Comparison between transsylvian-transinsular and transcortical-transtemporal approach for evacuation of intracerebral hematoma[1]

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ABSTRACT

PURPOSE: Hypertensive cerebral hemorrhage in the basal ganglia is a potentially life-threatening cerebrovascular disease with high mortality. Surgical evacuation is an important treatment for intracerebral hemorrhage. However, little is reported about the comparison on the efficacy of various approaches on the prognosis.

METHODS: Clinical data of 80 cases of intracerebral hemorrhage which surgically treated via transsylvian-transinsular approach or transcortical-transtemporal approach were collected. The proportion of post-surgery tracheostomy, incidence of digestive tract hemorrhage, revision surgery, the average length of hospital stay, and the six-month efficacy (defined by an ADL score) rate between these two groups were compared.

RESULTS: The six-month efficacy rates were 75% and 50% in patients receiving transsylvian-transinsular and transcortical-transtemporal surgery, respectively ($p<0.05$). Compared to the transcortical-transtemporal group, the proportion of revision surgery was statistically significantly lower in the transsylvian-transinsular group, ($p<0.05$). The proportion of post-surgery tracheostomy, the incidence of digestive tract hemorrhage, and the average length of hospital stay were lower in the transsylvian-transinsular group, compared to the transcortical-transtemporal group, but no statistically significant differences were noted in them between the two groups.

CONCLUSION: The transsylvian-transinsular approach for evacuation of intracerebral hematoma demonstrates limited complications, shorter length of hospital stay, and improved long-term efficacy and prognosis. These findings suggest this operative approach has potential for wider application.

Key words: Intracranial Hemorrhages. Transsylvian-Transinsular Approach.

Introduction

Intracerebral hematoma forms due to bleeding into cerebral parenchyma. Its incidence ranges between 12-15 per 10.000 people. It is especially common in the elderly in Asia and Africa. It is increasingly prevalent in patients receiving anti-coagulation treatment and a primary cause of morbidity and mortality for stroke patients[1,2]. The hematoma with small volume can be treated with conservative therapies, while larger hematoma is often removed through surgery. Though indications for surgery are controversial[1,3], it is still an important technique for treating cerebral hemorrhage. Cerebral hemorrhage in the basal ganglia is the most common hypertensive type of cerebral hemorrhage. Cerebral hemorrhage counts for 10-15% of all strokes in America, Europe, and up to 20-30% in Asia, and is a primary cause of morbidity and mortality[1]. Research shows that its incidence is higher in males than females[1], which is consistent with our study. Its 30-day mortality is 50% half of whom die within 24h. Additionally, capability of daily activities recovers in fewer than 20% patients within six months[1]. Multiple risk factors contribute to intracerebral bleeding and affect the prognosis, including cerebral amyloid angiopathy, hypertension, long-term use of anticoagulants and alcohol intake. Prognosis is related to GCS, large volume of hematoma, midline translocation, bleeding into cerebral ventricle, and surgical approaches[1,4]. It is often removed through the transsylvian-transinsular (TS-TI) approach or the transcortical-transtemporal (TC-TT) approach. However, little is reported about the comparison on the impact of various approaches on the prognosis. In the present study, we compared the outcomes of the two approaches for hypertensive cerebral hemorrhage to provide a basis for surgical removal of cerebral hematoma in the basal ganglia.

Methods

The study was approved by the Human Studies Committee of Third Military Medical University in China, and followed principles of the Declaration of Helsinki.

Of the 208 patients who were treated in our hospital due to spontaneous ICH between September 2006 and September 2008, 179 patients had ICH in the basal ganglia, of whom 161 received surgical treatment. Eighty patients with hypertensive cerebral hemorrhage received surgical removal of cerebral hematoma in our hospital from September 2006 to September 2008, including 49 males and 31 females, ranging in age from 39-77 years (average: 54.2±12.3 years). Forty-five patients had a history of hypertension of 0.5-11 years, and other patients were diagnosed as having hypertension when they were admitted to our hospital. On admission, on admission, patients were assigned to receive the transsylvian-transinsular (TS-TI) approach or the transcortical-transtemporal (TC-TT) approach. The Glasgow coma score (GCS) was 13~15 in 20 patients, 9~12 in 27, 6~8 in 24 and 3~5 in 9 (five in the TS-TI group and four in the TC-TT group). Thirty nine patients had one-sided mydriasis (25 in TS-TI group and 14 in TC-TT group); fifty, hemiplegia (29 in TS-TI group and 21 in TC-TT group); thirty-four, speech disorder (18 in TS-TI group and 16 in TC-TT group). All the patients were diagnosed as having intracerebral hemorrhage by brain CT according to the Classifications of Cerebrovascular Diseases revised by the Fourth Chinese National Congress of Cerebrovascular Diseases. The volume of hematoma was calculated as the long axis of the maximum hematoma x the short axis of the maximum hematoma x the number of slices /2. Twelve patients had a hematoma volume of 30-40 ml; 52, 40-50 ml; 16, 50-80 ml. The ASA grade I, II, III and IV was noted in 28, 11, 4 and two patients, respectively in the TS-TI group, and in 22, ten, two and one patients, respectively in the TC-TT group.

Hemostasis, rapid infusion of 20% mannitol and furosemide, control of risk factors, hypertension medications, anti-infection, brain cell protection (monosialoteterahexosyl ganglioside and edaravone), and symptomatic treatment were administered. All patients received surgery within 6h of hypertensive cerebral hemorrhage. During surgery, diuresis, hemostasis, antibiotics, nerve nutrition and symptomatic treatment were administered with monitoring of blood pressure and other vital signs. They underwent the TS-TI approach or the TC-TT approach during surgery.

Inclusion and exclusion criteria

Inclusion criteria: 1) hypertension: blood pressure higher than the upper limit of the normal range (140 mmHg); 2) Brain CT demonstrates that the hematoma in the basal ganglia or internal capsule or the supratentorial hematoma was more than 30 mL; 3) the GCS score ≥ 6; and 4) the time to surgery was within 6h.

Exclusion criteria: 1) hemorrhage caused by cerebral aneurysm, arteriovenous malformation, cerebral trauma, or stroke due to tumors; 2) hematoma in the cerebral ventricle or brain stem hemorrhage; 3) blood diseases or coagulopathy; 4) severe primary diseases; and 5) the time to surgery was over 6 h or the bleeding volume was over 80 ml.

Surgery and follow-up

For the TS-TI approach, an incision was made at 2 cm anterior to the tragus. The skull was exposed for about 5-6 cm and drilled. A 3 cm × 3 cm bone window was made by the rongeur. Bleeding was stopped by bone wax. The cerebral dura mater was incised in a Y shape. The Sylvian fissure was separated at the temporal side until the insula was visualised under the microscope. The middle cerebral artery branches were identified. A 1-cm incision in an avascular area of the insula and a 3-5 cm brain spatula were used to explore the hematoma cavity through the superior temporal gyrus. The responsible artery was generally the lenticulostriate artery whose bleeding could be stopped with electric coagulation. The cerebral dura mater was sutured with interrupted sutures and no drainage was required (Figure 1). If the hematoma volume was large and the brain tissue tension was high, an artificial fistula with a dandy cannula was made through cortex penetration to drain some hematoma for decompression purposes before the Sylvian fissure was separated to clear all hematoma.

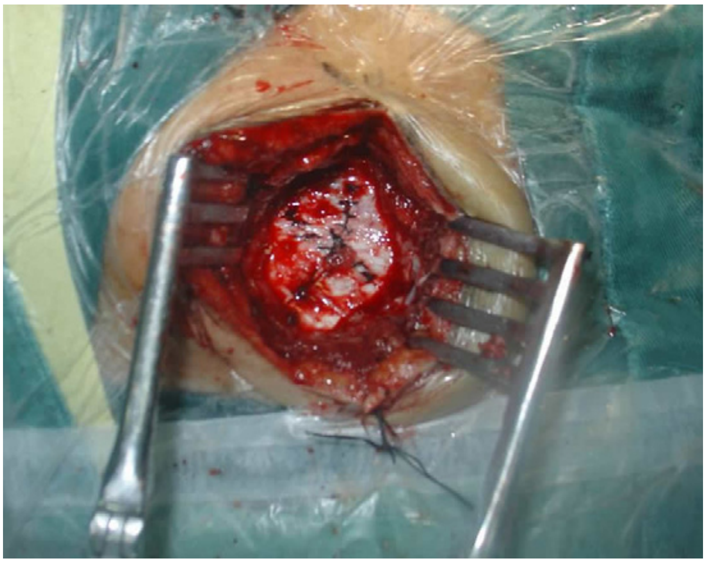

FIGURE 1 - Craniotomy via a small bone window.

The craniotomy was similar in the TC-TT approach to that in the TS-TI approach. After the temporal lobe was exposed, a 2 cm incision was made at the temporal cortex with the minimum distance from the hematoma until the hematoma cavity. The endotracheal tube was kept *in situ* post operation and its removal depended on the patients' conditions.

Brain CT scan was performed post operation and the need for revision surgery was evaluated according to the patient's condition. If brain CT showed a hematoma volume over 30 ml with midline disposition over 1 cm and no apparent improvement of consciousness, revision surgery was required. If the patients had GCS score > 9 and autonomous sputum discharge for 72h, the endotracheal tube was replaced by a tracheostomy.

Statistical analysis

SPSS version 13.0 was applied for all statistical analyses. Measurement data were analyzed using t test or analysis of variance; categorical data were analyzed using Chi-square test. A statistically significant difference was considered if $p<0.05$.

Results

Patients in the TS-TI group consisted of 45 males and 32 females, ranging in age from 39-60 years (average: 55.6±7.2 years) with a hematoma volume of 30-70 ml (average 42.3±10.1 ml). Patients in the TC-TT group consisted of 17 males and 18 females, aged 53.8±9.6 years with a hematoma volume of 28-52 ml (average 36.3±8.4 ml). There were no statistically significant differences in age, ASA grade, one-sided mydriasis, hemiplegia, hematoma volume, time to surgery, surgery duration, and intraoperative hemorrhage ($p>0.05$). There were more male patients than female patients (Table 1).

TABLE 1 - Comparison of general information.

Groups	Gender (male/female)	Age (years)	Hematoma volume (ml)	Time to surgery (h)
Transsylvian-transinsular	32/13	55.6±7.2	42.3±10.1	4.8±0.91
Transcortical-transtemporal	17/18	53.8± 9.6	36.3±8.4	4.6±0.86

Note: mean ± standard error. The males apparently had a higher incidence when compared with females ($p<0.05$).

Patients were evaluated using Activities of Daily Living (ADL's) Assessment at 6 months of follow up. Among 45 patients in the TS-TI group, three patients recovered daily activities and were able to work (Level I); 15 recovered family activities (Level II); 16 could walk with crutches or other support but needed care from others (Level III); and six and five patients were respectively were bed-bound for long or died (Level IV-V). Among 35 patients in the TC-TT group, one patient was rated as Level I; eight as Level II; nine as Level III; five as Level IV and 12 as Level V. In the group with TC-TT approach, 34 patients achieved favorable recovery (Level III or above), while in the TS-TI group, 18 patients achieved favorable recovery (Table 2). In addition, five and 12 patients died in the TS-TI group and TC-TT group, respectively. The overall rate of good outcome at six months was 75% and 50% in the TS-TI and TC-TT group, respectively, with a statistically significant difference between the two groups (X^2=5.19, $p<0.05$) (Table 3).

TABLE 2 - Comparison of ADL levels.

Groups	Level I	Level II	Level III	Level IV	Level V	Total
Transsylvian-transinsular	3	15	16	6	5	45
Transcortical-transtemporal	1	8	9	5	12	35
Total	4	23	25	11	17	80

Note: ADL assessment: Level I: social activities recovered; Level II: family activities recovered; Level III: walking with crutches but requiring care from others; Level IV: in bed with consciousness; and Level V: death.

TABLE 3 - Calculation of efficacy in the two surgical groups.

Groups	Favorable (ADL Level III or above)	Poor	Total
Transsylvian-transinsular	34	11	45
Transcortical-transtemporal	18	17	35
Total	52	28	80

Note: Better efficacy in the transsylvian-transinsular group compared with the transcortical-transtemporal group ($p<0.05$).

A brain CT at 6h post surgery was used to ascertain favorable surgical outcome (Figure 2). If a hematoma was found over 30 ml without improvement or deterioration of the disease, revision surgery was performed to remove the hematoma. In the group with TS-TI approach, three (8.5%) patients underwent revision surgery, while in the group with TC-TT approach, seven (15%) patients underwent revision. No statistically significant difference was found between the two groups ($p>0.05$, Chi-squared test) (Table 4). In addition, as the Sylvian fissure area is complex, brain tissue tension and blood vessel translocation as well as surgery itself may injury the blood vessel and cause cerebral arterial occlusion or venous thrombosis (Figure 3).

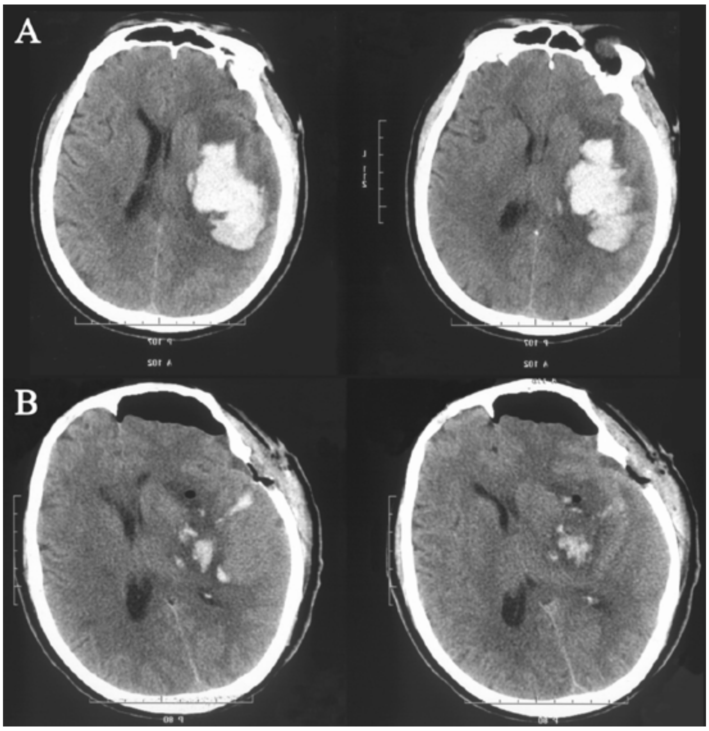

FIGURE 2 - Cerebral hemorrhage in the basal ganglia. **A**. Preoperative; **B**. Postoperative.

TABLE 4 - Comparison of revision surgery for removal of hematoma due to bleeding.

Groups	Revision surgery	No revision surgery	Total
Transsylvian-transinsular	3	42	45
Transcortical-transtemporal	7	28	35
Total	10	70	80

Note: $p>0.05$ between the transsylvian-transinsular group and the transcortical-transtemporal group (Chi-square test).

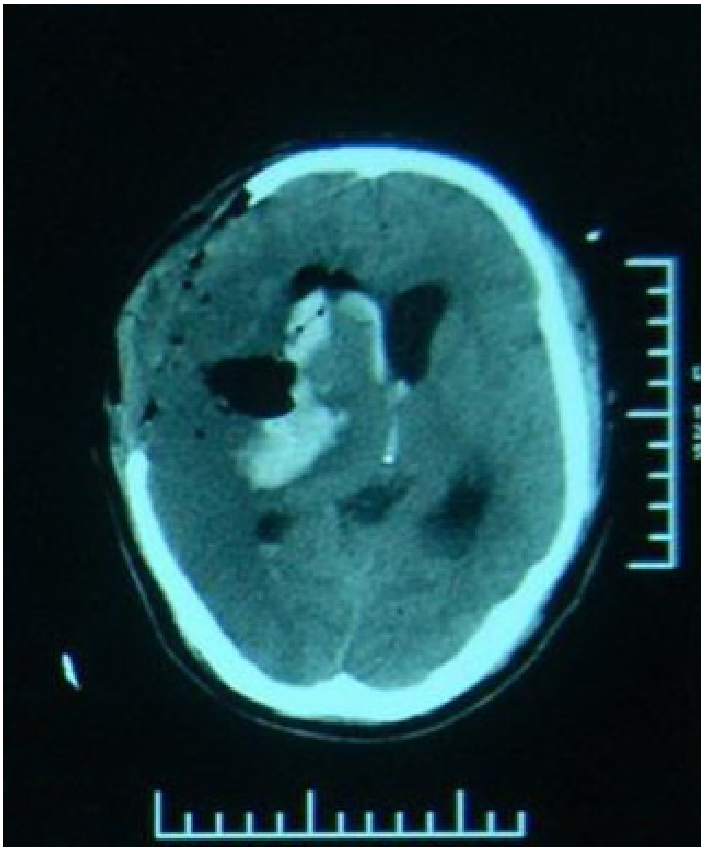

FIGURE 3 - Cerebral infarction due to middle cerebral artery injuries in the transsylvian-transinsular approach (In this case, craniotomy with bone flap was practiced for the transsylvian-transinsular approach). Patchy low density was shown in this figure.

Patients were monitored in the ward post-operatively with an endotracheal tube (ETT) still in situ plus a naso-gastric tube. In the transsylvian-transinsular group, tracheostomy was practiced in 16 patients; whereas, in the TC-TT group, it was done in 19 patients. No statistically significant difference was noted between the two groups (p>0.05). Coffee-like substances were drained through the gastric canal and used to diagnose a gastric tract ulcer in ten patients and 12 patients, respectively, in the transsylvian-transinsular and transcortical-transtemporal group. However, there was no statistically significant difference between two groups (p>0.05). The average lengths of hospital stay were 35 and 42 days, respectively in the transsylvian-transinsular and transcortical-transtemporal group, which was not statistically significantly different (p>0.05) (Table 5).

TABLE 5 - Comparison of postoperative complications and average length of hospital stay.

Groups	Tracheotomy (case)	Digestive tract ulcer (case)	Average length of hospital stay (d)
Transsylvian-transinsular	16	10	35
Transcortical-transtemporal	19	12	42
P	> 0.05	> 0.05	> 0.05

Note: Chi-square test.

Discussion

In clinical practice, hematoma with small volume (<10 ml) can be treated with conservative techniques and functional exercises for rehabilitation; however, for large hematoma that threatens life, surgery is required[5]. However, there is controversy over the surgical outcomes for intracerebral hematoma, such as survival and functional recovery.

Among different types of intracerebral hemorrhage, intracerebral bleeding in the basal ganglia is the most common, especially in the putamen, claustrum, and external capsule expanding to the surrounding area. There are mainly two surgery approaches for managing this type: the TS-TI approach and the TC-TT approach. The TC-TT approach is a classical pathway for clearing intracerebral bleeding in the basal ganglia. It is simple, and can clear most hematoma in the basal ganglia, so it is widely used in clinical practice. However, for this approach, the temporal cortex needs to be incised and the route through the superior temporal gyrus and middle temporal gyrus may damage structures such as the speech center[6,7]. The brain tissues may be dragged to a large extent and hematomas with large volume may not be cleared at a high position, adding to brain injuries and edema[8] and thus postoperative bleeding. In addition, for deep hematoma inferiorly, the incision may damage the vein of Labbe[16], leading to increased chance of complications. Previous studies show that cerebral hernia causes respiratory circulatory failure, and lung infections are a major cause of death after intracerebral hemorrhage[9]. Specifically, loss of consciousness, sputum discharge difficulty, and long-term use of suctioning are associated with lung infections. Another severe complication after intracerebral hemorrhage is digestive tract hemorrhage[19]. Nevertheless, the complications and effective treatment for them are equally important, and thus should be further investigated in future research. In this study, the proportion of post-surgery tracheostomy, the incidence of digestive tract hemorrhage, and the average length of hospital stay were lower for transsylvian-transinsular approach compared with the transcortical-transtemporal approach, but no statistically significant differences were noted in them between the two groups, which may be due to the limited sample size. In the present study, the good outcome rates were 75% and 50% in two surgeries with TS-TI vs. TC-TT respectively. Research shows that surgery itself may be injurious to brain tissues, and thus a correct approach has an influential impact on the prognosis[4]. Compared with previous studies, the good outcome rate was relatively high in our study. This may be in part because the patients in this study received surgery early (within 6h) under strict inclusion criteria and with a small hematoma volume[10,11], suggesting that early removal of hematoma can effectively improve the prognosis of intracerebral hematoma.

The TS-TI approach is traditionally used for diseases in the junction of frontal and temporal lobes, such as carotid aneurysm, vascular malformation and other lesions. It gives access to selective amygdalohippocampectomy, and exposure of anterior ambient cistern and posterior cerebral artery[6]. Recent studies have demonstrated that the TS-TI approach is better than the TC-TT approach in terms of both the mortality and long-term prognosis, and established it as a recommended approach for managing intracerebral hematoma[4,10,11]. Suzuki and Soto initially recommended the TS-TI approach for managing hematomas in the basal ganglia in 1972[12].In the TC-TT approach, the distance to the hematoma is 20-40 mm[13,14], and the Sylvian fissure is well exposed to release cerebrospinal fluid. With the natural gap between brain tissues and better lighting, an operative angle can be achieved to prevent unnecessary traction and subsequent brain oedema. In this study, ‘there was a trend with the TS-TI approach toward fewer complications than the TC-TT approach. In the TS-TI approach, the lenticulostriate artery, often responsible for cerebral hemorrhage in the basal ganglia, can be well exposed and its bleeding can be stopped with electric coagulation, thus avoiding revision surgery for postoperative bleeding[15].

The postoperative bleeding rate was lower in the TS-TI approach in our study. However, due to limited sample size and inclusion criteria, this finding should be further explored.

Moreover, there are other surgical approaches for supratentorial intracerebral hemorrhage, such as image-guided stereotactic hematoma aspiration combined with catheter drainage of hematoma as well as aided with fibrinolysin or urokinase therapy and evacuation of hematoma under endoscopy. Image-guided stereotactic hematoma aspiration aided with fibrinolysin therapy has advantages of fewer traumas, satisfying hematoma evacuation rate, and only local anesthesia, lower requirements on equipment and so on and has been widely applied in treating intracerebral hematoma in clinical. Single-center clinical research results confirmed it could significantly improve the survival rate and the quality of life in patients[16-18]. However, it cannot effectively control the progressive expansion of hematoma because it fails to control responsible vascular, so the rate of rebleeding after aspiration is higher[19]. In some cases, taking into consideration both the aspiration and drainage reaches unfavorable effect and cannot achieve the purpose of decompression[16]. Moreover, the blood clots crack in drainage process and release thrombin which may damage brain tissue and influence the recovery of neurological function[20,21]. Furthermore, because of long drainage time and drug injection through drainage tube, the drainage is difficult to care, which may result in an increase in local infection rate of scalp and then the fatal intracranial infection[16,22]. Due to above-mentioned shortcomings, the technology needs further improvement or uses more advanced surgical techniques. With the development of endoscopic technology, image-guidance technology and intraoperative imaging technology, endoscopic surgery for intracerebral hematoma gradually becomes a very promising surgical technology. Its advantages of small injury, only small bone flap in surgery, even a skull burr-hole, small perturbations on brain tissue, controlling responsible vascular and hemorrhagic spot under direct vision, short operation time and low rebleeding rate are gaining attentions from surgeons step by step. Recent clinical researches demonstrated the advantages of modern ventriculoscope system in removing various intracerebral and intraventricular hematoma, especially thalamic, deep brain parenchymal and intraventricular hemorrhage were obvious[23,24]. However, the ventriculoscope should be entered into the hematoma along the long axis of the hematoma with long puncture distance, so it may damage some nerve functions[25]; moreover, it requires high instrument, and need intraoperative image repositioning if the hematoma cannot be fully removed at the first punch[25], so it is difficult to be promoted. However, with the development of microscopy, for most of the hematoma, it still can reach and successfully remove the hematoma and control the responsible vascular under the microscope and fine lighting conditions through the shortest path and the least injury. However, it needs multi-center clinical researches in the future to verify which technology has more obvious advantages.

Conclusion

The TS-TI approach is superior over the TC-TT for return of ADLs after evacuation of intracerebral hematoma. With any neurosurgical operation, blood vessel damage causing cerebral artery infarction and brain oedema due to vein damage should be prevented by minimizing over-manipulation and brain tissue exposure.

References

1. Elliott J, Smith M. The acute management of intracerebral hemorrhage: a clinical review. Anesth Analg. 2010;110:1419-27.
2. van Asch CJ, Luitse MJ, Rinkel GJ, van der Tweel I, Algra A, Klijn CJ. Incidence, case fatality, and functional outcome of intracerebral haemorrhage over time, according to age, sex, and ethnic origin: a systematic review and meta-analysis. Lancet Neuro. 2010;9:167-76.
3. Adeoye O, Ringer A, Hornung R, Khatri P, Zuccarello M, Kleindorfer D. Trends in surgical management and mortality of intracerebral hemorrhage in the United States before and after the STICH trial. Neurocrit Care. 2010;13:82-6.
4. Shin DS, Yoon SM, Kim SH, Shim JJ, Bae HG, Yun IG. Open surgical evacuation of spontaneous putaminal hematomas: prognostic factors and comparison of outcomes between transsylvian and transcortical approaches. J Korean Neurosurg Soc. 2008;44:1-7.
5. Greenberg MS. Handbook of neurosurgery. 6ed. 2009. p.1290-2.
6. Wu A, Chang SW, Deshmukh P, Spetzler RF, Preul MC. Through the choroidal fissure: a quantitative anatomic comparison of 2 incisions and trajectories (transsylvian transchoroidal and lateral transtemporal). Neurosurgery. 2010;66:221-8.
7. Nagata S, Sasaki T. The transsylvian trans-limen insular approach to the crural, ambient and interpeduncular cisterns. Acta Neurochir (Wien). 2005;147:863-9.
8. Mitchell P, Mitra D, Gregson BA, Mendelow AD. Prevention of intracerebral haemorrhage. Curr Drug Targets. 2007;8:832-8.
9. Kim H, Lee JH, Choi SJ, Kim WK, Lee JS, Lee KH. Analysis of fatal intracranial hemorrhage in 792 acute leukemia patients. Haematologica. 2004;89(5):622-4.
10. Zheng JS, Yang F, Xu QS, Yu JB, Tang LL. Treatment of hypertensive intracerebral hemorrhage through keyhole transsylvian approach. J Craniofac Surg. 2010;21:1210-2.
11. Jianwei G, Weiqiao Z, Xiaohua Z, Qizhong L, Jiyao J, Yongming Q. Our experience of transsylvian-transinsular microsurgical approach to hypertensive putaminal hematomas. J Craniofac Surg. 2009;20:1097-9.
12. Suzuki J, Sato S. The new transinsular approach to the hypertensive intracerebral hematoma. Jpn J Surg. 1972;2:47-52.
13. Tanriover N, Rhoton AL Jr, Kawashima M, Ulm AJ, Yasuda A. Microsurgical anatomy of the insula and the sylvian fissure. J Neurosurg. 2004;100:891-922.
14. Rhoton AL. The supratentorial arteries. Neurosurgery. 2002;51:S53-120.
15. Xu LS, Zhou C, Xu MH, Chen GX. Logistic regression analysis of risk factors in hematoma enlargement in hypertensive intracerebral hematoma after surgical clot evacuation. Acta Acad Med Milit Tert. 2009;31:1596-8.
16. Tang ZP, Shi YH, Yin XP, Xu JZ, Zhang SM, Wang W. Modifying the details of aspiration operation may contribute to the improvement of prognosis of patients with ICH. Turk Neurosurg. 2012; 22:13-20.
17. Chen CH, Lee HT, Shen CC, Sun MH. Aspiration of hypertensive intracerebral hematoma with frameless and fiducial-free navigation system: technical note and preliminary result. Stereotact Funct Neurosurg. 2008;86:288-91.
18. Vespa P, McArthur D, Miller C, O'Phelan K, Frazee J, Kidwell C, Saver J, Starkman S, Martin N. Frameless stereotactic aspiration and thrombolysis of deep intracerebral hemorrhage is associated with reduction of hemorrhage volume and neurological improvement. Neurocrit Care. 2005;2:274-81.
19. Yang R, Zhang X, Wei W, Hong M, Yang Y, Hu Y. Relationship between acquired deficiency of vitamin K-dependent clotting factors and hemorrhage. J Huazhong Univ Sci Technolog Med Sci. 2010;30(3):312-7.
20. Adeoye O, Broderick JP. Advances in the management of intracerebral hemorrhage. Nat Rev Neurol. 2010;6:593-601.
21. Elliott J, Smith M. The acute management of intracerebral hemorrhage: a clinical review. Anesth Analg. 2010;110:1419-27.
21. Teernstra OP, Evers SM, Lodder J. Stereotactic treatment of intracerebral hematoma by means of aplasminogen activator: a multicenter randomized controlled trial (SICHPA). Stroke. 2003;34:968-74.
23. Nagasaka T, Tsugeno M, Ikeda H, Okamoto T, Inao S, Wakabayashi T. Early recovery and better evacuation rate in neuroendoscopic surgery for spontaneous intracerebral hemorrhage using a multifunctional cannula: preliminary study in comparison with craniotomy. J Stroke Cerebrovasc Dis. 2011;20:208-13.
24. Kuo LT, Chen CM, Li CH, Tsai JC, Chiu HC, Liu LC, Tu YK, Huang AP. Early endoscope-assisted hematoma evacuation in patients with supratentorial intracerebral hemorrhage: case selection, surgical technique, and long-term results. Neurosurg Focus. 2011;30:E9.
25. Miller CM, Vespa P, Saver JL, Kidwell CS, Carmichael ST, Alger J, Frazee J, Starkman S, Liebeskind D, Nenov V, Elashoff R, Martin N. Image-guided endoscopic evacuation of spontaneous intracerebral hemorrhage. Surg Neurol. 2008;69:441-6.

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