both $P>0.05$). NIHSS scores in group A were significantly lower than in group B at week 2 after surgery ($P<0.05$). ADL scores in group A were significantly higher than in group B at month 3 after surgery ($P=0.040$). Differences between postoperative and preoperative levels were statistically significant ($P<0.05$). Times to awakening of group A were significantly shorter than those of group B ($P=0.011$). Group A saw significantly less postoperative complications than group B ($P<0.001$). Conclusion: Stereotactic aspiration is more effective than craniotomies in the treatment of HICH. It can significantly shorten operative times and length of stays, effectively removing hematomas. Stereotactic aspiration can also effectively promote life quality by significantly improving recovery of neurological function and independent daily living. Therefore, it is worthy of clinical promotion.

Keywords: Hypertensive intracerebral hemorrhage, stereotactic aspiration, craniotomy

Introduction

Hypertensive intracerebral hemorrhage (HICH) is a clinical disease with high morbidity and mortality [1]. Though progress has been made improving treatment around the world, mortality remains high. Moreover, most HICH patients still suffer from various disabilities after treatment [2]. According to statistics, the number of elderly patients with HICH in China was as high as 130 million in 2017. Incidence among the young is also on the rise. If there is no effective treatment for the disease, the mortality of HICH patients will also increase on an annual basis. Statistics show that 13% of HICH patients died by 2017 [3]. Therefore, exploration of effective treatments is necessary.

At present, treatment for intracerebral hemorrhages at different locations generally includes medical and surgical treatments [4, 5]. The purpose of surgery is mainly to remove the hematoma and relieve intracranial pressure, allowing the recovery of compressed (non-damaged) neurons, preventing and reducing a series of secondary pathological changes after bleeding. This breaks the life-threatening vicious cycle [6]. Common surgical treatments are listed as follows. Cerebellar decompression surgery is the most important surgical treatment for hypertensive cerebellar hemorrhages. It can save lives and reverse neurological deficits. When the patient is still conscious, the operation effects are good [7]. Craniotomies may be effective for the midline shift caused by mass effects and early-stage cerebral herniation [8]. Hematoma clearance by perforating and enlarging bone window is suitable for large hematomas. Though it can completely remove hematomas, the huge surgical lesions will result in poor prognosis [9]. Stereotactic aspiration is suitable for patients that are old and frail, with hematomas deep inside the brain or those whose general condition is poor. The operative time is short and surgical lesions are small [10]. Ventricle puncture and drainage is convenient for the drainage solution to flow out after surgery, but postoperative brain herniation often occurs [11]. The two most common surgeries are stereotactic aspiration and craniotomies. With the advancement of neurosurgery, stereotactic aspiration has been increasingly applied in clinical treatment. Modern neurosurgery is characterized by minimal invasiveness, which not only presents less trauma but also produces a good prognosis.

With wider access to CT in the AffiliatedÁroucheng Hospital of Ji'ning Medical College, minimally invasive treatment of HICH has made rapid progress. However, very few analyses have focused on the clinical efficacy of stereotactic aspiration and craniotomies in the treatment of HICH. This study evaluated the efficacy of the two surgeries in terms of diagnosis and treatment of HICH.

Materials and methods

General information

A total of 60 HICH patients, admitted to Affiliated Zoucheng Hospital of Ji'ning Medical College, from January 2015 to January 2018, were recruited for the study. They were randomized into two groups, group A (n=30) undergoing stereotactic aspiration and group B (n=30) undergoing craniotomies. This study was approved by the Ethics Committee of Affiliated Zoucheng Hospital of Ji'ning Medical College and all participants provided informed consent.

Inclusion criteria: Patients diagnosed with hypertension, according to hypertension diagnostic criteria published by American College of Physicians in 2017 [12]; Patients that first suffered from the symptoms of sudden headache and dizziness, followed by symptoms of vomiting, paralysis, disturbance of consciousness, convulsions, and urinary incontinence; Patients that suffered from stiff neck and deep and slow breathing, with a snoring voice; Patients that suffered from increased cerebrospinal fluid pressure with red blood cells and increased protein identified in cerebrospinal fluid; Patients diagnosed with intracerebral hemorrhage by CT and MRI; Patients whose cerebral angiographies showed signs of space-occupying lesions; Patients whose intracranial bleeding volume exceeded 50% of the lateral brain ventricle, complicated by obstructive hydrocephalus; Patients with no complications; Patients that had not received any surgery before this study.

Exclusion criteria: Patients that suffered from ruptured congenital aneurysms, as well as cerebrovascular malformation, brain tumors, or blood diseases, such as aplastic anemia, leukemia, thrombocytopenic purpura, and hemophilia; Patients that suffered from physical trauma and intoxication; Patients at the late stage of brain herniation that suffered from bilateral mydriasis, decorticate rigidity, pathological respiration, and secondary brain stem injury; Patients that could not undergo surgery due to severe diseases in the lungs, kidneys, and spleen; Patients refusing to undergo surgery due to personal or family reasons.

Surgical procedures

The heads of the patients were shaved and skin over the surgical site was cleansed before they entered the operating theatre. Vital signs were monitored routinely after entering the operating theatre. After general anesthesia and disinfection, the location of incision was positioned according to CT scans.

Craniotomy [13]: A horseshoe-shaped incision (about 15-50 mm in length) was made and the surgical approach was selected in the patient's

Table 1. Comparison of baseline characteristics between the two groups

	Group A (n=30)	Group B (n=30)	t/χ^2	P
Gender (male/female)	22/8	20/10	0.079	0.779
Age Range (Y)	53.1±5.6	54.8±4.7	1.274	0.208
Site of bleeding			1.912	0.861
Putamen and basal ganglia	8	6		
Pons	2	1		
Cerebellum	1	3		
Subcortex	5	4		
Subcortex	10	12		
Cerebral ventricle	4	4		
Invasive blood pressure (mmHg)	184.36±23.67	190.27±20.37	1.084	0.283
Blood pressure classification upon admission			1.123	0.797
Mild	0	1		
Moderate	16	14		
Severe	14	15		
Risk level of hypertension upon admission			1.215	0.862
Low	1	3		
Medium	10	9		
High	15	15		
Highest	4	3		
GCS score	11.56±1.46	11.79±1.36	0.631	0.530

Note: GCS, Glasgow Coma Scale.

Table 2. Comparison of operative times and length of stays between the two groups

	Group A (n=30)	Group B (n=30)	t	P
Length of operation (min)	95.35±5.24	98.38±4.38	2.400	0.019
Length of stay (d)	3.08±1.12	4.04±1.23	3.161	0.003

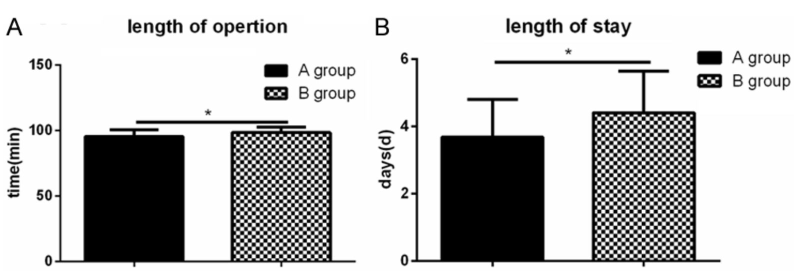

Figure 1. Comparison of operative times and length of stays between the two groups. *P<0.05.

relatively non-functional area. The scalp incision was 4 cm in diameter. Any skin or tissue above the area of the skull that would be taken out had been cut and moved out of the way before the incision was expanded with a retractor. A drill was used to make a hole in the skull. After the bone flap craniotomy, the dura mater was cut with a cross-shaped incision before the cerebral gyri were separated through the cerebral sulci to gain direct access to the hematoma. Next, the bone window was expanded to 3 cm in diameter. Drainage of the hematoma cavity was then conducted under direct vision. Bipolar coagulation was used for hemostasis if there was any active bleeding in small blood vessels. Hemostatic gauze or gelatin sponges were used for hemostasis if errhysis occurred. After surgery, a drainage tube was put under the skin to remove blood and fluid from the site of the surgery. A CT scan was then conducted.

Stereotactic aspiration: According to CT scans, the center of the hematoma was marked as the puncture point. The appropriate size of YL-1 type disposable intracranial hematoma crush-

Table 3. Comparison of incidence of rebleeding and postoperative hematoma volume between the two groups

	Group A (n=30)	Group B (n=30)	t/χ²	P
Incidence of rebleeding	5 (16.67%)	6 (20.00%)	0.113	0.742
Volume of hematoma				
Before surgery	44.28±1.43	43.57±3.29	1.084	0.283
Day 1 after surgery	30.26±2.37$^{\#\#\#}$	31.67±2.58$^{\Delta}$	2.204	0.032
Day 3 after surgery	21.46±2.38	21.37±3.02	2.720	0.898
Day 5 after surgery	14.07±4.58	13.64±4.48	2.197	0.715
Difference in hematoma volume before and after surgery				
Day 1 after surgery	14.02±1.38	11.92±1.63	5.386	<0.001
Day 3 after surgery	22.82±1.48	22.20±1.27	35.444	0.087
Day 5 after surgery	29.41±3.49	29.38±2.57	3.829	0.970

Note: Comparisons within group A are all based on preoperative levels: $^{\#\#\#}$P<0.001. Comparisons within group B are all based on preoperative levels: $^{\Delta}$P<0.05.

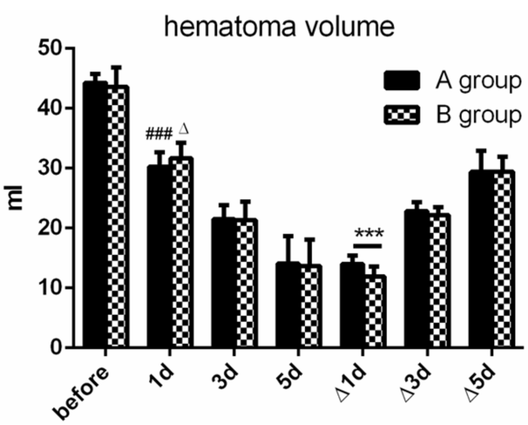

Figure 2. Comparison of postoperative hematoma volumes between the two groups. Before: before surgery; 1d: day 1 after surgery; 3d: day 3 after surgery; 5d: day 5 after surgery; $^{\Delta}$1d: difference in hematoma volume before surgery and at day 1 after surgery; $^{\Delta}$3d: difference in hematoma volume before surgery and at day 3 after surgery; $^{\Delta}$5d: difference in hematoma volume before surgery and at day 5 after surgery. For comparisons between two groups, ***P<0.001. Comparisons within group A are all based on preoperative levels $^{\#\#\#}$P<0.001. Comparisons within group B are all based on preoperative levels $^{\Delta}$P<0.05.

ing needles was selected and connected to the electric trepanning drill to directly drill the skull. The core needle was pulled out and replaced by a blunt plastic needle to push again into the middle of the hematoma. Next, the core needle was pulled out again and the drainage tube was connected. A 5 mL syringe was applied to slowly extract hematoma liquid. If there was any obvious resistance, the suction should be stopped immediately and the needle hematoma pulverizer should be put in place and repeatedly washed with hematoma irrigation solution. If the irrigation solution flowing out was light in color, then the drainage tube was put in place and a CT scan was conducted [14].

Efficacy assessment

Glasgow coma scale: Glasgow coma scale (GCS) scores were used to assess level of consciousness, involving measurements of eye response, verbal response, and motor response. The sum of these individual elements was the coma score. A higher score indicates a higher level of consciousness. GCS higher than 14 was defined as normal, while GCS below 7 was defined as coma. More severe comas produced lower scores. GCS 3 generally indicates brain death or poor prognosis [15].

National institutes of health stroke scale: The National Institutes of Health Stroke Scale (NIHSS) is a standardized neurology test. It is used to quantify neurological impairment of stroke patients that engage in clinical trials. The scale is composed of 15 items which describe neurological function. The NIHSS is a composite scale derived from the Toronto Stroke Scale, Oxbury Initial Severity Scale, and Cincinnati Stroke Scale. It involves all items in relation to cerebral arteriopathy, with 2 more items from Edinburgh-2 Coma Scale added into the NIHSS to examine patient mental states. These items include levels of consciousness, horizontal eye movement, visual field tests, facial palsy, motor arm, motor leg, limb ataxia, sensory, language,

Table 4. Comparison of impairment in neurological function between the two groups

	Group A (n=30)	Group B (n=30)	t/χ²	P
Before surgery	17.36±2.38	18.38±2.55	1.602	0.115
Week 2 after surgery	5.07±1.45###	6.93±1.73ΔΔΔ	4.642	<0.001
Difference in NIHSS score before and after surgery	12.29±1.58	11.45±1.08	0.349	0.019

Note: NIHSS, National Institute of Health Stroke Scale. Comparisons within group A are all based on preoperative levels: ###P<0.001. Comparisons within group B are all based on preoperative levels: ΔΔΔP<0.001.

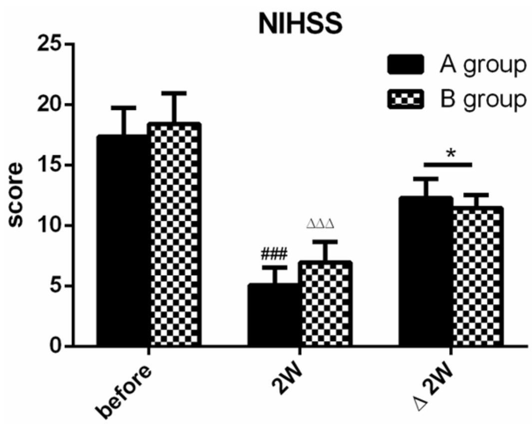

Figure 3. Comparison of NIHSS scores between the two groups. NIHSS: National Institutes of Health Stroke Scale; before: before surgery; 2W: week 2 after surgery; Δ2W: Difference in NIHSS scores before surgery and at week 2 after surgery. For comparisons within the group, *P<0.05. Comparisons within group A are all based on preoperative levels, ###P<0.001. Comparisons within group B are all based on preoperative levels, ΔΔΔP<0.001.

speech, extinction and inattention, and other items. These items were quantified by scores. Results were recorded. A higher score indicates more severe impairment in neurological function [16].

Activities of daily living: Activities of daily living (ADL) scores are used to measure a person's ability to perform basic tasks in daily life. The Barthel ADL index is used in the assessment, which involves 10 variables describing ADL and mobility. According to the need for help and the degree of help, there are four functional levels: 0, 5, 10, and 15, with a total score of 100. A higher score is indicative of stronger independence. For every item in the scale, patients should score 0 points if they fail to meet the standard. A result of above 60 indicates basic independence in daily living. A result of 40-60 indicates dependency in daily living and a result of 20-40 indicates great dependency in daily living. A result of below 20 indicates complete dependency in daily living. Patients that scored above 40 in the scale could see the best effects in rehabilitation treatment [17].

Statistical analysis

Measurement data are expressed as mean ± standard deviation ($\overline{x}$±sd) and were statistically processed using SPSS 17.0 software package. Comparisons between the two groups, before and after treatment, were based on paired t-tests. Comparisons within the group were based on independent-sample t-tests. Enumeration data are expressed as cases/percentage (n/%) and were compared with Chi-squared test or Fisher's exact test. GraphPad Prism 5.0 was used for analysis and graphing. P<0.05 indicates statistical significance.

Results

General information

There were no significant differences between two groups in gender, age range, site of bleeding, invasive blood pressure after entry, volume of hematomas, and GCS scores (all P>0.05). See **Table 1**.

Operative times and length of stays

Operative times and length of stays of group A were significantly shorter than those of group B (both P<0.05). See **Table 2** and **Figure 1**.

Incidence of rebleeding and postoperative hematoma volume

There were no significant differences in incidence of rebleeding between the two groups (P=0.742). However, the hematoma volume in group A was significantly lower than that in group B at day 1 (P<0.05), but not significantly different from that in group B at day 3 and day 5 after surgery (both P>0.05). There were significant differences between the two groups in

Table 5. Comparison of ADL scores between the two groups

	Group A (n=30)	Group B (n=30)	t	P
Before surgery	30.28±3.78	30.45±2.56	0.203	0.839
Month 3 after surgery	89.32±7.82#	85.37±6.72Δ	2.098	0.040
Difference in NIHSS score before and at week 2 after surgery	59.04±4.56	54.82±4.56	3.584	<0.001

Note: ADL, activities of daily living; NIHSS, National Institute of Health Stroke Scale. Comparisons within group A are all based on preoperative levels: #P<0.05. Comparisons within group B are all based on preoperative levels: ΔP<0.05.

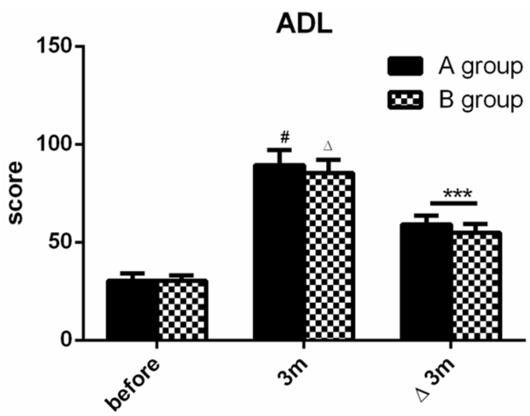

Figure 4. Comparison of ADL scores between the two groups. ADL: Activities of daily living; Before: before surgery; 3m: month 3 after surgery; Δ3M: Difference in ADL score before and at month 3 after surgery. For comparisons within the group, ***P<0.001. Comparisons within group A are all based on preoperative levels, #P<0.05. Comparisons within group B are all based on preoperative levels, ΔP<0.05.

differences between preoperative hematoma volume and hematoma volume at day 1 after surgery (P<0.05). There were no significant differences between the two groups in differences between preoperative hematoma volume and hematoma volume at day 3 and day 5 after surgery, respectively (both P>0.05). See **Table 3** and **Figure 2**.

Comparison of impairment in neurological function between the two groups

There were no significant differences in NIHSS scores between the two groups before surgery (P>0.05). NIHSS scores in group A were significantly lower than those in group B at week 2 after surgery (P<0.01). There were significant differences between the two groups in differences of NIHSS scores before and after surgery (P<0.05). See **Table 4** and **Figure 3**.

Comparison of ADL scores between the two groups

There were no significant differences in ADL scores between the two groups before surgery (P>0.05). ADL scores in group A were significantly higher than those in group B at 3 months after surgery (P=0.040). There were significant differences between the two groups in differences of ADL scores before and after surgery (P<0.01). See **Table 5** and **Figure 4**.

Comparison of times to awakening between two groups

Times to awakening in group A were significantly shorter than those in group B (P=0.011). See **Table 6**.

Postoperative complications

Group A saw significantly less postoperative complications than group B (P<0.001). See **Table 7**.

Discussion

HICH is one of the most common cerebrovascular diseases, accounting for about 20% to 30% cases of acute intracerebral hemorrhages in China. A previous study found that the pathogenesis of hypertensive intracerebral hemorrhages was that chronic hypertension would induce structural changes in the wall of cerebral perforating arteries, causing microaneurysms. A rupture of microaneurysms or small resistance arteries with hyaline degeneration is the reason for intracerebral hemorrhages. Hemorrhages cause the compression of ganglia, which may be life threatening [18]. It is crucial for the survival of HICH patients to get prompt diagnosis and treatment. There are currently no specific and effective treatments for this disease, but it is generally recognized that surgery should be conducted as soon as possible. Surgical treatment can eliminate mass effects caused by hematomas and toxins as soon as possible. With the development of minimally invasive techniques in neurosurgery, stereotactic aspiration uses CT to locate the center of the hematoma. Thus, the positioning is more accurate. With a set of tools, including the intracranial hematoma puncture needle and electric

Table 6. Comparison of times to awakening between the two groups

	Group A (n=30)	Group B (n=30)	t	P
Time to awakening (min)	36.28±5.78	40.45±6.56	2.612	0.011

Table 7. Comparison of postoperative complications between the two groups

Postoperative complications	Group A (n=30)	Group B (n=30)	X^2	P
Postoperative rebleeding	2	3	12.381	<0.001
Pulmonary infection	0	3		
Intracranial infection	0	2		
Hemiplegia	1	3		
Aphasia	0	2		
Mental disorder	1	4		
Total	4	17		

trepanning drill, the diameter of the drilled hole on the skull and dura mater is less than 1 cm [19]. With several steps including puncture with fine needle, hematoma extraction, the application of hematoma liquefaction agent, and continued drainage, the hematoma is removed, with reduced intracranial pressure and the disease treated.

This study found that hematoma volumes were less after stereotactic aspiration. A possible reason is that intracranial hematomas are reached by using a puncture needle with less than 1 cm in diameter connected to disposable brain puncture cannula, with the help of CT scan. In this surgery, the bone flap craniotomy is not needed. The residual hematoma is drained out of the brain by vacuum suction. By the end of stereotactic aspiration, urokinase is used to dissolve blood clots to make a more thorough removal of the residual hematoma. The intracranial hematoma is removed using a multi-orbital, multi-target approach. This surgery is accurate in hematoma positioning, allowing the surgeon to hit the target and, at the same time, avoid the important function areas in brain [20]. The scalp incision in the craniotomy is 4 cm in diameter, indicating that its wound area is 3-4 times larger than that of stereotactic aspiration [21]. Therefore, residual hematomas are less after stereotactic aspiration.

The current study found that patients undergoing stereotactic aspiration had lower NIHSS scores than patients undergoing craniotomies. Stereotactic aspiration could improve ADL scores. Though treatment effects of craniotomies are better, this procedure is prone to injuring nerves during surgery. Complications often occur after surgery, including neurological dysfunction, such as hemiplegia aphasia, mental disorders, and dysgnosia, disturbing patient lives and work [22]. Stereotactic aspiration minimizes damage to brain tissue using special silicone hoses for puncturing, thereby lessening impairment of neurological function. Results of this study indicate that incidence of postoperative complications was lower in patients that underwent stereotactic aspiration than in patients that underwent craniotomies. This is attributed to less trauma caused by stereotactic aspiration. Therefore, patients undergoing stereotactic aspiration not only have less trauma, but also shorter operative times, times to awakening, and length of stays. Moreover, they also have lower incidence of postoperative complications.

The current study had certain limitations, however. There were insufficient clinical samples in this study, with only 60 patients recruited. More clinical samples are needed to verify present conclusions. More studies are warranted, exploring the detailed mechanisms of stereotactic aspiration in the treatment of HICH.

Stereotactic aspiration is more effective than craniotomies in the treatment of HICH. It can significantly shorten operative times and length of stays, effectively removing hematomas. It can also effectively promote patient life quality by significantly improving the recovery of neurological function and independent daily life. Therefore, it is worthy of clinical promotion.

Disclosure of conflict of interest

None.

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