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The effect of different surgical methods and timing of surgery on the clinical efficacy in patients with hypertensive intracerebral hemorrhage in basal ganglia

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Abstract

Objective: To explore the effect of different surgical methods and timing on the clinical efficacy of patients with hypertensive intracerebral hemorrhage (HICH) in basal ganglia. *Methods:* A total of 200 patients with HICH in basal ganglia were divided into traditional craniotomy (TC) group, small bone window craniotomy (SBWC) group and neuroendoscopic minimally invasive surgery (NMIS) group. And they were also divided into ultra-early group, early group and delayed group, depending on the timing of surgery. The operation time, intraoperative blood loss, hematoma clearance rate and incidence of complications among different groups were recorded and analyzed. The National Institutes of Health Stroke Scale (NIHSS) and Glasgow outcome scale (GOS) were used to evaluate the neurological function and prognosis. *Results:* The NMIS group was superior to the TC group and SBWC group in terms of operation time, and intraoperative blood loss, hematoma clearance rate, complication 6-months NIHSS scores and the GOS scores ($P<0.05$). There was no significant differences in operation time, intraoperative blood loss, hematoma clearance rate and complication among the ultra-early group, the early group and the delayed group ($P>0.05$). While the ultra-early group was superior to the early group and the delayed group in terms of 6-month NIHSS scores and the GOS scores.

Conclusion: NMIS could reduce the operation time, intraoperative blood loss, and complications, and improve the hematoma clearance rate and prognosis of patients with HICH in basal ganglia. And the ultra-early surgical treatment improved the prognosis of patients with IHCH in basal ganglia.

Keywords: Hypertensive intracerebral hemorrhage, basal ganglia, surgical methods, surgical timing, clinical efficacy

INTRODUCTION

Hypertensive intracerebral hemorrhage (HICH) is a common clinical cerebral parenchymal hemorrhage disease, with the characteristics of acute onset, high mortality and disability rate, which is more common in middle-aged and elderly people.[1,2] The basal ganglia hemorrhage is a the most common site of HICH, accounting for approximately 70% of HICH.[3,4] Hematoma formed by HICH cause local metabolic disorders and circulatory disorders by compressing brain tissues, and eventually causes irreversible brain damage, affecting the neurological function, which is manifested as severe headache, coma, restlessness and other clinical symptoms, seriously affecting the quality of life of patients.[5,6] Therefore, timely removal of hematoma and release of its compression on brain tissue is the key to the treatment of HICH.

Surgery is currently an effective way to treat HICH. HICH in basal ganglia is usually treated with conventional craniotomy, which can effectively eliminate the hematoma and has a definite clinical effect. However, there are limitations such as large trauma and slow recovery.[1] With the continuous progress of medicine and the development of surgical technology, the minimally invasive surgery has been widely used and plays an important role in the treatment of HICH. The minimally invasive hemotoma evacuation is a simple and quick operation, and could avoid the injury of brain tissues and blood vessels to reducing the risk

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of postoperative mortality and complication.[7,8] However, due to the high requirements for equipment and physicians, its clinical application also has certain limitations. Therefore, it is still in controversies about the choice between the conventional craniotomy and minimally invasive surgery for treatment of HICH.

Currently, there are three types of surgical timing for HICH in basal ganglia: ultra-early (onset to treatment time ≤6 h), early (6-24 h) and delayed (≥24 h).[9] Some studies have pointed out that the hematoma has a short compression time on brain tissue in the ultra-early stage, and removing the hematoma at this time can reduce secondary brain tissue damage, inhibit the occurrence of brain edema, and effectively improve the postoperative outcomes.[10] However, some studies have suggested that the intracranial hemorrhage of patients with HICH is still unstable in the ultra-early stage, which may lead to difficulties in hemostasis or secondary bleeding, prompting that surgery is more effective within 7-24 h of bleeding.[11] There is some controversy regarding the timing of surgery for HICH in clinic.

During the treatment of HICH, there are significant differences in the prognosis of patients with different surgical methods or timing. Better surgical methods and timing are beneficial for improving the prognosis and quality of life of patients.[12] In the clinical treatment of HICH in basal ganglia, it is currently unclear which surgical method and timing can effectively improve the clinical efficacy and prognosis of patients. In the present study, the clinical data of 200 patients with HICH in basal ganglia were retrospectively analyzed, the clinical efficacy and prognosis of patients among different surgical methods and different surgical timing were compared, to obtain the best surgical method and timing, providing experience for clinical treatment of HICH in basal ganglia.

METHODS

Patients

A total of 200 patients with HICH in basal ganglia who underwent surgery in Zhangqiu District People's Hospital from January, 2019 to December, 2022 were included. According to the different surgical methods, the patients were divided into three groups: Traditional craniotomy (TC) group (n=46), small bone window craniotomy (SBWC) group (n=80), and neuroendoscopic minimally invasive surgery (NMIS) group (n=74). The patients were divided into ultra-early group (time from onset to operation <6h, n=66), early group (time from onset to operation 6-24h, n=68) and delayed group (time from onset to operation ≥24h, n=66), depending on the timing of surgery.

Inclusion and exclusion criteria

Inclusion criteria were: ① Clinical examination conformed to the diagnostic criteria of HICH, all patients were first onset basal ganglia hemorrhage and supratentorial hemorrhage confirmed by computed tomography(CT); ② All patients were admitted less than 72 h after hemorrhage; ③ All patients met the indications for surgical treatment, which they received, with a bleeding volume of 30-80mL; ④ Glasgow come scale(GCS) score ≥6; ⑤ Age was ranging from 40 to 70 years old; ⑥ Complete case data.

Exclusion criteria were: Patients with ① cerebral hemorrhage caused by cerebral aneurysm, vascular malformation and other reasons were confirmed by CT angiography; ② mixed malignant tumors, with dysfunction of important organs, blood diseases or self-regulatory diseases patients with immune diseases.

Surgical procedures

All patients were given conventional treatment such as oxygen supply, correction of water electrolyte balance, intracranial pressure reduction and vital signs monitoring when being admitted into the hospital.

Patients in the TC group underwent conventional craniotomy with a large bone flap. In brief, the amount and site of hematoma was determined by head computed tomography (CT). Under general anesthesia, the bone window with a diameter of 6-10 cm was usually selected at the nearest point of intracranial hematoma to avoid the large blood vessels and main functional areas of the brain as much as possible. The hematoma was removed in direct view after cranium was open. Electrocoagulation was used for hemostasis and the drainage tubes was retained. The bone flap was reset and the incision was sutured.

Patients in the SBWC group underwent small bone window craniotomy. Before the operation, the specific location of hematoma was determined by head CT. Under general anesthesia, a small bone window with a diameter of 3-4cm was selected at the nearest point of intracranial hematoma to avoid the large blood vessels and the main functional areas of the brains as much as possible. The hematoma was aspirated by means of a microscope. Electrocoagulation was used for hemostasis and the drainage tubes was retained. The bone flap was reset and the incision was sutured.

Patients in the NMIS group underwent neuroendoscopic minimally invasive surgery. In brief, the position of hematoma was determined using head CT. After general anesthesia, a 3-4cm incision was made with the center of the bone hole as the center to fully expose the cranium. A bone hole with diameter was 2-3 cm was drilled, and a neuroendoscopy set (STORZ, Germany) was punctured into the hematoma cavity, and the neuroendoscope was inserted. The hematoma was removed under the the neuroendoscope. Electrocoagulation was used for hemostasis, the drainage tubes was inserted after surgery, and the incision was sutured.

Evaluation indices for efficacy and follow-up

The operation time, intraoperative blood loss, hematoma clearance rate were recorded and analyzed. Post-operative CT scan was re-examined within 24h (12-24h) after surgery to calculate the hematoma clearance rate. Hematoma clearance rate=(preoperative hematoma volume under CT - postoperative residual hematoma volume under CT within 24h after surgery) / preoperative hematoma volume under CT ×100%. And the incidence of postoperative complications were recorded, including intracranial infection, pulmonary infection, and rebleeding.

All patients were followed up for 6 months by telephone or outpatient examination. The National Institutes of Health Stroke Scale (NIHSS) was used to evaluate the recovery of neurological function. The Glasgow outcome scale (GOS) was used to evaluate the postoperative efficacy of patients. In brief, class I (1 point) indicated death, class II (2 points) indicated vegetative survival with only sleep/wake cycle; class III (3 points) indicated severe disability, and the patients awake but disabled, and required daily care; class IV (4 points) meant mildly disabled but the patients could live independently; class V (5 points) meant good recovery and normal life. A score of 4-5 was considered excellent.

Statistical analysis

SPSS21.0 statistical software was used to analyze the data. Measurement data were expressed in the form of mean ± standard deviation. The comparison among multiple groups were analyzed by one-way analysis of variance and Bonferroni test was used for pairwise comparison. Count data were expressed as [n (%)], and analyzed by chi-square test. $P<0.05$ was considered to be statistically significant.

RESULTS

Comparison of the general data of patients with different surgical methods and surgical timing

As shown in Table 1, there was no significant difference in gender, age or other general data of patients with different surgical methods($P>0.05$). And no significant difference was observed in gender, age, hematoma volume or other general data of patients with different surgical timing($P>0.05$), Table 2.

Comparison of operation-related indicators of patients with different surgical methods

As shown in Figure 1, the operation time and intraoperative blood loss of the NMIS group were significantly lower than those of the SBWC group and TC group ($P<0.05$). The operation time and intraoperative blood loss of the SBWC group were lower than those of the TC group ($P<0.05$). The hematoma clearance rate of the NMIS group and SBWC group was higher than that of the TC group ($P<0.05$), while there was no significant difference in hematoma clearance rate between the NMIS group and SBWC group ($P>0.05$).

Comparison of postoperative complications of patients with different surgical methods

There was no significant difference in the intracranial infection, pulmonary infection and rebleeding of patients with different surgical methods. The total complication rate in the NMIS group and the SBWC group were 6.76% and 11.25%, respectively, significantly lower than that in the TC group (23.91%), ($P<0.05$), Table 3.

Comparison of prognosis of patients with different surgical methods

As shown in Figure 2, the NIHSS score in the NMIS group was significantly lower than that in the TC group ($P<0.05$). Meanwhile, the GOS score distribution of the three groups at 6 months after operation was statistically different ($P<0.05$). The excellent rate of GOS in the NMIS group was significantly higher than that in the TC group and the SBWC group ($P<0.05$). (Table 4)

Table 1: Comparison of general data among different surgical methods

Group	Gender		Age	Hematoma volume (mL)	GCS score	NIHSS score	Time interval from onset to operation (h)
	Male	Female					
TC group (n=46)	25	21	57.54±8.19	47.93±11.19	9.13±1.87	19.57±5.48	13.87±10.75
SWBC group (n=80)	41	39	59.68±7.76	47.15±11.65	8.79±1.70	18.59±5.99	13.80±9.85
NMIS group (n=74)	36	38	57.01±8.10	46.26±11.17	9.20±2.09	18.38±5.54	13.97±10.47
F/χ^2	0.372		2.336	0.319	1.028	0.657	0.005
P	0.830		0.099	0.727	0.360	0.520	0.995

GCS: Glasgow come scale, NIHSS: National Institutes of Health Stroke Scale, TC: traditional craniotomy, SBWC: small bone window craniotomy, NMIS: neuroendoscopic minimally invasive surgery

Table 2: Comparison of general data among different timing of surgery

Group	Gender		Age	Hematoma volume (mL)	GCS score	NIHSS score	Surgical methods		
	Male	Female					TC	SBWM	NMIS
Super early group (n=66)	31	35	57.59±7.75	47.64±10.41	9.05±2.11	19.76±5.81	15	27	24
Early group (n=68)	34	34	58.68±8.40	48.11±12.97	8.88±1.68	18.10±4.68	16	28	24
Delayed group (n=66)	37	29	58.32±8.03	45.22±10.30	9.14±1.89	18.36±6.45	15	25	26
F/χ^2	1.133		0.314	1.253	0.309	1.629	0.287		
P	0.568		0.731	0.288	0.735	0.199	0.991		

GCS: Glasgow come scale, NIHSS: National Institutes of Health Stroke Scale, TC: traditional craniotomy, SBWC: small bone window craniotomy, NMIS: neuroendoscopic minimally invasive surgery

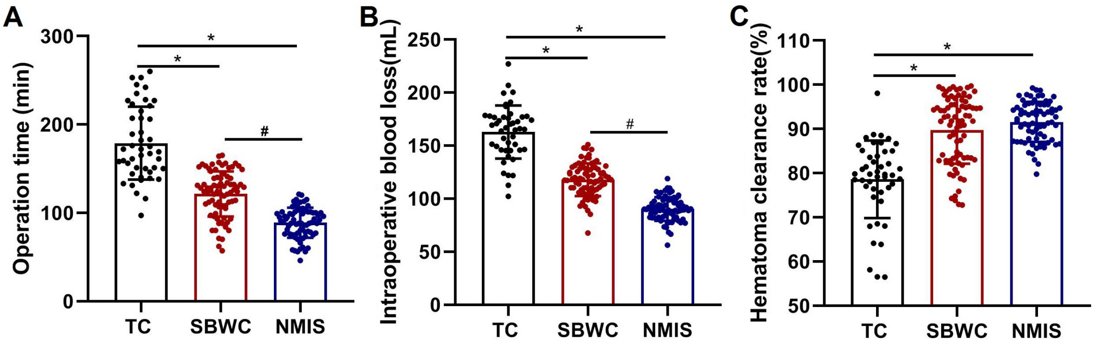

Figure 1. The histogram of perioperative indicators of patients with different surgical methods. (A) Operation time of patients with different surgical methods. (B) Intraoperative blood loss of patients with different surgical methods. (C) Hematoma clearance rate of patients with different surgical methods. TC: traditional craniotomy, SBWC: small bone window craniotomy, NMIS: neuroendoscopic minimally invasive surgery; * P<0.05, *vs* TC group; # P<0.05, *vs* SBWC group.

Table 3: Comparison of complications of patients with different surgical methods [n(%)]

	Intracranial infection	Pulmonary infection	Rebleeding	Total complication rate
TC group (n=46)	1(2.17)	7(10.94)	5(10.87)	11(23.91)
SBWC group (n=80)	2(2.50)	5(6.25)	3(3.75)	9(11.25)
NMIS group (n=74)	1(1.35)	4(5.41)	2(2.70)	5(6.76)
χ^2	0.560	3.803	3.805	7.824
P	1.000	0.136	0.166	0.020

TC: traditional craniotomy, SBWC: small bone window craniotomy, NMIS: neuroendoscopic minimally invasive surgery

Comparison of operation-related indicators of patients with different surgical timing

As shown in Figure 3, there was no significant differences in operation time, intraoperative blood loss and hematoma clearance rate among the ultra-early group, the early group and the delayed group (P>0.05).

Comparison of postoperative complications of patients with different surgical timing

There was no significant difference in intracranial infection, pulmonary infection and rebleeding among patients with different surgical timing. The total complication rate of the ultra-early group, the early group and the delayed group were 12.12%, 10.29% and 15.15%, respectively. There was no

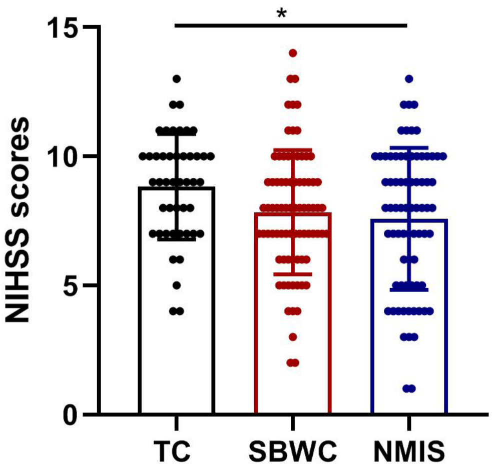

Figure 2. NIHSS score of patients with different surgical methods.
TC: traditional craniotomy, SBWC: small bone window craniotomy, NMIS: neuroendoscopic minimally invasive surgery; * P<0.05, *vs* TC group

Table 4: Comparison of GOS score of patients with different surgical methods

	GOS score 1	GOS score 2	GOS score 3	GOS score 4	GOS score 5	Excellent rate[n(%)]
TC group (n=46)	3	7	14	14	8	22(47.83)
SBWC group (n=80)	3	14	22	26	15	41(51.25)
NMIS group (n=74)	0	8	15	31	20	51(68.92)*#
F/χ^2			7.146			6.948
P			0.028			0.031

TC: traditional craniotomy, SBWC: small bone window craniotomy, NMIS: neuroendoscopic minimally invasive surgery; * P<0.05, *vs* TC group; # P<0.05, *vs* SBWC group.

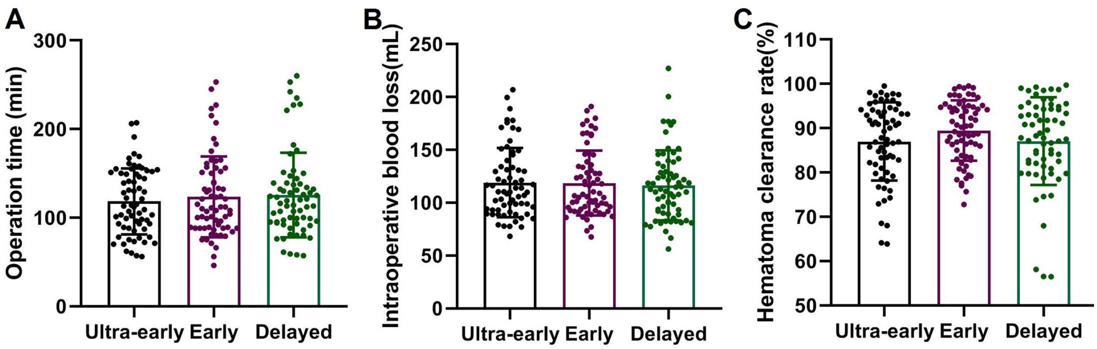

Figure 3. The histogram of perioperative indicators of patients with different surgical timing
(A) Operation time of patients with different surgical timing. (B) Intraoperative blood loss of patients with different surgical timing. (C) Hematoma clearance rate of patients with different surgical timing.

significant difference in total complication rate among the three groups (*P*>0.05). (Table 5)

Comparison of prognosis of patients with different surgical timing

As shown in Figure 4, the NIHSS score in the ultra-early group was lower than that in the early group and the delayed group(*P*<0.05). And the GOS score distribution of the three groups at 6 months after operation was statistically different (*P*<0.05). The excellent rate of GOS in the ultra-early group was significantly higher than that in the early group and the delayed group (*P*<0.05). (Table 6)

DISCUSSION

Surgery is the main method of clinical treatment for HICH. Surgical intervention has advantages for hematoma removal in the basal ganglia since it can remove the hematoma effectively and decrease the compression of intracranial hematoma on the brain tissue, and improve the neurological function and prognosis of patients and the incidence of complications.[13-15] The common surgical methods for HICH in basal ganglia were as follows: large bone flap hematoma removal, small bone window micro hematoma removal, and neuroendoscopic minimally invasive hematoma removal.[16] However, there is no consensus on which surgical method is the best choice. A large bone flap hematoma removal is a traditional surgical method commonly used in the clinical treatment of HICH, with the main feature: fully expose the surgical field of vision. The removal of hematoma can be carried out under the direct vision of the operator, which can quickly reduce the pressure of hematoma on the intracranial brain tissue. However, the large exposure range and long operation time, the risk of brain tissue and nervous system injury will increase correspondingly, and the probability of postoperative complications of patients will also increase, which may affect the prognosis of patients.[17,18]

Compared with the traditional craniotomy, the SBWC microsurgery has a relative small incision, the size and position of the hematoma can be clearly observed under the microscope. The operation can be completed in a relatively short time, and reduce damage to the brain tissue. Moreover, the complication profile of SBWC microsurgery is favorable, and the efficacy is significant.[8,19]

With the continuous development of endoscopy

Table 5: Comparison of complications of patients with different surgical methods[n(%)]

	Intracranial infection	Pulmonary infection	Rebleeding	Total complication rate
ultra-early group (n=66)	2(3.03)	4(6.06)	2(3.03)	8(12.12)
early group (n=68)	0(0.00)	6(8.82)	3(4.41)	7(10.29)
delayed group (n=66)	2(3.03)	6(9.09)	5(7.58)	10(15.15)
χ^2	2.175	0.507	1.421	0.735
P	0.398	0.848	0.521	0.691

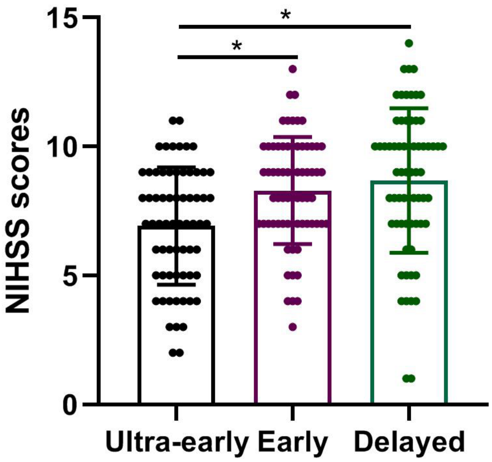

Figure 4. NIHSS score of patients with different surgical timing
* P<0.05, *vs* ultra-early group.

in recent years, endoscopic treatment has been proven safe and effective with certain advantages over traditional craniotomy.[20] As a new minimally invasive surgical technique, NMIS can be better remove the hematoma under a good lighting system and visual field, with less damage and smaller surgical incision, short operation time and other advantages, which can effectively reduce postoperative complications and improve the prognosis of patients.[17,21,22]

However, SBWC microsurgery and NMIS still have certain clinical limitations: it is difficult to stop bleeding when the intraoperative blood loss is large; and good surgical expertise of the operator are the key factors to success. So the three surgical methods had respective advantages and disadvantages. Yang *et al*.[23] have demonstrated that treating HICH with SBWC has lower neurological impairment, shorter operation time and hematoma disappeared time, and better efficacy. Xu *et al*.[24] have showed that compared to the large bone flap craniotomy, minimally invasive craniotomy with SBW can shorten the operation time, reduce the intraoperative blood loss and the lactic acid and CRP levels, promote the recovery of patients, and significantly improve the prognosis of patient. Sun *et al*.[25] have found that compared with traditional craniotomy, neuroendoscopic treatment of HICH could better remove intracranial hematoma, reduce intraoperative bleeding and postoperative brain edema around the hematoma, shorten the operation time and hospitalization time, and improve the prognosis of patients. Gui *et al*.[26] have indicated that neuroendoscpic surgery is more effective and safe, cause less bleeding and has better prognosis and nerve function recovery compared to small bone window craniotomy in the treatment of hypertensive cerebral hemorrhage. Lv *et al*.[27] also have found that compared with microsurgery with small bone window craniotomy with a side cleft, the neuroendoscopic surgery can significantly improve the hematoma clearance rate, reduce intraoperative hemorrhage and postoperative cerebral tissue edema, and improve surgical efficiency in patients with HICH in basal ganglia. However, the long-term prognosis of patients who undergo craniotomy through the lateral fissure is similar to that of patients who undergo neuro-endoscopic surgery. On the basis of existing studies, this study compared the clinical efficacy of three surgical methods: larger bone flap craniotomy and small bone window minimally invasive surgery, neuroendoscopic minimally invasive surgery in patients with HICH in basal ganglia, found that the operation time, intraoperative blood loss and complication rate of the NMIS group and the SBMC group were significantly lower than those of the TC group, and the hematoma clearance rate was higher than that of the TC group. However, the prognosis of the NMIS group was significantly better than that of the SBWC group and TC group, suggesting that the efficacy of neuroendoscopic minimally invasive surgery in the treatment of HICH in the basal ganglia was more significant, and significantly improved the prognosis of patients.

Table 6: Comparison of GOS score of patients with different surgical timing

	GOS score					Excellent rate[n(%)]
	1	2	3	4	5	
ultra-early group (n=66)	1	3	16	25	21	46(69.70)
early group (n=68)	2	10	20	25	11	36(52.94)*
delayed group (n=66)	3	16	15	21	11	33(50.00)*
F/χ^2			11.384			6.115
P			0.003			0.047

* P<0.05, *vs* ultra-early group.

However, it might lead to bias in the results because that the hematoma volumes of all patients in this study was 30-80 mL, that is, the inclusion criteria of cases were different.

The optimal operation time is the key to affect the surgical effect and prognosis of HICH patients. Studies have shown that perihematoma cranial nerve damage occurs at 3-6 h after hemorrhage in patients with HICH, and the damage continues to worsen over time, eventually causing irreversible damage to the cranial nervous system and function.[28] Liu *et al*.[29] have found that stereotactic minimally invasive surgery for moderate amount of HICH in basal ganglia within 6 h of onset has a high hematoma clearance rate, a low incidence of complications within 30 d, and a good recovery of activities of daily living at 6 months after surgery. Yuan *et al*.[30] have found that surgery within 24 h is defined as early treatment, and the early CT-guided stereotactic hematoma aspiration may improve the postoperative neurological function of patients with HICH in basal ganglia. Therefore, early surgery and rapid removal of cerebral hemorrhage could reduce the damage of secondary cerebral edema to the nervous system, which is beneficial to the prognosis of patients. So in the present study, the clinical efficacy of surgery at three surgical timings: ultra-early stage, early stage and delayed stage in patients with HICH in basal ganglia were compared, and found that the NIHSS score and GOS score at 6 months after operation of patients with HICH in basal ganglia in the ultra-early group were significantly better than those of in the early group and delayed group. It was suggested that the surgery at ultra-early stage promoted the recovery of neurological function and improved the prognosis of patients with HICH at basal ganglia, consistent with the results of Cui *et al*.[31] However, the study of Li *et al*.[32] have indicated that, the optimal timing of hematoma removal for cerebral hemorrhage cannot be simply defined as early or late, it should be customized based on the physiological indicators of the patient, such as the position and the quantity of hemorrhage, and surgical methods, which allow a comprehensive judgment. Therefore, the surgical timing of patients with HICH should be comprehensively judged according to the position and the quantity of hemorrhage, and surgical methods.

However, this study had certain limitations, such as small sample size and only 6 months of follow-up, which may cause bias in the statistical results. So, the results still need to be further verified by a large size and longer follow-up time. And the subgroup analysis in the ultra-early group, early group and delayed group would be performed to explore the impact of surgical methods on the clinical efficacy, to comprehensively judged the optimal surgical methods and timing for HICH patients.

In conclusion, neuroendoscopic minimally invasive surgery could significantly improve the hematoma clearance rate, reduce the operation time, intraoperative blood loss, and complications and effectively improve the prognosis of patients with HICH in basal ganglia. In addition, the ultra-early surgical treatment was of great significance to promote the rehabilitation of patients and improve their prognosis.

DISCLOSURE

Ethics: This study was approved by the hospital ethics committee and has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. All patients or their families were aware of the purpose or significance of this study and signed informed consent.

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Conflict of interest: None.

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