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Original Article

Effects and influence of ultra-early small bone window minimally invasive evacuation of intracranial hematoma and craniotomy on patients

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Abstract: Objective: We aimed to explore the therapeutic effects of ultra-early small bone window minimally invasive evacuation of intracranial hematoma and craniotomy on patients with cerebral hemorrhage and the influence on their puncture bleeding rate and prognosis. Methods: 90 patients with cerebral hemorrhage were randomly divided into two groups; group A included 45 patients treated with ultra-early small bone window craniotomy, group B included 45 patients who were treated with ultra-early minimally invasive evacuation of intracranial hematoma to compare the perioperative indicators, intracranial hematoma volume, neurological function, and occurrence rate of postoperative complications. Cox Regression was used to analyze the independent prognostic factors in patients with cerebral hemorrhage. Results: The operative time, length of hospital stay, intraoperative bleeding volume, and puncture bleeding rate in group A were higher than those in group B. The intracranial hematoma volume reduced obviously after the operation in both groups; however, group A was much larger than that in group B. The NIHSS scores reduced considerably after the operation in both groups; however, group A were much higher than those of group B. The total rate of all complications in group A was much higher than that in group B. The postoperative 3-year survival rate in group A was much lower than that in group B. Conclusions: More patients should undergo the minimally invasive operation owing to its characteristics of minimal trauma, little bleeding, and favorable prognosis.

Keywords: Ultra-early small bone window, mini-invasive evacuation of intracranial hematoma, craniotomy, cerebral hemorrhage, therapeutic effect

Introduction

As a common emergency and severe disease of the nervous system in the neurology department, cerebral hemorrhage is a spontaneous hemorrhage caused by the infusion of massive amounts of blood into the brain parenchyma after the sudden rupture of the blood vessel in the brain. Therefore, this disease is characterized by rapid disease progression and sudden onset [1, 2]. Most patients with cerebral hemorrhage experience this disease because of a rupture in the parts of the brain wall in cerebral arteriosclerosis caused by hypertension. After the hyaline degeneration of the arterial wall, the increasing degree of brittleness can also lead to rupture. Moreover, the disease may be aggravated due to emotional instability, impatience, and irritability; therefore, disease progression is rapid and difficult to control [3]. Patients with cerebral hemorrhage often have neurological dysfunction and cognitive dysfunction at the time of onset, and the intracranial hematoma will press the nerve and damage the brain tissues after onset; this can further cause loss of body functions, such as language and limbs [4]. The persistent cephalophyma and encephaledema affect the intracranial water-electrolyte balance and block the circulation; therefore, delayed treatment may cause irreversible brain injury and thus aggravate the disease [5]. The treatment methods of cerebral hemorrhage mainly include operative treatment, medical treatment, and clinical rehabilitation. Therefore, medical treatment can effectively slow disease progression with respect to blood pressure, intracranial pressure, and hemostasis, while the operative treatment can achieve better therapeutic effect in hematoma evacuation, rapid recovery of neurological function, and alleviation of pressure on the nerve [6, 7]. The operative treatment in the early stage can cure the disease lesions directly; however, different operative methods and techniques are used for cerebral hemorrhage and they have their corresponding advantages and disadvantages; therefore, it is crucial to discuss the best operative method for cerebral hemorrhage.

Without the liquefaction of intracranial hematoma, the hematoma cannot be removed easily in the early stage; therefore, it is necessary to inject urokinase or other drugs to liquefy the hematoma and remove it completely. The early small bone window craniotomy expands the range of exposure with the use of a microscope and maximally removes the intracranial hematoma, thus providing a favorable operative treatment space [8, 9]. As one of the common operations for cerebral hemorrhage, the small bone window mini-invasive evacuation of intracranial hematoma has advantages, such as small operative incision, full reduction of intracranial pressure, complete hemostasis, simple operative procedures, and short operative time. Furthermore, the application of microscopic technique prevents considerable damage to important cerebral functions that is conducive to the recovery of body functions and reduces the occurrence rate of postoperative brain injury [10, 11].

Therefore, in this study, the small bone window minimally invasive evacuation of hematoma and craniotomy were used to treat patients with ultra-early cerebral hemorrhage. The corresponding therapeutic effects, puncture bleeding rates, and prognoses were observed to provide reference for clinical treatment and distinguish among the different operative effects on cerebral hemorrhage.

Materials and methods

General data

A total of 90 patients with cerebral hemorrhage were selected and randomly divided into the following two groups: group A included 45 patients with ultra-early small bone window craniotomy and group B included 45 patients treated with ultra-early minimally invasive evacuation of intracranial hematoma. Further, the study population included 54 men and 36 women, with an average age of 63.05 ± 7.73 y, including 28 cases of basal ganglia hemorrhage, 37 cases of lobar hemorrhage, and 25 cases of thalamic hemorrhage.

Inclusion and exclusion criteria

As per the inclusion criteria, (1) patients diagnosed with cerebral hemorrhage through craniocerebral CT examination within the disease time of 6 h and (2) those with their disease states in conformity with the diagnostic criteria stipulated by the Academic Association for Cerebrovascular Diseases were included [12].

As per the exclusion criteria, (1) patients who developed cerebral hemorrhage because of trauma, (2) those with cerebral hemorrhage with congenital vascular malformation, (3) patients with a medical history of cerebral stroke and myocardial infarction, (4) patients with abnormal blood function, (5) patients with cognitive disorders or communication disorders, and (6) patients with poor compliance were excluded. All the patients and their family members agreed to participate in this study and signed the informed consent form. This experiment was approved by the ethics committee of West China Hospital, Sichuan University.

Experiment reagents and materials

The neuroendoscopy equipment were purchased from B. Braun Melsungen AG; the puncture needle was purchased from Shenzhen Baimusi Precision Technology Co., Ltd.; the craniocerebral CT machine was purchased from Shanghai SONI Electrical Technology Co., Ltd.; the bipolar electrocoagulation was purchased from Jining Hongsheng Medical Devices Co., Ltd.; the drainage tube was purchased from Shenzhen MEDIC Precise Plasthetics Co., Ltd.; and the urokinase was purchased from Beijing Solarbio Science & Technology Co., Ltd.

Operative methods

Craniotomy: The patients in group A were treated with craniotomy. The full-view operation was performed through neuroendoscopy. After the administration of the general anesthesia, an arc-shaped incision was made on the skull with a projection line of the lateral cracked skull-squamous suture in the anterior portion of temporal bone as the center. The maximum diameter of the bone window was 3 cm, and the cortex incision was ≤ 2 cm. The U-shaped incision was made on the cranial dura mater. After the lateral fissure of the posterior limbs, the encephalopuncture was performed to detect the hematoma to avoid damage to the important blood vessels. After the evacuation of the hematoma in the full-view condition, the hemostasis was performed. Then, the drainage tube was inserted, the cranial dura mater was sutured, and the bone flap was repositioned.

Minimally invasive evacuation of intracranial hematoma: The patients in group B were treated with minimally invasive evacuation of hematoma. Craniocerebral CT imaging was used to determine the part with the largest volume of hematoma; we then marked the incision and administered anesthesia. Without any damage to the important blood vessels, the "S-shaped" incision or longitudinal incision was made to the trans-lateral fissure and hematoma in the main area of the hematoma. The bone window of 2-3 cm was made by drilling the skull. Then, the dura mater behind the bone window was opened, and the aspirating needle was inserted into the operative cavity. After the blood clots in the hematoma were removed and the drainage was unobstructed, the drainage tube for the hematoma cavity was used for continuous aspiration. After the drainage liquid changed from dull red to clear, the aspiration was stopped, and the hematoma evacuation was suspended. Bipolar electrocoagulation was used for thorough hemostasis. Then, the incision was sutured, the drainage was opened, and the drainage tube was indwelt in the body. If the blood clots were hard, the urokinase (10,000 U/2 mL) was used to dissolve them. Postoperatively, a cerebral CT examination was performed to observe the recovery statuses of the patients in the two groups. Postoperative adjuvant therapies were administered to maintain the water-electrolyte balance as well as to prevent inflammation and infections.

Postoperative follow-up: The postoperative follow-up lasted for 3 years via telephonic contact and clinical re-examination to assess the survival statuses of the patients. In the first year, the patients were followed up every 3 months; thereafter, they were followed up every 6 months.

Observation targets: (1) Perioperative indicators: The average operative time, length of hospital stay, intraoperative bleeding volume, and puncture bleeding rate were observed and recorded in the two groups. (2) Intracranial hematoma volume: Craniocerebral CT examination was performed to detect, record, and observe the intracranial hematoma volume before and after the operation. (3) Neurological function: The National Institutes of Health Stroke Scale (NIHSS) was used to evaluate the neurological impairment before and after the operation. The severity of neurological impairment was proportional to the NIHSS scores [13]. (4) The occurrence rate of postoperative complications was observed and recorded in the two groups. (5) The survival statuses of the patients in the two groups were recorded 3 years after treatment. Next, the patients were divided into the death group and the survival group according to the survival statuses of the patients at 3 years. Cox Regression was used to analyze the mortality risk factors of the patients.

Statistical methods

In this experiment, the SPSS 19.0 statistical software (Bejing NDTimes Technology Co., Ltd.) was used for the statistical analyses of the experimental data; the chi-square test was used for enumeration data; the measurement data was represented in terms of mean ± standard deviation values; the t test was used for making comparisons between the groups; the paired-samples *t* test was used for making comparisons between the groups before and after the treatment; the Kaplan-Meier analysis was used to analyze the survival curves; Multiple-factor Cox Regression was used to analyze the independent prognostic factors that affected patients with cerebral hemorrhage; and the Graphpad Prism8 was used for the picture plots. A *P* value < 0.05 indicated statistical significance.

Results

Comparison of the general data of the subjects in the two groups

There was no significant difference in the basic characteristics, such as sex, age, smoking, drinking, cerebral infarction, and hypertension, of the two groups (P > 0.05), as shown in **Table 1**.

Table 1. Comparison of the general data of the subjects in the two groups

Group	Group A (n=45)	Group B (n=45)	X^2/t	*P* value
Sex (case)			0.045	0.833
Male	24 (53.33)	23 (51.11)		
Female	21 (46.67)	22 (48.89)		
Age (years)	62.67 ± 7.74	63.23 ± 7.69	0.344	0.731
Smoking history (case)			0.185	0.667
Yes	19 (42.22)	17 (37.78)		
No	26 (57.78)	28 (62.22)		
Drinking history (case)			0.180	0.671
Yes	24 (53.33)	26 (57.78)		
No	21 (46.67)	19 (42.22)		
Cerebral infarction (case)			0.090	0.764
Yes	7 (15.56)	6 (13.33)		
No	38 (84.44)	39 (86.67)		
Hypertension (case)			0.476	0.490
Yes	12 (26.67)	15 (33.33)		
No	33 (73.33)	30 (66.67)		
Diabetes (case)			0.073	0.788
Yes	8 (17.78)	9 (20.00)		
No	37 (82.22)	36 (80.00)		
Disease type (case)			0.210	0.900
Basal ganglia hemorrhage	13 (28.89)	15 (33.33)		
Lobar hemorrhage	19 (42.22)	18 (40.00)		
Thalamic hemorrhage	13 (28.89)	12 (26.67)		
Bleeding volume (mL)	69.93 ± 5.42	70.09 ± 5.43	0.140	0.889
Disease time to admission time (h)	4.53 ± 0.93	4.72 ± 0.92	0.974	0.333

Comparison of the perioperative indicators of the two groups

The operative time (P < 0.001), length of hospital stay (P < 0.001), intraoperative bleeding volume (P < 0.001), and puncture bleeding rate (P=0.026) in group A were much higher than those in group B, indicating a statistically significant difference (P < 0.05), as shown in **Table 2**.

Comparison of the intracranial hematoma volume before and after the operation in the two groups

There was no statistically significant difference in the intracranial hematoma volume before the operation in the two groups (P=0.818). After the operation, the intracranial hematoma volume reduced obviously in the two groups, showing a statistically significant difference (P=0.003). The intracranial hematoma volume of group A was larger than that of group B (P < 0.001). The details are shown in **Table 3**.

Comparison of the NIHSS scores before and after the operation in the two groups

There was no significant difference in the preoperative NIHSS scores of the subjects in both the groups (P=0.962). After the operation, there was a significant reduction in the NIHSS scores of both the groups (P < 0.001). The NIHSS scores of group A were higher than those of group B (P < 0.001). The details are shown in **Table 4**.

Comparison on the postoperative complications rate of the two groups

The total complication rate in group A was higher than that in group B (P=0.048), as shown in **Table 5**.

Table 2. Comparison of the perioperative indicators in the two groups

Group	Group A (n=45)	Group B (n=45)	X^2/t	*P* value
Operative time (h)	3.46 ± 0.27	1.02 ± 0.11	56.140	< 0.001
Length of stay (d)	28.13 ± 1.91	14.81 ± 1.23	39.330	< 0.001
Intraoperative bleeding volume (mL)	204.43 ± 6.24	6.34 ± 0.27	212.800	< 0.001
Puncture bleeding rate (%)	7 (15.56)	1 (2.22)	4.939	0.026

Table 3. Comparison of the intracranial hematoma volume before and after the operation in both the groups

Group		Group A (n=45)	Group B (n=45)	t	*P* value
Intracranial hematoma volume (mm^3)	Before the operation	27.42 ± 9.83	26.94 ± 9.89	0.231	0.818
	After the operation	17.92 ± 9.18	12.16 ± 8.78	3.042	0.003
t		4.738	7.497		
P value		< 0.001	< 0.001		

Table 4. Comparison of NIHSS scores before and after operation in two groups

Group		Group A (n=45)	Group B (n=45)	t	*P* value
NIHSS* scores	Before the operation	29.42 ± 9.87	29.52 ± 9.86	0.048	0.962
	After the operation	20.42 ± 8.72	10.57 ± 8.17	5.530	< 0.001
t		4.584	9.927		
P value		< 0.001	< 0.001		

*: National Institutes of Health Stroke Scale.

Table 5. Comparison of the occurrence rate of postoperative complications in the two groups

Group	Group A (n=45)	Group B (n=45)	X^2	*P* value
Infection	3 (6.67)	1 (2.22)	-	-
Rehemorrhagia	4 (8.89)	2 (4.44)	-	-
Gastrointestinal stress ulcer	4 (8.89)	1 (2.22)	-	-
Total occurrence rate of complications	11 (24.44)	4 (8.89)	3.920	0.048

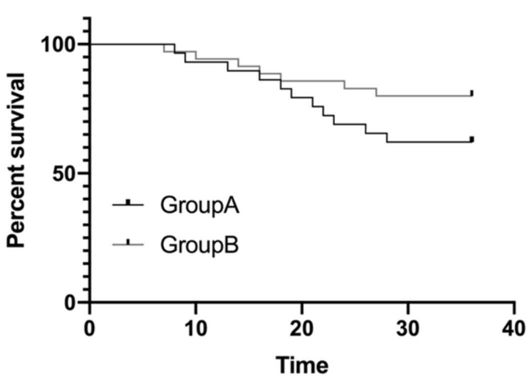

Figure 1. Comparison of the 3-year survival rate in the two groups. The postoperative 3-year survival rate was 44.44% in group A and 80.00% in group B. The postoperative 3-year survival rate in group A was much lower than that in group B (P < 0.05).

Comparison of the 3-year survival rate in the two groups

The postoperative 3-year survival rate was 44.44% (20/45) in group A and 80.00% (36/45) in group B. The postoperative 3-year survival rate of group A was lower than that of group B (P < 0.05), as shown in **Figure 1**.

Single-factor analyses

During the follow-up period, the patients were divided into the survival group (n=56) and the death group (n=34) according to the survival statuses of the patients at 3 years. The clinical data of the survival group and death group were collected for single-factor analysis. As shown in the single-factor analysis, the progno-

Table 6. Single-factor analyses (n [%])

Clinicopathologic features	Survival group (n=56)	Death group (n=34)	X^2	*P* value
Age (years)			0.011	0.915
< 63	29 (51.79)	18 (52.94)		
≥ 63	27 (48.21)	16 (47.06)		
Sex (case)			0.032	0.859
Male	34 (60.71)	20 (58.82)		
Female	22 (39.29)	14 (41.18)		
Preoperative bleeding volume (mL)			21.951	< 0.001
≤ 70	13 (23.21)	25 (73.53)		

Table 7. Table for value assignment

Factor	Value assignment
Bleeding volume	≥ 70 = 1, < 70 = 0
Operation type	Mini-invasive evacuation of intracranial hematoma = 1, craniotomy = 0
Breaking into ventricles	Yes = 1, No = 0
Complicated cerebral infarction	Yes = 1, No = 0
Complicated hypertension	Yes = 1, No = 0
Puncture bleeding	Yes = 1, No = 0
Postoperative complications	Infection = 2, rehaemorrhagia = 1, gastrointestinal stress ulcer = 0
Death situation	Death = 1, survival = 0

Table 8. Multiple-factor analysis

Factor	B	S.E	Wals	*P* value	Exp (B)	95% C.I. of EXP (B)	
						Lower limit	Upper limit
Bleeding volume	1.355	0.764	3.154	0.034	3.563	4.178	15.942
Operation type	0.457	0.336	6.756	0.006	1.535	2.266	9.866
Breaking into ventricles	0.861	0.284	8.021	0.004	2.335	2.899	10.598
Complicated cerebral infarction	1.357	0.783	5.574	0.008	3.326	2.274	7.668
Complicated hypertension	1.613	0.782	2.435	0.015	1.384	1.568	2.453
Puncture bleeding	1.452	0.824	2.145	0.014	2.435	1.824	5.347
Postoperative complications	0.962	0.433	4.502	0.024	2.642	2.227	9.733

Note: B: constant term; SE: standard deviation; Wals: chi-square value; sig: *P* value; Exp (B): odds ratio; 95% C.I. of EXP (B): 95% confidence interval of odds ratio.

sis of patients was affected by the bleeding volume, operation type, breaking into ventricles, complicated cerebral infarction, complicated hypertension, puncture bleeding, and postoperative complications (P < 0.001). However, no significant difference was noted regarding sex (P=0.915) and diabetes-related complications (P=0.859), as shown in **Table 6**.

Multiple-factor logistic regression analyses

Multiple-factor logistic regression analyses was used to analyze the factors that influenced prognosis; we found that the survival prognosis of patients with cerebral hemorrhage was affected by the bleeding volume (P=0.034), operation type (P=0.006), breaking into ventricles (P=0.004), complicated cerebral infarction (P=0.008), complicated hypertension (P=0.015), puncture bleeding (P=0.014), and postoperative complications (P=0.024), as shown in **Tables 7** and **8**.

Discussion

Generally, the pathogenic process in cerebral hemorrhage is dynamic. Clinically, this process is divided into the following three stages: hematoma formation, hematoma expansion, and perihematomal edema. The last two stages are closely associated with patients' prognosis [14]. The hematoma size and content have certain impact on the neurological function. When the hematoma volume content exceeds 30 mL, the survival rate of patients with cerebral hemorrhage reduces considerably. The edema in the tissues surrounding the hematoma may cause secondary brain injury and lead to irreversible tumidness and necrosis of brain tissues [15]. Several researches have focused on the operative time of cerebral hemorrhage, and there is some evidence that the rehemorrhagia rate and death rate were more likely to increase after the operative treatment in the ultra-early stage, and the most effective operative time was 6-12 h after cerebral hemorrhage [16]. Some other studies have showed that the long-term existence of intracranial hematoma could not relieve intracranial hypertension because the cranial nerve cells under the pressure environment were likely to cause brain injury and brain cell apoptosis. However, ultra-early operation can not only remove the hematoma before irreversible injury to avoid the formation of vicious circle, but also enhance the overall therapeutic effect on patients and improve the living standard of patients with cerebral hemorrhage after the operation [17]. In addition, after the patients with cerebral hemorrhage are treated with small bone window evacuation of hematoma in the ultra-early stage, they can undergo a second operation if rehemorrhagia occurs after the first operation. Therefore, the evacuation of intracranial hematoma and craniotomy were conducted and how thesetwo approaches affected therapeutic effect and prognosis of patients in ultra-early stage were documented and discussed.

We observed the intracranial hematoma volume of the two groups before and after the operation and found that the intracranial hematoma volume of the two groups reduced after the operation. Further, the intracranial hematoma volume of group A was much larger than that of group B, implying that the small bone window minimally invasive evacuation of hematoma could remove the hematoma of the cerebral hemorrhage and accomplish the operative aim of complete removal of the hematoma more effectively in comparison with craniotomy. Some research studies have shown [18] that the expansion degree of the hematoma volume could be regarded as a simple predictive indicator for the clinical prognosis of intracranial hemorrhage. An increase in the hematoma volume affects the intracranial blood flow, damages the balance and steady state of the intracranial tissues, and directly influences the prognosis of patients with cerebral hemorrhage. Considering these previous reports in light of our findings, we found that the small bone window minimally invasive evacuation of hematoma not only removed the hematoma more effectively, but also removed the factors that hindered the clinical prognosis of patients with cerebral hemorrhage. We studied and observed the changes in the neurological function of the two groups before and after the operation and found that the NIHSS scores of the two groups reduced obviously after the operation, and the NIHSS scores in group A were much higher than those in group B. Some studies have shown [16, 19] that the craniotomy that was used to remove the hematoma had the advantages of clear view and easy hemostasis; however, it also involved the disadvantages of larger trauma and longer operative time. Moreover, the electric coagulation hemostasis and the suture by pulling the peripheral brain tissues could easily lead to neurological impairment and seriously damage the peripheral nerve tissues. Some other research studies have shown [20, 21] that the minimally invasive evacuation of hematoma reduced the intracranial pressure as well as relieved the intracranial edema and cytotoxicity caused by the damage to the cytokines and free radicals, thus reducing the severity of neurological impairment at the time of removing the hematoma. The above-mentioned studies indicate that these two operative methods could recover the neurological function of patients with cerebral hemorrhage, consistent with our results. Our study further verified that the minimally invasive evacuation of hematoma had a superior therapeutic effect on the recovery of neurological function. With respect to the operative indicators, the results showed that the operative time, length of hospital stay, intraoperative bleeding volume, and puncture bleeding rate in group A were much higher than those in group B. These operative indicators indicated that the minimally invasive evacuation of intracranial hematoma was simpler than craniotomy, with lower occurrence rates of puncture bleeding and intraoperative bleeding and higher achievement ratio of operation. Further research of the postoperative complications in the two groups showed that the total occurrence rate of complications in group A was much higher than that in group B. Previous researches have showed [22, 23] that the cerebral hemorrhage operation easily caused infection, rehemorrhagia, and other adverse reactions. The postoperative secondary cerebral hemorrhage primarily resulted from poor blood pressure control, and the postoperative infection was influenced by the anti-inflammatory treatment and the area of the operative wound. The results implied that minimally invasive evacuation of hematoma could stabilize and control the intracranial pressure, reduce the area of the exposed wound, decrease the possibility of an inflammatory reaction and accelerate postoperative patient recovery. We recorded the 3-year survival rates of the two groups via follow-up and found that the postoperative 3-year survival rate in group A was much lower than that in group B. This implied that the patients treated with minimally invasive evacuation of the hematoma had better survival at 3 years after the operation, and their survival chances were higher than those in patients with cerebral hemorrhage treated with craniotomy. The operative methods could be regarded as indicators that influenced the mortality of the patients with cerebral hemorrhage. A previous study has reported [23] that the evacuation of intracranial hematoma through operation obviously enhanced the long-term survival rate of patients with cerebral hemorrhage and improved the survival quality and level, consistent with our reports to a certain extent. In order to conduct a detailed investigation of the possible factors that affected the survival of the patients in the two groups, we conducted multiple-factor Cox Regression analysis and found that the independent mortality factors for patients with cerebral hemorrhage included bleeding volume, operation type, breaking into ventricles, complicated cerebral infarction, complicated hypertension, puncture bleeding, and postoperative complications. This further verified that different operative methods affected the prognosis of patients and the survival statuses of patients were also influenced by factors, such as the bleeding volume, puncture bleeding, and postoperative complications. The above results showed that minimally invasive evacuation of hematoma was superior to craniotomy in terms of control over bleeding and complications, and this may be the reason for the higher survival rate of patients treated with minimally invasive evacuation of hematoma than that of patients treated with craniotomy.

In conclusion, in comparison with craniotomy, minimally invasive evacuation of hematoma improved the therapeutic effect, reduced the puncture bleeding rate, and enhanced the prognosis and survival situation more effectively. The selection of these two operation types could be regarded as a factor that influenced the mortality of patients with cerebral hemorrhage. However, this study has certain limitations because it only discussed the therapeutic effects of minimally invasive evacuation of hematoma and craniotomy in the ultra-early stage rather than in other onset periods.

Therefore, the evaluation of the postoperative effect and prognosis of cerebral hemorrhage operation in this study cannot be regarded as a reference standard for all patients with cerebral hemorrhage. Further research is warranted to confirm the present findings.

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Disclosure of conflict of interest

None.

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