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Original Article

Clinical efficacy and prognosis of standard large trauma craniotomy for patients with severe frontotemporal craniocerebral injury

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Abstract: Objective: To observe the clinical efficacy, incidence of postoperative complications, and the quality of life in patients with severe craniocerebral injury undergoing standard large trauma craniotomy. Methods: Seventy-eight patients with severe craniocerebral injury who had been admitted to Hubei Hanchuan People's Hospital were selected retrospectively and assigned into an observation group and control group according to the treatment received, with 39 patients in each group. Patients in the control group were treated with conventional decompressive craniotomy and those in the observation group with standard large trauma craniotomy. The prognosis (GOS score), intracranial pressure before and after surgery, neurological functions (NIHSS score), cerebral hemodynamics (Vm, Vs, PI), quality of life (SF-36 score) and postoperative complications were compared. Results: The number of patients whose GOS scores were graded 5 was markedly higher in the observation group than that in the control group (P<0.05). The postoperative intracranial pressure and NIHSS scores in the observation group were lower than those in the control group (P<0.001). The postoperative Vm, Vs and PI were lower in the observation group than those in the control group, respectively (P<0.001). There was no statistical difference in the incidence of complications in the two groups (P>0.05). The SF-36 scores in the observation group were higher than those of the control group (P<0.01). Conclusion: Standard large trauma craniotomy is effective in treating patients with severe frontotemporal craniocerebral injury. It decreases intracranial pressure, improves neurological function and quality of life and results in a good prognosis.

Keywords: Severe craniocerebral injury, standard large trauma craniotomy, conventional decompressive craniotomy, postoperative complications, quality of life

Introduction

Severe frontotemporal craniocerebral injury, a serious trauma mainly resulting from violence, develops rapidly with a relatively high morbidity and mortality. Therefore, treatment for the injury has always been a difficult clinical problem. Currently, surgery, specifically the removal of hematoma by craniotomy, is the main treatment for severe frontotemporal craniocerebral injury to cure patients' primary injury, prevent and treat their secondary injury [1]. With conventional decompressive craniotomy, a part of the skull would be removed to create a bigger opening within the brain and help blood flow back to the brain during surgery. This surgery has been widely used in clinical settings since Kocher applied it in treating craniocerebral injury for the first time in 1901 [2]. However, there are risks of injuring normal tissue while applying conventional decompressive craniotomy to clear hematoma and necrosis, resulting in poor prognosis in patients when that happens. So, the focus of this research was to find an optimal surgery to improve the prognosis of patients with severe frontotemporal craniocerebral injury.

Over recent years, standard large trauma craniotomy is widely used to treat patients with severe frontotemporal craniocerebral injury. It creates a large and low bone window, which fully exposes the anterior frontal lobe, the temporal lobe base, and the temporal pole so that surgeons are able to remove all the hematoma, control hemorrhage resulting from laceration of bridging vein in the sagittal sinus of the ophthalmic vein and prevent cerebral hernia [3, 4]. Compared with conventional decompressive craniotomy, standard large trauma craniotomy can avoid cerebral incarceration and necrosis and increase cerebral oxygen partial pressure and blood flow, thus realizing adequate decompression in the brain. Recently, although various decompressive craniotomies have been applied to the treatment of craniocerebral injury, no standards have been set up to assess the outcome of the surgeries, resulting in many controversies [5]. It was reported that conventional decompressive craniectomy only produced short-term rather than long term beneficial prognosis [6]. Therefore, this study aimed to provide theoretical support for improving patients' prognosis by retrospectively comparing the clinical data of patients with severe frontotemporal craniocerebral injury.

Material and methods

General data

Seventy-eight patients with severe craniocerebral injury who had been admitted to Hubei Hanchuan People's Hospital were selected retrospectively and assigned into an observation group and control group according to the treatment they had received, with 39 patients in each group. Patients in the control group were treated with conventional decompressive craniotomy and those in the observation group with standard large trauma craniotomy. This study was approved by the Medical Ethics Committee of Hubei Hanchuan People's Hospital.

Inclusion and exclusion criteria

Patients were eligible if they had a history of significant trauma; their GCS scores were less than 8; they had been confirmed with severe frontotemporal craniocerebral injury by cranial CT scan and showed signs of cerebral hematoma or hemorrhage; the time from trauma to admission was less than 12 h; they were expected to live for over 3 months; they had indications for craniotomy; their family had signed informed consent.

Patients were excluded if they were complicated with severe injuries at other sites, such as visceral rupture and comminuted fracture of extremities; they were confirmed dead during operation; their cerebral injury was not caused by violence; they showed surgical contraindications; they had dysfunctional coagulation or they had severe infectious disease.

Methods

The health condition of patients was evaluated before surgery, with routine tests of blood, liver and kidney function and electrocardiogram being performed and vital signs monitored. After patients were sent into operation room, routine disinfection was conducted, skin over the operating site was prepared and a fenestrated surgical drape was placed.

Patients in the control group were treated by conventional decompressive craniotomy. During surgery, they were placed in supine position under general anesthesia with tracheal intubation. Then a U-shaped incision was made at the top of the frontotemporal or frontoparietal area with a bone window of 6 to 8 cm. Next, the intracranial hematoma, subdural edema, and necrotic brain tissues were removed and the temparolis myofascial flap and periosteum were freed. Thereafter, the dura mater was sutured with a drainage tube being placed. At the end of the surgery, the skull was closed.

Patients in the observation group were treated by standard large trauma craniotomy. As in the control group, they were also placed in supine position under general anesthesia with tracheal intubation. Then a curved incision was made at the top of the frontotemporal area, that went along the anterior ear vertically down to 1 cm in front of the tragus at the zygomatic arch, where it curved towards the parietal tubercle in parallel with superior sagittal sinus along the midline and ended at the temporal region, 2 to 3 cm from the middle hairline. The myocutaneous flap was opened to expose the frontal base. Then, five to six holes were drilled on the skull and sawed. The skull was subsequently replaced to expose its base, with an exposed area of 12*15 cm. Thereafter, the dura mater in the anterior temporal region was cut open in T shape to fully expose the anterior and middle skull base as well as the parietal lobe, so as to remove edema, cerebral contusion and laceration, and necrotic brain tissue in the brain both outside and inside the dura mater. At the end, a drainage tube was placed and the dura mater was sutured.

Outcome measures

Primary outcome measures

Patients were followed up for 6 months to record their postoperative outcome, evaluated by GOS Score [7]. Death was rated as grade 1; persistent vegetative state with sleep cycle and eye movement was rated as grade 2; severe disability that required nursing was rated as grade 3; moderate disability retaining the ability to perform self-care but needing assistance or protection in some daily activities was rated as grade 4; good recovery with minor disability but exerting no impact on normal life was rated as grade 5.

Intracranial pressure and neurologic function at 48 hours before and after surgery: Four to six mL of cerebrospinal fluid was extracted by lumbar puncture for routine and biochemical tests. ELECTRON-B2000 intracranial pressure non-invasive monitor (Shanghai Hanfei Medical Instrument Co., Ltd., China) was used to measure intracranial pressure during the extraction. Damage to neurologic function in the two groups was assessed using NIHSS score, which includes 10 items including facial palsy, consciousness, language, sensory, visual field test, horizontal eye movement, speech, extinction and inattention, motor leg and motor arm. The total score is 42, with a higher score indicating worse damage [8].

Cerebral hemodynamics at 48 hours before and after surgery: The Vm, Vs, and PI were monitored in patients for 48 h using an EME Companion TC2021-III Ultrasonic Transcranial Doppler Blood Flow Analyzer (Germany) [9].

Secondary outcome measures

Postoperative complications: Postoperative complications, including cranial hydrocephalus, edema, intracranial infection, traumatic seizure and cerebral hernia, were recorded.

Quality of life: Patients were followed up for 6 months to record their postoperative quality of life, assessed by SF-36 score [10]. The scale includes 8 dimensions, which are vitality, social role functioning, bodily pain, emotional role functioning, physical role functioning, mental health, physical functioning and general health, with 36 items in total. Each item is scored from 0 to 100, with lower score denoting poorer quality of life.

Statistical analysis

SPSS 23.0 software was used for data processing. The measurement data conforming to normal distribution were expressed as mean ± standard deviation ($\overline{x}$ ± sd). Independent sample t test was used for comparison of measured data between the two groups and paired t test was applied for comparison of measured data within each group. The counted data were expressed as cases or percentage (n/%). The χ^2 test and Chi-square test with Yates' continuity correction were used, with $P<0.05$ considered as significant.

Results

General data

General data including age, time from trauma to admission, gender, cause, type of injury and GCS score were compared (all $P>0.05$). General data in the two groups were comparable. See **Table 1**.

Prognosis

There was no significant difference in the proportions of grade 1, grade 2, grade 3 and grade 4 patients by GSC score between the two groups (all $P>0.05$), but the proportion of grade 5 patients was significantly higher in the observation group than that in the control group ($P<0.05$). See **Table 2**.

Intracranial pressure and neurologic function

There was no significant difference in intracranial pressure and NIHSS score between the two groups before surgery (all $P>0.05$). The intracranial and NIHSS scores in the two groups all declined after surgery, with those in the observation group significantly lower than the control group, respectively (all $P<0.001$). See **Table 3**.

Cerebral hemodynamics

There was no significant difference in cerebral hemodynamics between the two groups before

Table 1. Comparison of general data between groups (%, $\bar{x}$ ± sd)

Group	Control group (n=39)	Observation group (n=39)	t/χ^2	P
Age (years old)	44.5±6.2	43.1±6.0	1.014$^{\Delta}$	0.314
Time from being injured to admission	45.49±9.37	48.05±9.81	1.179$^{\Delta}$	0.242
Gender			0.482$^{\blacktriangle}$	0.488
Male	22	25		
Female	17	14		
Cause			0.936$^{\blacktriangle}$	0.817
Car accident	15	13		
Falling	11	15		
Being hit	8	7		
Others	5	4		
Type of the injury			0.720$^{\blacktriangle}$	0.698
Cerebral contusion and laceration	11	8		
Subdural hematoma and cerebral contusion and laceration	20	21		
Intracranial hematoma and cerebral contusion and laceration	8	10		
GCS score	6.22±0.58	6.10±0.55	0.938$^{\Delta}$	0.351

Note: $^{\Delta}$denotes that independent sample t test was used and $^{\blacktriangle}$denotes χ^2 was used for between-group comparison. GCS: Glasgow Coma Scale score [10].

Table 2. Comparison of GOS scores between groups (n, %)

Group	Control group (n=39)	Observation group (n=39)	χ^2	P
Grade 1	3 (7.69)	2 (5.13)	0.000	1.000
Grade 2	5 (12.82)	4 (10.26)	0.000	1.000
Grade 3	10 (25.64)	6 (15.38)	1.258	0.262
Grade 4	11 (28.21)	8 (20.51)	0.626	0.429
Grade 5	10 (25.64)	19 (48.72)	4.446	0.035

Note: Chi-square test with Yates' continuity correction was used for comparison between groups.

surgery (all P>0.05). The Vm, Vs, and PI in the two groups were all decreased after surgery, with those in the observation group markedly lower than the control group, respectively (all P<0.001). See **Figure 1**.

Incidence of postoperative complications

There was no significant difference in the incidence of complications between the two groups. The incidence was 12.82% in the observation group and 20.51% in the control group (P>0.05). See **Table 4**.

Quality of life

There was no significant difference in SF-36 score between the two groups before surgery (all P>0.05). The overall scores of vitality, social role functioning, bodily pain, emotional role functioning, physical role functioning, mental health, physical functioning and general health all increased, with the scores in the observation group higher than the control group, respectively (P<0.01). See **Figure 2**.

Discussion

Craniocerebral injury produces blood in the cerebrospinal fluid, which stimulates blood vessels in the lateral fissure area and causes edema that directly compresses the vessels, resulting in a cerebral blood flow disorder or loss of blood supply on the injured side in the brain [11]. At the same time, due to the injury, a peptide with strong cardiovascular responses is produced in the brain, which strengthens parasympathetic tone but inhibits sympathetic tone, leading to a decrease of cerebral perfusion pressure and loss of blood supply to the brain. This damages neurologic function and results in respiratory depression. Also, calcium ions continuously produced by various physiologic activities of the body further damage the nervous tissue and aggravate cerebral edema [12]. Therefore, it is important to clear the edema to relieve the mass effect and reduce intracranial pressure for the treatment of severe craniocerebral injury.

Table 3. Intracranial pressure and NIHSS score in the two groups ($\bar{x}$ ± sd)

Group	Control group (n=39)	Observation group (n=39)	t	P
Intracranial pressure (mmHg)				
Before surgery	27.65±2.84	28.02±2.97	0.562$^{\Delta}$	0.576
After surgery	24.40±2.23***	21.36±2.11***	6.184$^{\Delta}$	<0.001
NIHSS (score)				
Before surgery	32.72±4.41	31.81±4.03	0.951$^{\Delta}$	0.345
After surgery	19.55±1.90***	17.14±1.74***	5.842$^{\Delta}$	<0.001

Note: $^{\Delta}$means between-group comparison with the use of two-independent sample test; and paired t test was used for within-group comparison between before and after surgery, ***P<0.001. NIHSS: National Institutes of Health Stroke Scale.

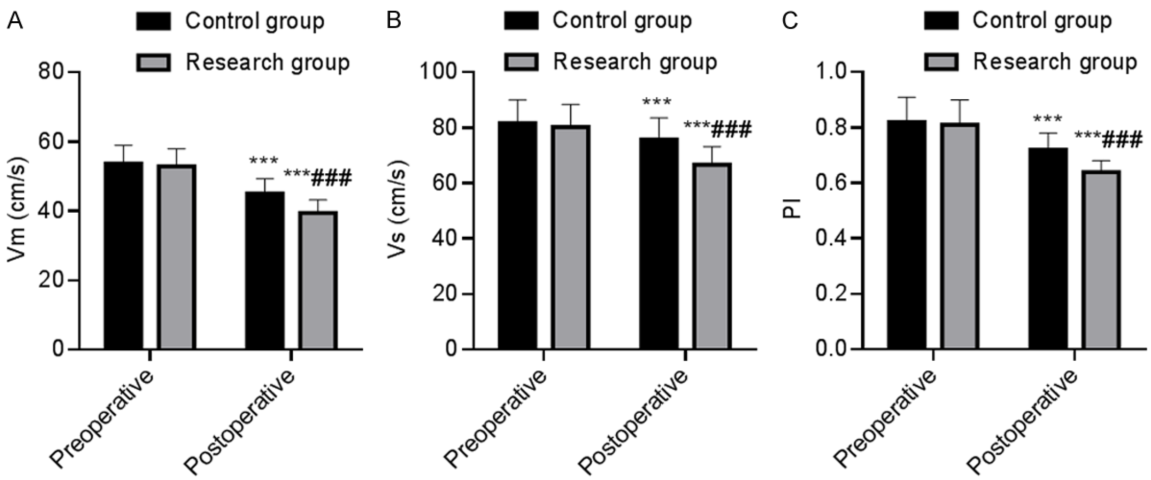

Figure 1. Comparison of cerebral hemodynamics between groups. A: Vm; B: Vs; C: PI. Compared within group before surgery using paired t test, ***P<0.001; compared to the control group after surgery using independent sample test, $^{###}$P<0.001.

Table 4. Comparison of the incidence of postoperative complications between groups (n, %)

Group	Control group (n=39)	Observation group (n=39)	χ^2	P
Hydrocephalus	2 (5.13)	1 (2.56)	0.000	1.000
Intracranial edema	2 (5.13)	2 (5.13)	0.000	1.000
Intracranial infection	1 (2.56)	0 (0.00)	0.513	0.481
Traumatic seizure	1 (2.56)	1 (2.56)	0.000	1.000
Cerebral hernia	2 (5.13)	1 (2.56)	0.000	1.000
Total incidence rate	8 (20.51)	5 (12.82)	0.831	0.362

Note: χ^2 test was used for comparison between groups.

Most bone flap decompressive craniotomies for severe craniocerebral injury, though, have saved many lives, and only open a small bone window in the frontal and frontotemporal flaps. However, incarcerated or bulging brain tissue occur in some patients due to inadequate decompression or small and high bone window, leading to aggravated necrosis and even hernia in the brain [13, 14]. Besides, a small bone window canot fully reveal the cerebral base, which might make the surgeon fail to remove all of the hematoma [15]. The results of this study showed that the percentage of grade 5 patients by GOS score was higher in the observation group than the control group, and intracranial pressure and NIHSS scores in the observation group were lower than the control group. This suggests the standard large trauma craniotomy was more beneficial in decreasing intracranial pressure, improving neurologic function and prognosis. Wang et al. reported that standard large trauma craniotomy could adequately decrease intracranial pressure to alleviate neurological impairment, and

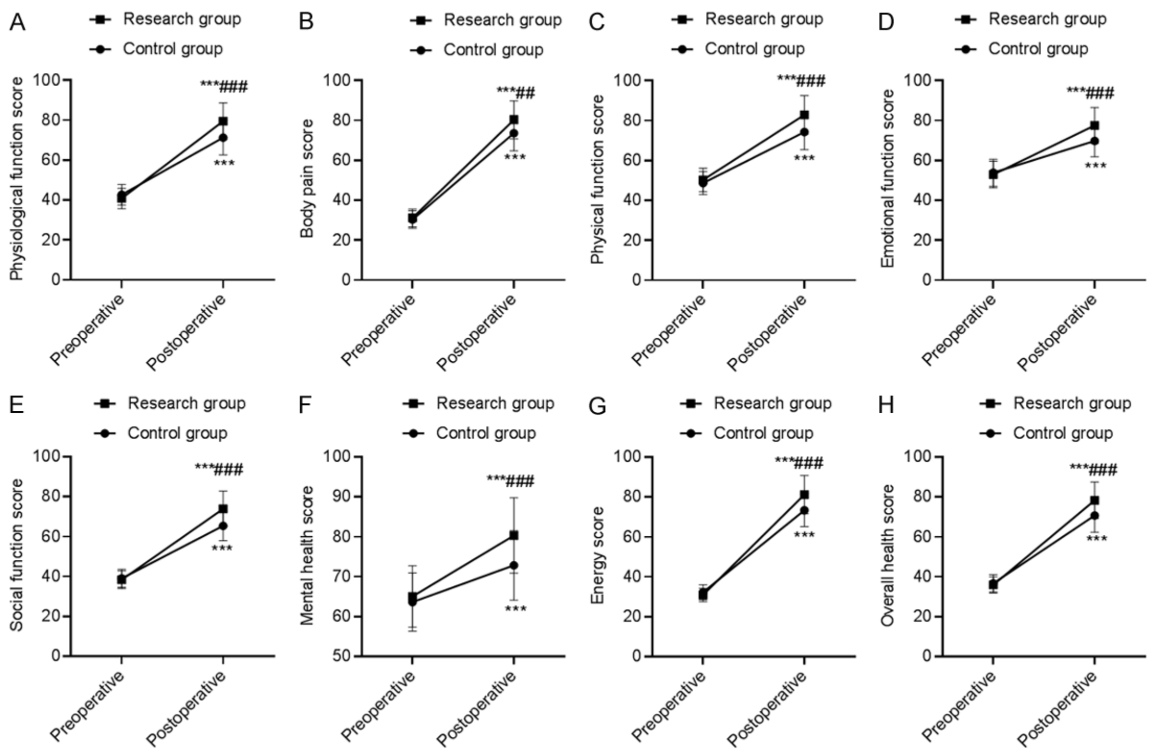

Figure 2. Comparison of SF-36 scores between groups. A: Physical functioning; B: Body pain; C: Physical role functioning; D: Emotional role functioning; E: Social role functioning; F: Mental health; G: Vitality; H: General health. Compared within group before surgery using paired t test, ***P<0.001; compared to the control group after surgery using independent sample t test, ###P<0.001.

improve patients' GOS scores and their postoperative quality of life, consistent with our results [16].

Compared to conventional decompressive craniotomy that only opens a small bone window, standard large trauma craniotomy provides a better surgical field of view that fully exposes operating areas such as the frontal lobe, temporal lobe, anterior cranial fossa, and middle cranial fossa. Surgeons performing the standard surgery are also able to control lacerated bleeding in the sagittal sinus and petrosal vein and remove all hematoma in the temporal pole and cerebral base. Since CT scan does not always show all the hemorrhagic area in patients with acute bleeding, a wide surgical field of view helps to completely remove the hematoma in the cerebral base [17]. During a standard large trauma craniotomy, a relatively big bone window is created to decrease the intracranial pressure and alleviate the compression against blood vessels in the lateral fissure area caused by cerebral edema. Also, edema aggravated by hypoperfusion due to loss of blood flow to the brain would be decreased, which is conducive to relieving brain hernia [18]. In the end, the use of dural tension-reduced suture can reconstruct a physiologic barrier for the dura mater, which prevents blood leaking into dura mater and the occurrence of complications such as leakage of cerebrospinal fluid through the incision, intracranial infection, hydrocephalus, and adhesions between cortical tissue in the brain [19, 20]. It is important to note that the incision has surgical risks that are high since it removes a large bone flap to create a large bone window. This surgery also damages more physiologic structures in the cranial cavity, resulting in slow recovery and the probability of cerebral tissue dislocation. Also, standard craniotomy removes a whole bone flap to clear the hematoma so as to rapidly reduce intracranial pressure, but edema might occur as a result of ruptured blood vessels in the brain [21]. Our study also showed that there was no significant difference in the incidence of postoperative complications between the two groups, indicating that standard large trauma craniotomy did not differ substantially from conventional craniotomy in terms of the incidence of complications.

Moreover, severe craniocerebral injury results in severe pathological changes in cerebral hemodynamics. Cerebral blood flow velocity will be increased because the injury compresses or displaces blood vessels, which stimulates the vessels and the tissues around them, thereby releasing some vasoactive substances to increase blood flow velocity. Severe craniocerebral injury also disables the blood vessels in performing their regulating role, leading to a decrease in vascular resistance, which accelerates cerebral blood flow. Besides, severe craniocerebral injury damages cell membranes, resulting in the release of more intracellular calcium ions than expected, which increases the permeability of the cell membrane to calcium ions and thus causes vasoconstriction [22, 23]. Therefore, monitoring cerebral hemodynamics is of great value in evaluating the development of craniocerebral injury as well as its degree. This study showed that indicators of cerebral hemodynamics were better improved in the observation group than those in the control group after surgery, suggesting standard large trauma craniotomy is more conducive to improving cerebral hemodynamics and regulating vascular functions than conventional craniotomy. Jiang et al. noted that standard large trauma craniotomy for decompression in patients with severe craniocerebral injury was effective in improving their cerebral hemodynamic changes, which agrees with our study [24]. It was also reported that the quality of life of patients during a 6-month follow-up was markedly better in the observation group than that in the control group, further proving that standard large trauma craniotomy produces beneficial effects on patients' short-term prognosis. However, this study was designed only with a short-term follow-up period with small sample size and a single center. Therefore, further studies are needed to verify these results.

In summary, standard large trauma craniotomy, which can decrease intracranial pressure, improve neurologic function and quality of life, and result in good prognosis, is effective in the treatment of patients with severe craniocerebral injury. In addition, improving prognosis remains the focus of clinical research on the treatment of patients with severe craniocerebral injury. In this research, it was confirmed that standard large trauma craniotomy was effective in treating these patients with improved prognosis. More studies are needed to find out the indications of surgery, and also follow up patients' prognosis.

Disclosure of conflict of interest

None.

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