Int J Clin Exp Med 2020;13(12):10012-10018
www.ijcem.com /ISSN:1940-5901/IJCEM0122648

Original Article

Minimally invasive stereotactic surgery in treating hypertensive basal ganglia hemorrhage at different time periods

Weixing Jin, Jin Chen, Yue Wang, Yong Yang, Feng Shen, Fei Zhu

Department of Neurological Surgery, No.171 Hospital of PLA, Jiujiang, Jiangxi Province, China

Received September 18, 2020; Accepted October 14, 2020; Epub December 15, 2020; Published December 30, 2020

Abstract: Objective: Our aim was to explore the clinical efficacy of minimally invasive stereotactic surgery on hypertensive basal ganglia hemorrhage (HBGH) at different time periods. Methods: In this prospective study, 90 HBGH patients were selected in the observation group and treated with minimally invasive stereotactic surgery within 6 hours after onset, and 90 HBGH patients in the control group given the same surgery 6-24 hours after onset. The clinical efficacy, neurological injury, inflammatory factor (C-reactive protein, tumor necrosis factor-α and interleukin-6) levels and postoperative complications were observed before and after treatment in both groups. Results: The observation group showed a significantly higher proportion of good prognosis (60.23% vs. 34.83%) and markedly lower complication rates (9.09% vs. 21.35%) than the control group ($P < 0.05$). After treatment, the inflammatory factor levels decreased, and NIHSS and ADL scores increased in both groups, as compared with those before treatment ($P < 0.001$), while the observation group revealed better results in these indicators than the control group ($P < 0.001$). Conclusion: Ultra-early stereotactic surgery for HBGH can reduce inflammatory reactions and complication rates, and ameliorate neurological function and prognosis.

Keywords: Minimally invasive stereotactic technique, hypertensive basal ganglia hemorrhage, clinical efficacy, inflammatory factor, neurological function, complication

Introduction

Hypertension-induced cerebral hemorrhage, clinically known as hypertensive intracerebral hemorrhage (HICH), is one of the most serious complications in hypertensive patients. Of all HICHs, hypertensive basal ganglia hemorrhage (HBGH), is a cerebral hemorrhage resulting from lenticulostriate artery aneurysm rupture in the region of basal ganglia, which is the most common type, accounting for about 70% [1, 2]. The key in treating HBGH is timely and effective removal of the hematoma, relief of brain tissue compression and reduction of intracranial pressure to reduce nerve injuries and ameliorate the prognosis [3]. Surgery is a valid treatment for HBGH and is widely used in clinical practice. Currently, there are many surgical programs but no uniform selection criteria [4]. In traditional craniotomy, local hematoma can be almost completely removed, but many postoperative complications occur due to the long-term operation time, large trauma and inaccurate location assessment of the hematoma [5].

Stereotactic surgery, a minimally invasive treatment, is reported to have better efficacy compared with traditional craniotomy in treating HBGH, due to the development of microscopic technology and its application in HBGH in recent years [6]. Nevertheless, the timing and indications for stereotactic surgery of HBGH are still controversial. A previous study revealed that stereotactic surgery was comparatively effective in the ultra-early stages (within 6 hours after onset), yet another study found that the efficacy in the early stage (6-24 hours after onset) was similar to that in the ultra-early stage [7, 8]. Based on the research findings, we investigated the effect of stereotactic minimally invasive surgery on HBGH at different time periods, so as to provide a basis for future clinical research.

Materials and methods

General information

This prospective study was conducted in 180 HBGH patients admitted to the Department of Neurosurgery of No.171 Hospital of PLA from May 2017 to February 2020, with a mean age of 48.9±10.3 years (range: 20-74 years). The patients were randomly divided into the observation group (n = 90) and the control group (n = 90) by a random number table method. The observation group was treated with ultra-early minimally invasive stereotactic surgery with a mean age of 48.4±10.5 years, while the control group was given early minimally invasive stereotactic surgery with a mean age of 49.1±9.8 years. After surgery, long-term follow-up was performed in both groups. Besides, written informed consent form was obtained from all the patients, and ethical approval for the study was given by the Ethics Committee of No.171 Hospital of PLA.

Inclusion and exclusion criteria

Patients were included if they were diagnosed with HBGH according to the criteria defined by *Chinese Guidelines for the diagnosis and treatment of cerebral hemorrhage (2014)* [9]; were aged between 18-75 years; had a blood loss of > 30 mL; received surgery within 24 hours from symptom onset.

Patients were excluded if they were unable to tolerate the surgery; associated with severe coagulation disorders or severe heart, liver, kidney and other diseases; had decreased quality of life owing to mental disorders or cerebrovascular diseases; were not suitable for the surgery (e.g., difficult or inconvenient follow-up).

Surgical methods

Before the surgery, all the patients were given routine blood and urine tests, liver and kidney function tests, coagulation function and immunological tests, as well as routine chest X-ray and ECG tests. Once any abnormality was found, consultations in relevant departments were arranged for treatment and correction. Moreover, blood pressure was regulated in all patients, blood glucose was adjusted in patients with comorbidity of HBGH and diabetes, and sedatives were applied to patients with dysphoria. Then skin preparation for brain surgery was performed, and urinary catheter, gastric tube, etc. were placed in accordance with the individual situations. Stereotactic surgery was undertaken in both groups, and the surgical program was as follows. First, a stereotactic frame (Aerotech, Longterm Technology Inc., Beijing, China), and apparatus (Leksell-G, Elekta AB, Stockholm, Sweden) was prepared for use and the patient's head was secured properly. Then the entry point was determined by using 32-row with 64-slice spiral CT device (GE LightSpeed Pro, Siemens, USA). As a puncture point, it was about 2-3 cm anterior to the coronal suture at the site of cerebral hemorrhage (relatively nonfunctional area), and then a small incision was made in the region and skull drilling was performed. Subsequently, the puncture needle was advanced into the hematoma to break up the blood clot, followed by stereotactic aspiration of hematoma. The aspiration volume was about 80% of the previous blood loss. After a large quantity of hematoma clearance, a drainage tube was placed timely for drainage under CT guidance. The surgical intervention was undertaken within 6 hours in the observation group and at 6-24 hours in the control group after onset.

Outcome measures

Primary outcomes: Operation time: Operation time was recorded from the first skin incision to the completion of skin suturing.

Initial hematoma clearance rate: The volume of hematoma was observed again by CT after surgery. The hematoma clearance rate (%) = (preoperative blood loss - postoperative blood loss)/preoperative blood loss * 100.

Length of postoperative hospital stay: The number of days of hospitalization was recorded after surgery.

Hematoma disappearance time: The disappearance time of hematoma was also recorded from completion of surgery to reexamination of brain CT.

Efficacy evaluation at 3 months postoperatively: Outcome was classified according to the Glasgow Outcome Scale (GOS) as: favorable (Grade IV-V) or unfavorable (Grade I-III), with Grade V being defined as good recovery, and Grade I as dead [10].

Table 1. Comparison of general information and baseline data (x ± sd, n)

Items	Observation group (n = 88)	Control group (n = 89)	χ^2/t	P
Age (year)	48.4±10.5	49.1±9.8	0.459	0.647
Gender (male/female)	59/29	54/35	0.778	0.378
Site of bleeding (left/right)	49/39	55/34	0.683	0.409
Blood loss (mL)	57.65±14.23	58.54±15.54	0.397	0.692
GOS	8.65±2.31	8.94±2.54	0.794	0.428
BMI (kg/m^2)	23.78±2.62	23.26±2.81	1.273	0.205
Comorbidity				
CHD (n)	25	27	0.079	0.778
Diabetes mellitus (n)	32	37	0.505	0.477
Hyperlipidemia (n)	59	57	0.176	0.675
Obesity (n)	35	31	0.462	0.497

Note: BMI: body mass index; CHD: coronary heart disease; GOS: Glasgow outcome score.

Table 2. Comparison of perioperative and postoperative outcomes (x ± sd)

Items	Observation group (n = 88)	Control group (n = 89)	t/χ^2	P
Length of hospital stay (d)	10.3±2.6	10.5±2.9	0.483	0.680
Operation time (min)	57.69±8.78	59.45±8.98	1.138	0.189
Initial hematoma clearance rate (%)	76.23±8.34	75.23±8.78	0.777	0.438
Hematoma disappearance time (d)	3.9±0.9	3.7±1.1	1.323	0.187

Table 3. Comparison of postoperative efficacy (n, %)

Items	Observation group (n = 88)	Control group (n = 89)	χ^2	P
I	3 (3.41%)	5 (5.62%)	12.217	0.016
II	12 (13.64%)	15 (16.85%)		
III	20 (22.73%)	38 (42.70%)		
IV	32 (36.36%)	18 (20.22%)		
V	21 (23.86%)	13 (14.61%)		
Good prognosis	53 (60.23%)	31 (34.83%)	11.445	0.001

Determination of inflammatory factor levels: Fasting venous blood (5 mL) was collected after admission and at 8:00 AM on postoperative day 14 from each subject. C-reactive protein (CRP; mI002999-1), tumor necrosis factor-α (TNF-α; mI063192-1) and interleukin-6 (IL-6; mI059930-1) in serum were determined by enzyme-linked immunosorbent assay using kits from Shanghai Enzyme-linked Biotechnology Co., Ltd., China.

Secondary outcomes: Before treatment and after 3 months of treatment, the National Institutes of Health Stroke Scale (NIHSS) was used to assess the neurological deficits (0-42 points), with higher scores indicating more severe nerve injuries [11]; the activities of daily living (ADL) scale were applied to assess self-care ability (0-100 points), with higher scores revealing better self-care ability [12].

Comparison of postoperative complications: The incidences of postoperative pulmonary infection, re-bleeding, epilepsy, and stress ulcer were recorded.

Statistical analysis

All data analyses were performed with the SPSS 22.0 software. The measurement data with a normal distribution were expressed as mean ± standard deviation (x ± sd). Independent t-test was used for the comparison between the two groups, and paired t-test was applied for the comparison within the same group (both expressed as t) if the data were accorded with homogeneity of variance. In addition, Pearson chi-square test (χ^2 test) was adopted for the comparison of enumeration data presented as the case/percentage (n/%). $P < 0.05$ was considered statistically significant.

Table 4. Comparison of inflammatory factors before and after the treatment (x ± sd)

Items	Before treatment		After treatment	
	Observation group	Control group	Observation group	Control group
CRP (mg/L)	6.45±1.92	6.87±1.78	4.76±1.51$^{**,\#\#\#}$	5.62±1.46*
TNF-α (μg/mL)	122.47±18.32	122.76±17.92	85.97±14.92$^{***,\#\#\#}$	103.22±16.35***
IL-6 (μg/mL)	350.87±36.92	354.67±38.82	272.87±25.98$^{***,\#\#\#}$	317.92±30.23***

Note: Compared within the same group before treatment, *P < 0.05, **P < 0.01, ***P < 0.001; compared with the control group after treatment, $^{\#\#\#}$P < 0.001. CRP, C-reactive protein; TNF, tumor necrosis factor; IL, interleukin.

Table 5. Comparison of NIHSS and ADL scores before and after the treatment

Items	NIHSS (points)	ADL (points)
Before treatment		
Observation group	25.42±3.22	57.33±7.53
Control group	25.37±3.16	57.92±6.93
t	0.104	0.542
P	0.917	0.588
After treatment		
Observation group	12.23±2.44$^{\#\#\#}$	82.32±6.45$^{\#\#\#}$
Control group	15.34±2.32$^{\#\#\#}$	75.23±5.98$^{\#\#\#}$
t	8.691	7.585
P	< 0.001	< 0.001

Note: Compared within the same group before treatment, $^{\#\#\#}$P < 0.001. NIHSS: National Institutes of Health Stroke Scale; ADL: activities of daily living.

Results

Comparison of baseline data

There were 88 patients in the observation group (2 were lost to follow-up) and 89 in the control group (1 was lost to follow-up). No statistical difference was identified in age, gender, site of bleeding, blood loss, Glasgow outcome score at admission, body mass index and comorbidity between the two groups (P > 0.05). See **Table 1**.

Comparison of intraoperative and postoperative indicators

No statistical difference was found in terms of the length of hospital stay, operation time, initial hematoma clearance rate and hematoma disappearance time between the two groups (P > 0.05), as shown in **Table 2**.

Comparison of postoperative efficacy

The observation group revealed a significantly higher proportion of good prognoses than that the control group (60.23% vs. 34.83%, P < 0.05), as shown in **Table 3**.

Comparison of inflammatory factor levels before and after treatment

Before treatment, there was no significant difference regarding the levels of CRP, TNF-α and IL-6 between the two groups (P > 0.05). After treatment, the levels of CRP, TNF-α and IL-6 in both groups were markedly decreased as compared with those before treatment (all P < 0.05), while the observation group showed a much greater decrease in the levels than the control group (P < 0.001). See **Table 4**.

Comparison of NIHSS and ADL scores before and after treatment

Before treatment, there was no significant difference regarding the NIHSS and ADL scores between the two groups (P > 0.05). After treatment, the NIHSS and ADL scores in both groups were significantly improved, as compared with those before treatment (P < 0.001), while the observation group showed significantly better results than the control group (P < 0.001). See **Table 5** and **Figure 1**.

Comparison of postoperative complications

The overall complication rate after surgery in the observation group was much lower than that in the control group (9.09% vs. 21.35%, P < 0.05), as shown in **Table 6**.

Discussion

HICH is a common clinical acute critical illness, posing a great negative impact on individuals' quality of life due to its high rate of mortality and disability [13]. Early detection and effective surgical treatment can significantly enhance the prognosis and quality of life of patients [14]. It is reported that minimally invasive ste-

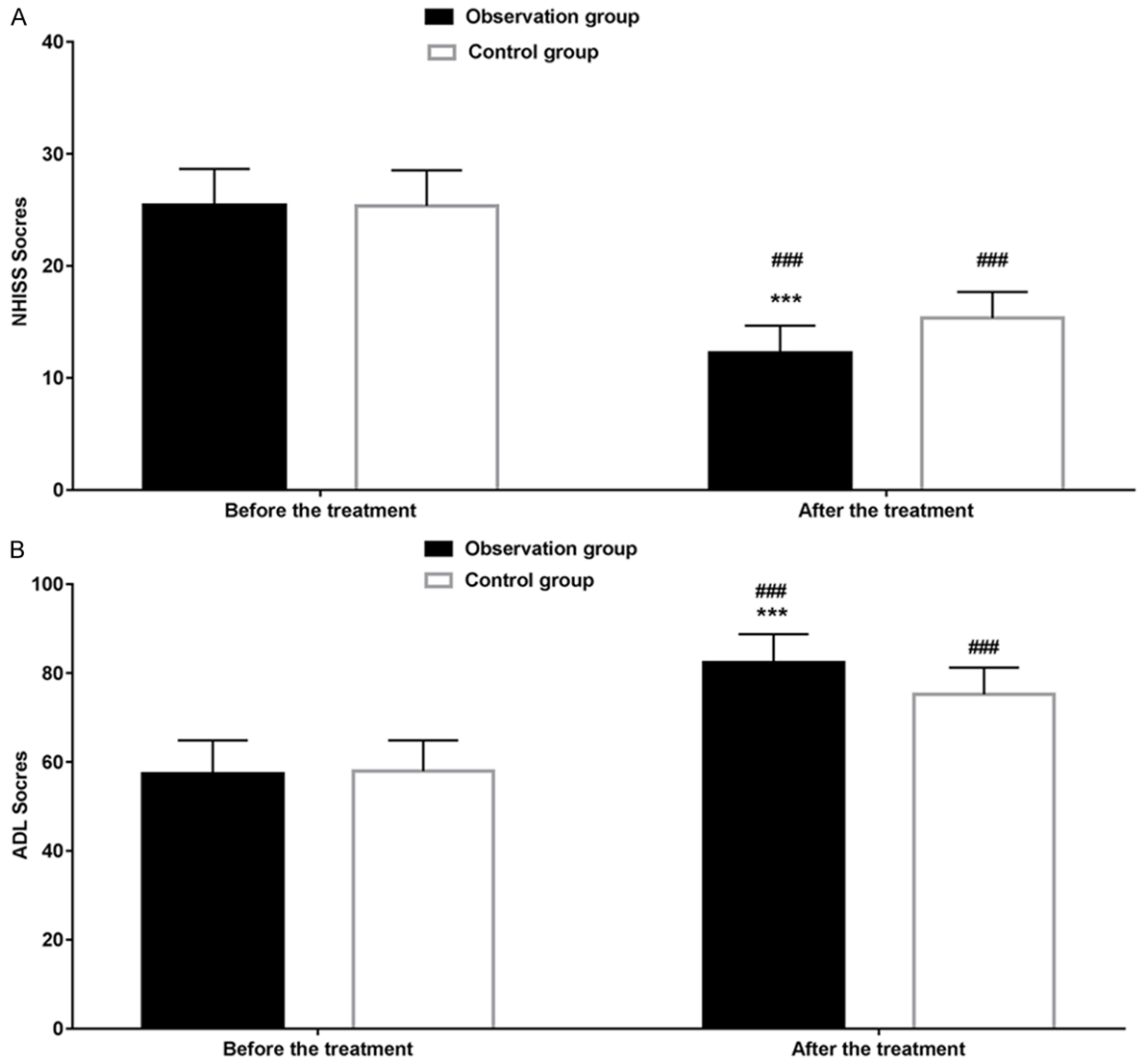

Figure 1. Comparison of NIHSS and ADL scores before and after the treatment. A. Comparison of NIHSS score; B. Comparison of ADL score. Compared within the same group before the treatment, $^{###}P < 0.001$; compared with the control group after the treatment, $^{***}P < 0.001$.

Table 6. Comparison of postoperative complications (n, %)

Postoperative complications	Observation group (n = 88)	Control group (n = 89)	χ^2	P
Pulmonary infection	3 (3.41%)	7 (7.87%)	1.648	0.199
Recurrent bleeding	1 (1.14%)	4 (4.49%)	1.818	0.178
Epilepsy	2 (2.27%)	3 (3.37%)	0.194	0.659
Stress ulcer	2 (2.27%)	5 (5.62%)	1.304	0.254
Overall complication rate	8 (9.09%)	19 (21.35%)	5.143	0.023

reotactic surgery has obvious advantages (minimal trauma, accurate location and high safety) for HBGH, exerting better effects than craniotomy on initial hematoma clearance rate and hematoma absorption time [6, 15]. In our study, the surgical method was basically the same in both groups except for timing of the operation, thus no significant difference was found between the two groups in the intraoperative and postoperative indicators. A previous study revealed that the therapeutic effect is comparatively significant within 24 hours after HBGH

[16]. Also, studies in recent years have unveiled that hematoma is formed within 30 min after HBGH, and bleeding stopped spontaneously at about 6 h after HICH due to the influence of coagulation mechanism. At this time, progressive degeneration and necrosis of the white matter around the hematoma produce cerebral edema. As time goes by, the edema around the hematoma continues to develop, which exacerbates the disease [17]. Based on the findings above, some scholars argued that the removal of the hematoma in the ultra-early stage (within 6 hours after onset) could alleviate nerve injury and facilitate the postoperative recovery of neurological function [1]. Additionally, NIHSS and ADL scores are indicators for neurological impairment and self-care ability, respectively [11, 12]. Our study demonstrated that the proportion of good prognosis was significantly higher, and the NIHSS and ADL scores were better in the observation group than in the control group. This may be because ultra-early stage hematoma clearance relieved the compression and edema of brain tissue, thereby reducing the neurological injury.

Furthermore, the inflammatory response plays an important role in the occurrence and development of HBGH and is correlated with the prognosis of HBGH [18]. Inflammatory factors increase cerebral microvascular and blood-brain barrier permeability, which aggravates the damage to the perihematomal brain tissue and thus produces a vicious circle [19]. Accordingly, there is evidence that early surgical evacuation of the hematoma could reduce the inflammatory response, reducing the injury of surrounding brain tissue and improving neurological function [20]. In our study, the inflammatory factor levels were comparatively high in both groups before surgery, while the observation group showed better results in inflammatory factor levels than the control group. This may be due to the decreased inflammatory responses following hematoma clearance.

As to postoperative complications, the complication rates were markedly lower in the observation group than in the control group, which may be related to the fact that ultra-early evacuation of hematoma is conducive to patient recovery in HBGH [13, 21]. In consistent with our study, another study showed that hematoma clearance performed within 6 hours after onset resulted in a lower incidence of postoperative complications [22].

The sample size in this study is small and the follow-up period is not long enough, hence, multicenter studies with larger sample sizes and longer follow-up periods are needed for a deeper understanding of the mechanism of ultra-early minimally invasive stereotactic surgery for HBGH on improving neurological function in the future.

To sum up, ultra-early stereotactic surgery for HBGH can reduce inflammatory responses and complication rates, and ameliorate neurological function and prognosis, which is worthy of further clinical research and application.

Disclosure of conflict of interest

None.

Address correspondence to: Fei Zhu, Department of Neurological Surgery, No.171 Hospital of PLA, No.18 East Gate of Lufeng East Road, Xunyang District, Jiujiang 332000, Jiangxi Province, China. Tel: +86-0792-7166251; Fax: +86-0792-7166251; E-mail: zhufei17yh@163.com

References

[1] Sun Y, Xu B and Zhang Q. Nerve growth factor in combination with Oxiracetam in the treatment of hypertensive cerebral hemorrhage. Pak J Med Sci 2018; 34: 73-77.

[2] Guo YT, Li WP, Zhou ZW, Huang YT, Chen QB, Wu HW, Deng YF and Lei BX. Plasma glucose, serum albumin, and serum triglyceride, could influence and predict the prognosis of patients with supratentorial hypertensive intracerebral hemorrhage. Int J Clin Exp Med 2019; 12: 10461-10469.

[3] Fernandez-Sanz A, Aladren-Sangros JA, Tejada-Meza H, Cruz-Velasquez GJ, Angel-Rios LF, Seral-Moral P, Artal-Roy J and Marta-Moreno J. Signs predicting early growth of intracerebral haemorrhage in computer tomography without enhancement and mortality. Rev Neurol 2018; 67: 242-248.

[4] Hostettler IC, Seiffge DJ and Werring DJ. Intracerebral hemorrhage: an update on diagnosis and treatment. Expert Rev Neurother 2019; 19: 679-694.

[5] Ziai W, Carhuapoma JR, Nyquist P and Hanley DF. Medical and surgical advances in intracerebral hemorrhage and intraventricular hemorrhage. Semin Neurol 2016; 36: 531-541.

[6] Hersh EH, Gologorsky Y, Chartrain AG, Mocco J and Kellner CP. Minimally invasive surgery for intracerebral hemorrhage. Curr Neurol Neurosci Rep 2018; 18: 34.

[7] Hegde A and Menon G. Modifying the intracerebral hemorrhage score to suit the needs of the developing world. Ann Indian Acad Neurol 2018; 21: 270-274.
[8] Chen T, Xu G, Tan D and Wu C. Effects of platelet infusion, anticoagulant and other risk factors on the rehaemorrhagia after surgery of hypertensive cerebral hemorrhage. Eur Rev Med Pharmacol Sci 2015; 19: 795-799.
[9] Department of Neurology, Chinese Medical Association, Cerebrovascular Disease Group and Chinese Society of Neurology. Chinese guidelines for the diagnosis and treatment of cerebral hemorrhage (2014). Chin J Neurol 2015; 48: 435-444.
[10] Zhang BF, Wang J, Liu ZW, Zhao YL, Li DD, Huang TQ, Gu H and Song JN. Meta-analysis of the efficacy and safety of therapeutic hypothermia in children with acute traumatic brain injury. World Neurosurg 2015; 83: 567-573.
[11] Lyden P. Using the national institutes of health stroke scale: a cautionary tale. Stroke 2017; 48: 513-519.
[12] Hong HG, An HS, Sarzynski E and Oberst K. New composite measure for ADL limitations: application to predicting nursing home placement for Michigan MI choice clients. Med Care Res Rev 2019; 1077558719886735.
[13] Vedicherla SV, Foo AS, Sharma VK, Ting EY, Sein L, Chou N and Yeo TT. The "blush" sign on computed tomography angiography is an independent predictor of hematoma progression in primary hypertensive hemorrhage. J Stroke Cerebrovasc Dis 2018; 27: 1878-1884.
[14] Hori YS, Ohkura T, Ebisudani Y, Umakoshi M, Ishi M, Oda K, Aoi M, Inoue T, Furujo M, Tanaka H and Fukuhara T. Hypertensive cerebral hemorrhage in a patient with turner syndrome caused by deletion in the short arm of the X chromosome. Pediatr Neurosurg 2018; 53: 167-170.
[15] Xu X, Zheng Y, Chen X, Li F, Zhang H and Ge X. Comparison of endoscopic evacuation, stereotactic aspiration and craniotomy for the treatment of supratentorial hypertensive intracerebral haemorrhage: study protocol for a randomised controlled trial. Trials 2017; 18: 296.
[16] Watson K, Broscious R, Devabhakthuni S and Noel ZR. Focused update on pharmacologic management of hypertensive emergencies. Curr Hypertens Rep 2018; 20: 56.
[17] Zhao J, Mao Q, Qian Z, Zhu J, Qu Z and Wang C. Effect of mild hypothermia on expression of inflammatory factors in surrounding tissue after minimally invasive hematoma evacuation in the treatment of hypertensive intracerebral hemorrhage. Exp Ther Med 2018; 15: 4906-4910.
[18] Xu H, Changyaleket B, Valyi-Nagy T, Dull RO, Pelligrino DA, Schwartz DE and Chong ZZ. The role of HMGB1 in pial arteriole dilating reactivity following subarachnoid hemorrhage in rats. J Vasc Res 2016; 53: 349-357.
[19] Umahara T, Uchihara T, Hirokawa K, Hirao K, Shimizu S, Hashimoto T, Terasi H and Hanyu H. Time-dependent and lesion-dependent HMGB1-selective localization in brains of patients with cerebrovascular diseases. Histol Histopathol 2018; 33: 215-222.
[20] Pasi M, Charidimou A, Boulouis G, Auriel E, Ayres A, Schwab KM, Goldstein JN, Rosand J, Viswanathan A, Pantoni L, Greenberg SM and Gurol ME. Mixed-location cerebral hemorrhage/microbleeds: underlying microangiopathy and recurrence risk. Neurology 2018; 90: e119-e126.
[21] Guan N, Wu BH, Liu LM, Yang YF, Li YL, Zhang R, Ren LJ and Liu L. Research progress on etiology and related mechanism of intracerebral hemorrhage. Chin J Geriatr Heart Brain Vessel Dis 2016; 18: 670-672.
[22] Dietrich SK, Mixon MA, Rogoszewski RJ, Delgado SD, Knapp VE, Floren M and Dunn JA. Hemodynamic effects of propofol for induction of rapid sequence intubation in traumatically injured patients. Am Surg 2018; 84: 1504-1508.