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Effects of STC on postoperative recovery of disturbance of consciousness in traumatic multiple intracranial hematoma patients

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Abstract

Objective: The study explored the therapeutic value of standard trauma craniectomy (STC) for the treatment of traumatic multiple intracranial hematoma.

Methods: Clinical data of traumatic multiple intracranial hematoma patients who underwent surgical treatment in 2014 and 2015 were collected. The STC group and a control group according to the surgical mode, 48 and 30 cases were randomly selected from each group, respectively. Statistical analysis was performed on the change in the Glasgow coma scale (GCS) score from before the operation to 1 day, 1 week and 1 month postoperatively through repeated analysis of variance and Wilcoxon rank-sum analysis.

Results: Significant differences in the GCS were observed at different time points for the two operative modes ($P < .01$), and an interaction was observed between time and treatment groups ($P < .05$). The rates of change of the GCS score for the two surgical modes were most obviously different at 3 days and 1 week postoperatively ($P \leq .001$, $P < .01$). No statistically significant differences were observed in the rates of change of the GCS at 1 month postoperatively ($P > .05$).

Conclusions: Compared to conventional craniotomy, STC has obvious effects on the recovery after disturbance of consciousness at 1 week postoperatively but does not result in a significant improvement in recovery at 1 month postoperatively.

Abbreviations: GCS = Glasgow coma scale, STC = standard trauma craniectomy, TMIH = traumatic multiple intracranial hematoma.

Keywords: consciousness, disturbance, postoperative recovery, standard trauma craniectomy, traumatic multiple intracranial hematoma

1. Introduction

Traumatic multiple intracranial hematoma (TMIH) refers to hematomas of more than two sites or types after severe craniocerebral injury[1] and exhibits an incidence of approximately 10% to 25% of intracranial hematomas. This type of hematoma is severe, urgent, changes rapidly, and has a poor prognosis; patients often have persistent coma or sharp changes in or disturbances of consciousness. Tentorial incisure herniation and a bilateral pyramidal sign often appear in its early stages, and the fatality rate is four times that of single-shot intracranial hematoma.[2,3] Intracranial pressure is the major cause of death.[2] Jiang et al.[4] advocated the use of USA standard trauma craniectomy (STC) to treat patients with acute supratentorial intracerebral hematoma, cerebral contusion and

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malignant intracranial high pressure. This technique involves complete decompression and a wide exposure range and operative field, which are beneficial for removing the hematoma, managing focal hemorrhage and correcting cerebral metabolic acidosis and cerebral microcirculation disorder caused by cerebral anoxia, thus relieving encephaledema and improving patient outcomes.[5–7] Although STC has advantages over the traditional surgery, which uses a conventional bone flap, in promoting complete hemostasis, removing multiple hematomas and cerebral herniation, and relieving intracranial high pressure, which require treatment in TMIH patients, the effectiveness of STC for various craniocerebral injuries remains controversial.[8–10] International of STC for the treatment of TMIH have rarely been reported. This study comprehensively analyzed the effects and benefits of STC compared with conventional craniotomy on patient recovery after a disturbance of consciousness. Repeated analysis of variance and Wilcoxon rank-sum analysis were performed using the Glasgow coma scale (GCS) scores of 60 patients with multiple intracranial hematomas obtained before the operation and at various time points for one month after the operation.

2. Materials and methods

2.1. Clinical information

Clinical information was collected from TMIH patients who underwent surgical treatment in the Neurosurgery Department of Jilin First Hospital between January 2014 and December 2014. The exclusion criteria were as follows: patients who died within 1 month, required a secondary surgery, were lost to follow-up, and had genetic diseases, hydrocephalus, malignant encephalocele, or multiple organ dysfunction. The patients were divided into a standard trauma craniectomy group (STC group, n=48) and a conventional craniotomy group (control group, n=30). These patients were given a physical examination of the nervous system to determine the GCS score before the operation and at 24 hours, 3 days, 1 week and 1 month postoperatively, and the related data are shown in Table 1.

2.2. Surgical method

Preoperative CT imaging results were evaluated. If a hematoma of one side was large, with a blood amount of more than 30 ml, and the midline was shifted to the other side by more than 0.5 cm, the craniotomy was performed on this side. If the brain surface tension was higher at the end-stage of the surgery, the head CT scan was reviewed immediately to observe whether contralateral bleeding was increased. If the blood amount was increased or the midline structures were shifted to the operative side, then a craniotomy was performed on the contralateral side. If the bilateral preoperative blood volume was large, extensive cerebral contusion was present, or bilateral cerebral ventricles and cerebral cisterns were displayed unclearly, then a bilateral craniotomy was performed, even though the midline structures were not shifted. For infratentorial hematomas or contusions due to obvious space-occupying effects, surgical treatment was required, and supratentorial and infratentorial craniotomies were conducted simultaneously. The mode of craniotomy surgery adopted in the STC group was the USA standard trauma craniotomy, which consisted of removing a bone flap and performing a dural de-stretching suture operation.[11] In the control group, a horseshoe flap, an improved frontotemporal flap or a large coronary flap of the corresponding site was used depending on the position of hematoma.

2.3. Statistical methods

Observation indexes (i.e., the patient's general information and GCS score) of clinical data were analyzed with SPSS 15.0. General information and the preoperative GCS scores were compared with a t test and the data were expressed as mumber and mean ± SD, and changes in the GSC scores in different surgical groups and at different time points were analyzed with repetitive analysis of variance and Wilcoxon rank-sum tests. The repetitive analysis of variance was analyzed by Graphpad prim 8.0. First, Mauchly Test of Sphericity was conducted. If the results met the spherical assumption ($P > .05$), analysis of variance was performed without adjustment for freedom; otherwise, the lower-bound correction coefficient was adopted. Since the only observation variable was the GCS score, single-variable repeated analysis of variance was used rather than multiple-variable analysis.

3. Results

3.1. Comparison of general information

Of the 78 patients, 62 were male, and 16 were female. The STC group included 38 men and 10 women with an average age, preoperative time and preoperative GCS score of 45.3 ± 18.4 years, 12.8 ± 17.7 hours and 8.4 ± 2.4 points, respectively. The control group included 24 men and 6 women with an average age, preoperative time and preoperative GCS score of 48.5 ± 13.7 years, 14.8 ± 20.9 hours and 8.4 ± 2.6 points, respectively. As shown in Table 1, the results of t tests showed no significant differences in any indicators ($P > .05$).

3.2. Repetitive analysis of variance of different operative modes

The GCS scores of the STC group and the control group before the operation (0 h) and at 24 hours, 3 days, 1 week, and one month postoperatively did not meet the spherical assumption

Table 1

General information.

Group	Age (yr, x ± s)	T	Sex		Glasgow coma scale score (X ± s)				
			Male	Female	0 h	24 h	3 d	7 d	1 w
Control	48.5 ± 13.7	14.8 ± 20.9	24	6	8.4 ± 2.6	8.0 ± 2.9	8.4 ± 3.1	10.6 ± 3.1	12.9 ± 2.1
standard trauma craniectomy	45.3 ± 18.4	12.8 ± 17.7	38	10	8.4 ± 2.5	9.6 ± 2.9	10.7 ± 2.7	12.5 ± 2.2	13.2 ± 2.2

Table 2

Mauchly test of sphericity.

Mauchly's W	χ^2	df	P
0.373	73.454	9	.000

Table 3

Tests of within-subjects effects (Sphericity assumed).

Source	Sum of squares	df	Mean square	F	P
Time	1087.147	1.000	1087.147	311.331	.000
Time * method	2.101	1.000	2.101	0.602	.440
Error (time)	265.387	76.000	3.492		

($P<.001$) (Table 2); therefore, the intra-subject effect test (Table 3) was adopted, and the results showed significant differences in GCS scores at different time points (F=311.331, $P<.001$). No significant differences was found between the time factor and the treatment group (F=0.602, $P>.05$). An inter-subject effect test (Table 4) showed significant differences between different surgical modes (F=5.323, $P<.05$). These results can be intuitively expressed with an interactive contour diagram (Fig. 1). The effects of the STC group and the control group on GCS scores were similar, but the effects of different time points on the GCS score varied significantly; the GCS score was significantly increased over time. The interactions between different operation modes and time (e.g., the effects of different operation modes at different time points) on the GCS score were not similar, and the GCS score was more significantly improved in the STC group within 1 week after the operation (3 d and 1 w).

3.3. Wilcoxon rank-sum analysis of the rate of change of the GCS score at different postoperative time points and with different operative surgical modes

To further determine whether the rate of change of the GCS score varies with different operative modes at different time points and the effects of different operative modes on the GCS score at different postoperative time points, we used the preoperative GCS score as the baseline and calculated the change in GCS score at each postoperative time point [rate of change of the GCS score=(GCS score at each time point - baseline GCS score)/baseline GCS score]. The statistical analysis was performed with the Wilcoxon rank-sum test. Significant differences were found between different surgical modes for the rate of change of the GCS score at 24 hours and 1 week postoperatively (Table 5). A scatter diagram was plotted according to the mean value and standard deviation of the statistical results (Fig. 2). The rate of change rate of the GCS score was obviously elevated in the STC group at 24 hours and 1 week postoperatively compared to the control group.

Table 4

Tests of between-subjects effects.

Source	Sum of squares	df	Mean square	F	P
Intercept	38861.723	1.000	38861.723	1560.676	.000
Method	132.554	1.000	132.554	5.323	.024
Error	1892.443	76.000	24.901		

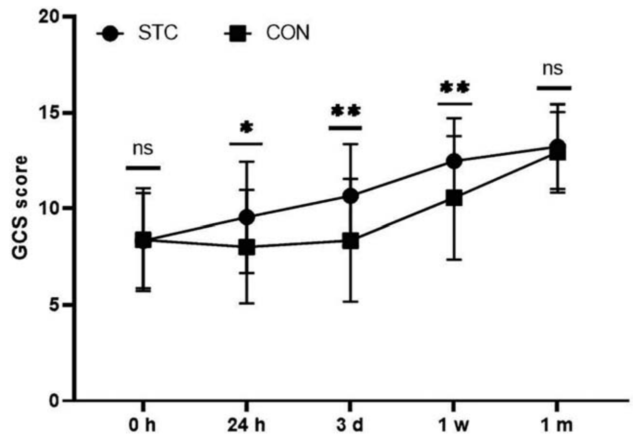

Figure 1. Estimated marginal means of the GCS score as a function of time for the two different methods used. Method 1 refers to the STC group, and Method 2 refers to the control group.

4. Discussion

TMIH refers to hematomas of more than two sites or types after severe craniocerebral injury[1,3] and is characterized by significantly increased craniocerebral pressure, a wide injury range, the need for complex treatment and a very poor prognosis.[3,11] Conventional bone flap surgery is considered inadequate to completely stop the bleeding and remove necrotic tissue; even combined with bone flap decompression, the postoperative brain tissue swelling and high cranial pressure cannot be resolved due to insufficient decompression, a small bone window, and brain tissue incarceration at the edge.[2] Therefore, determining the characteristics of intracranial multiple hematomas and quickly and correctly selecting a surgical treatment is of great importance. However, presently, for bilateral multiple intracranial hematomas, especially bilateral simultaneous hematomas without an obvious shift of the midline, a fixed international standard is still lacking.[2] STC was proposed by in the late 1980 s and involves complete decompression and a wide exposed range, which are beneficial for removing the hematoma, managing the focal hemorrhage, improving the focal blood flow, and correcting cerebral metabolic acidosis and cerebral microcirculation disorders caused by cerebral anoxia.[4] STC has been widely used for surgical treatment of craniocerebral injuries, such as acute epidural hematomas, acute subdural hematomas, and cerebral contusion and laceration.[3,12,13] Although STC has been widely applied in TMIH due to its advantages, some scholars still believe that it has potential risks. The major concern is that contralateral late-onset hematoma caused by rapid intraoperative decompression induces vicious encephalocele, which aggravates brain edema.[14] In addition, the prognostic value of STC for various craniocerebral injuries has been questioned by some scholars in recent years.[8–10]

Table 5

Results of the Wilcoxon Rank-sum analysis.

	0 h	24 h	3 d	1 w	1 m
Wilcoxon W	1892.000	985.000	889.00	932.500	1117.500
P	.967	.039	.002	.009	.469

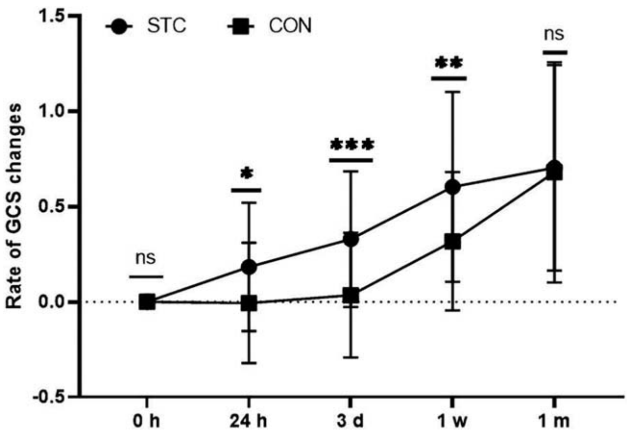

Figure 2. Comparison of the rate of change of the GCS score at each time point for the two groups.

A review of literature on the curative effect of STC showed significant differences in control groups, observation indexes, the time window and grading standard, and statistics for continuous data for each time point, and analyses of the presence of interactions among various factors were lacking. Statistical outcomes mainly focused on the mortality and morbidity, and the observation time window was more concentrated in the middle-to-advanced postoperative period. Coma scales were often treated as qualitative data, and comparisons were often made between the observation time points and preoperative points, resulting in substantial differences in the conclusions of researchers.[8–10,12] This study was a retrospective study aiming to systemically examine the curative effects of STC on TMIH at 1 month postoperatively. To avoid variability of the results, we excluded potential interference factors, such as death, severe complications, hydrocephalus, and secondary operations, and determined only the GCS score at each postoperative time point using patients who underwent conventional bone flap surgery as the control group. Repeated analysis of variance was used to determine differences in the effects of various surgical modes on the GCS score within 1 month postoperatively and whether the effects changed as time progressed. The rank-sum test was used to determine whether differences existed between the two surgical modes regarding the recovery of the GCS score at each time point.

The statistical analysis showed that the GCS score significantly increased until one month postoperatively. However, compared to conventional surgery, STC did not exhibit an advantage in improving the recovery after disturbance of consciousness. The major factor that affected recovery after disturbance of consciousness was time rather than operation mode, and the results were similar to those of Chen et al.[10] Previous studies have shown that pathologic conditions, such as hematoma, edema, inflammatory reaction, and gliosis, are stabilized and resolved by 1 month after the operation,[15] indicating that some causes of disturbance of consciousness are gradually eliminated by 1 month postoperatively. Thus, disturbances of consciousness gradually recover, which is consistent with our result that time was the main factor that affected the recovery of disturbance of consciousness. Additionally, the differences between different operative modes were not the major factor that affected the recovery of disturbance of consciousness during this period, which indicates that STC does not significantly improve the recovery of disturbance of consciousness within 1 month postoperatively. We speculated that except for TMIH patients with severely protruded brain tissues, such as vicious encephalocele and hydrocephalus, STC does not play an active role in the overall recovery trend of pathological conditions (hematoma, edema, inflammatory reaction, and gliosis) of TMIH patients within 1 month.

Although STC was not a significant factor in the postoperative recovery of TMIH patients, we could deduce an interaction between time and operation mode from the results. Thus, the effects of different operative modes on the GCS at different time points were not the same. Figure 1 shows that at 1 week postoperatively, the GCS score increased significantly faster in the STC group than that in the control group, which was also verified by the rank-sum test (i.e., the improvement rate of the GCS score in the STC group was obviously better than that of the control group at 1 week postoperatively). This result showed that STC had a positive effect on consciousness recovery at an early postoperative stage of TMIH. This result may have occurred due because the characteristics of STC mentioned above, including complete decompression, are beneficial for hematoma removal, improvement of local blood flow, and correction of cerebral microcirculation disorders. Previous studies have shown that the major cause of poor prognosis in patients with traumatic brain injury is the secondary damage caused by biochemical cascades, such as brain edema and inflammatory reactions, which occur several days after injury.[16,17] The results in Figure 1 show that the GCS scores of the STC group at each postoperative time point were substantially increased, while the GCS scores of the control group were not obviously improved by 24 hours postoperatively. Thus, we can speculate that compared to the conventional operation mode, the effect of STC on the early postoperative improvement of disturbance of consciousness in TMIH patients may be related to good control of secondary injury in the early postoperative period. STC can promote early postoperative recovery of disturbance of consciousness caused by TMIH, but in the middle-to-advanced postoperative stage (e.g., one month), it has no obvious advantage, suggesting that the advantage of STC to control secondary damage in the early postoperative stage does not guarantee a good long-term outcome of disturbance of consciousness in TMIH patients. Thus, the role of STC in controlling secondary injury in the early postoperative stage is not related to the postoperative long-term coma index. However, this does not mean that STC is of no value to the long-term prognosis of TMIH patients. Because coma can be caused by the ascending reticular activation system and extensive cortical neuron damage, the GCS score does not reflect the specific causes of coma, and nerve dysfunction is not only characterized by disturbance of consciousness. Therefore, clear conclusions could not be drawn for STC regarding its mechanism for improving early postoperative recovery from disturbance of consciousness, its intervention mechanism for controlling secondary injury, and whether it has a protective role for neurons and fibers.

5. Conclusion

STC has positive effect on the recovery of disturbance of consciousness in the early postoperative period for TMIH patients, while it has little effect on improving the recovery from disturbance of consciousness during later postoperative periods. This result may have been found because STC has can control secondary damage at the early postoperative stage, but further studies are required to determine whether this procedure has an effect on the middle-stage postoperative prognosis.

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References

[1] Romodanov AP, Pedachenko EG. [traumatic intracranial hematomas]. Vopr Neirokhir 1975;3–9.
[2] Caroli M, Locatelli M, Campanella R, et al. Multiple intracranial lesions in head injury: clinical considerations, prognostic factors, management, and results in 95 patients. Surg Neurol 2001;56:82–8.
[3] Yang C, Li Q, Wu C, et al. Surgical treatment of traumatic multiple intracranial hematomas. Neurosciences (Riyadh) 2014;19:306–11.
[4] Jiang JY, Xu W, Li WP, et al. Efficacy of standard trauma craniectomy for refractory intracranial hypertension with severe traumatic brain injury: a multicenter, prospective, randomized controlled study. J Neurotrauma 2005;22:623–8.
[5] Alexander EJr. Management of severe traumatic brain injury by decompressive craniectomy. Neurosurgery 2001;48:704.
[6] Coplin WM, Cullen NK, Policherla PN, et al. Safety and feasibility of craniectomy with duraplasty as the initial surgical intervention for severe traumatic brain injury. J Trauma 2001;50:1050–9.
[7] Schneider GH, Bardt T, Lanksch WR, et al. Decompressive craniectomy following traumatic brain injury: ICP, CPP and neurological outcome. Acta Neurochir Suppl 2002;81:77–9.
[8] Cooper DJ, Rosenfeld JV, Murray L, et al. Decompressive craniectomy in diffuse traumatic brain injury. New Engl J Med 2011;364:1493–502.
[9] Huang YH, Lee TC, Lee TH, et al. Thirty-day mortality in traumatically brain-injured patients undergoing decompressive craniectomy. J Neurosurg 2013;118:1329–35.
[10] Chen SH, Chen Y, Fang WK, et al. Comparison of craniotomy and decompressive craniectomy in severely head-injured patients with acute subdural hematoma. J Trauma 2011;71:1632–6.
[11] Marmarou A, Lu J, Butcher I, et al. Prognostic value of the Glasgow Coma Scale and pupil reactivity in traumatic brain injury assessed pre-hospital and on enrollment: an IMPACT analysis. J Neurotrauma 2007;24:270–80.
[12] Vigue B. Update on medical management of severe head trauma. Neurochirurgie 2003;49:583–94.
[13] Maas AI, Steyerberg EW, Butcher I, et al. Prognostic value of computerized tomography scan characteristics in traumatic brain injury: results from the IMPACT study. J Neurotrauma 2007;24:303–14.
[14] Motohashi O, Kameyama M, Kon H, et al. Two cases of impending herniation due to multiple traumatic acute subdural hematomas: combination of burr hole evacuation and craniotomy. No Shinkei Geka 2003;31:529–35.
[15] Cortez SC, McIntosh TK, Noble LJ. Experimental fluid percussion brain injury: vascular disruption and neuronal and glial alterations. Brain Res 1989;482:271–82.
[16] Park E, Bell JD, Baker AJ. Traumatic brain injury: can the consequences be stopped? Can Med Assoc J 2008;178:1163–70.
[17] McKee AC, Daneshvar DH. The neuropathology of traumatic brain injury. Handb Clin Neurol 2015;127:45–66.