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*Original Article*

# Clinical effects of intracranial pressure monitoring on traumatic craniocerebral injury prognosis

Xu Yang[1], Shibin Song[2]

[1]*Department of Neurosurgery, The First People's Hospital of Guiyang, Guiyang, Guizhou Province, China;*
[2]*Department of Neurosurgery, Affiliated Hospital of Guizhou Medical University, Guiyang, Guizhou Province, China*

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**Abstract:** Objective: The aim of the current study was to explore the effects of intracranial pressure (ICP) monitoring on the prognosis of patients with traumatic craniocerebral injuries, providing an experimental basis for surgical treatment of craniocerebral injuries. Methods: From January 2015 to December 2017, 100 patients with traumatic brain injuries, admitted to the Department of Neurosurgery at The First People's Hospital of Guiyang, were selected. They were randomly divided into the observation group and control group. Within 24 hours after admission, intracranial hematomas and brain contusions were removed. Patients in the observation group were monitored for ICP, while patients in the control group were not monitored. Hospitalization days, in-hospital mortality rates, incidence rates of extracranial complications, incidence rates of intracranial infections, hospitalization costs, postoperative Glasgow Outcome Scale (GOS) scores, and total amounts of mannitol were compared between the two groups. Results: Hospitalization days and in-hospital mortality rates of patients in the observation group were significantly lower than those in the control group (P=0.003, P=0.047). There were no significant differences in incidence rates of intracranial infection (6.0% vs 8.0%) or incidence rates of extracranial complications (44.0% vs 60.0%). Compared with the control group, hospitalization costs and GOS scores of patients in the observation group, at discharge, were prominently increased. Moreover, the total amount of mannitol decreased markedly, showing statistically significant differences (P=0.013, P<0.001, P=0.026). Conclusion: ICP monitoring can effectively improve the prognosis of patients with craniocerebral injuries. Therefore, it is worthy of clinical promotion.

**Keywords:** Traumatic craniocerebral injury, intracranial pressure monitoring, prognosis, Glasgow outcome scale

## Introduction

Traumatic craniocerebral injuries produce high morbidity and mortality rates [1, 2]. The main cause is an overall increase of intracranial pressure (ICP) [3]. ICP is pressure exerted by the cranial cavity content against the inner wall of the cranial cavity. Increased ICP can lead to a series of serious reactions, including decreases in cerebral perfusion pressure and cerebral blood flow, disorders of blood circulation systems, and obstructions of venous sinus refluxes. These factors, in turn, cause cerebral ischemia and even cerebral hernia, severely endangering patient lives [4, 5]. Evidently, timely detection and treatment of high ICP is one of the important measures of reducing mortality rates of patients with traumatic craniocerebral injuries.

ICP monitoring is a method of dynamically recording and displaying changes of ICP in digital signals, using a probe invasively inserted into the brain [6, 7]. This method plays an important role in effectively monitoring craniocerebral injuries, guiding clinical diagnosis, treatment, and prognosis [8, 9]. However, there are few studies concerning the effects of ICP monitoring at present.

For the present study, 100 patients with traumatic craniocerebral injuries, treated in the Department of Neurosurgery at The First People's Hospital of Guiyang, from January 2015 to December 2017, were selected as study subjects. Effects of ICP monitoring on the prognosis of these patients were investigated, aiming to provide an experimental basis for treatment of traumatic craniocerebral injury patients.

## Materials and methods

*Study subjects*

The current study was approved by the Ethics Committee of The First People's Hospital of Guiyang. Informed consent was obtained for each subject. A total of 100 patients with traumatic craniocerebral injuries were selected as study subjects. They were divided into the observation group (n=50) and control group (n=50), according to the application of invasive ICP monitoring. This was in accordance with patients and family member wishes. Patients in the observation group were monitored by ICP, while those in the control group were not monitored.

Inclusion criteria: patients aged 20-60 years old; Patients with obvious traumatic changes in the brain detected by craniocerebral computed tomography (CT) or magnetic resonance imaging (MR), including brain contusions, intracerebral hematomas, subdural hematomas, and epidural hematomas; Patients with Glasgow Coma Scale (GCS) scores between 6-8 points. GCS scores included eye opening response (1-4 points), verbal response (1-5 points), and motor response (1-6 points); Patients that underwent intracranial hematoma removal or combined decompressive hemicraniectomy within 24 hours after injury; Patients without vital organ injuries in the liver, kidneys, pancreas, and spleen.

Exclusion criteria: patients with spontaneous bleeding, a history of severe chronic disease, or surgical contraindications, such as coagulation abnormalities, were excluded.

*Invasive ICP monitoring*

All patients received craniocerebral CT or MR scans within 24 hours after injury. Patient conditions and specialist assessments were timely evaluated after admission. Upon admission, according to craniocerebral CT or MR results, a clear surgical indication could be confirmed as larger intracranial hematomas, severe brain contusions and midline displacement ≥0.5 cm, and progressively aggravated disturbances of consciousness with less intracranial hematomas, as well as an increase in intracranial hematomas in the repeated brain CT. Therefore, intracranial hematoma removals were performed. Decompressive hemicraniectomy procedures were carried out when necessary. Preoperative treatments, including electrocardiogram monitoring, oxygen inhalation, and other routine treatments, were performed. Patients with dyspnea were assisted with breathing using a ventilator after an artificial airway was established. Moreover, hemostasis, venous channel establishment, and anti-shock treatments were conducted in patients with open injuries.

The invasive ICP monitor (CAMINO MPM-1, Codman) was manufactured by Johnson & Johnson. Methods were as follows [10]: after clearing the intracranial hematomas, the probe was taken out from the ICP monitoring suit. After connecting the device, the probe was placed at a depth of 1 mm under the surface of the normal saline to record the calibration value. At the medial margin of incision, a puncture needle was inserted into the tissues under galea aponeurotica. Next, the needle was removed at more than 7 cm from the incision. Monitoring sensor lines were subcutaneously implanted and placed in the brain parenchyma. All operations were performed in accordance with aseptic techniques, with postoperative ICP changes closely observed.

*Outcome measures*

Main outcome measures included incidence rates of intracranial infections and extracranial complications. These were compared between the two groups. Extracranial complications included wound infections, pulmonary infections, arteriovenous thrombosis in the lower extremities, and liver/kidney damage. Postoperative Glasgow Outcome Scale (GOS) scores and total amounts of mannitol in the two groups of patients were also compared [11]. GOS scores were assessed at discharge. Assessment criteria were as follows: 1) Good recovery (5 points): good recovery of neurological function, normal working and learning, and no obvious appearance in brain CT or MR scans; 2) Moderate disability (4 points): there existed some neurological or mental disorders. However, the patients could take care of their lives basically by themselves. Brain CT or MR examinations were basically normal; 3) Severe disability (3 points): patients showed serious functional or mental disorders and needed to be

**Table 1.** Comparison of general data

| Group | Observation group (n=50) | Control group (n=50) | $t/\chi^2$ | P |
|---|---|---|---|---|
| Age (years) | 39.6±2.5 | 41.2±2.8 | 0.716 | 0.513 |
| Gender (male/female) | 32/18 | 35/15 | 0.407 | 0.523 |
| GCS score | 9.7±0.8 | 9.4±0.6 | 0.710 | 0.631 |
| Cause of injury | | | 0.233 | 0.629 |
| Traffic injury | 38 | 40 | | |
| Fall injury | 12 | 10 | | |
| Type of cerebral hematoma | | | 0.668 | 0.716 |
| Intracerebral hematoma | 19 | 16 | | |
| Subdural hematoma | 20 | 24 | | |
| Epidural hematoma | 11 | 10 | | |

Note: GCS, Glasgow Coma Scale.

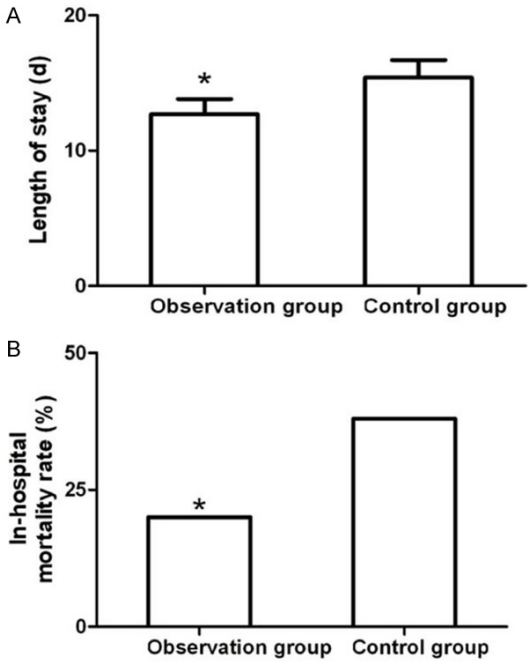


**Figure 1.** Comparison of hospitalization days and in-hospital mortality rates in the two groups of patients. A: Hospitalization days; B: In-hospital mortality rates. Compared with the control group, *P<0.05.

cared for. Brain CT or MR examinations were remarkably better after admission; 4) Persistent vegetative state (2 points): patients were in prolonged comas or coma vigils, with no prominent changes in general data, compared with those before admission. Patients showed no response or even showed worsened conditions after lengthy treatment; and 5) Death (1 point): postoperative death.

Minor outcome measures included hospitalization days, in-hospital mortality rates, and hospitalization costs. These measures were compared between the two groups of patients.

*Statistical analysis*

Statistical analyses were performed with SPSS20.0 software. Measurement data are expressed as mean ± standard deviation ($\bar{x}$ ± sd). The two sets of measurement data that met normal distribution were compared using independent sample t-tests. Enumeration data are presented as percentages. Comparisons between the groups were tested by Chi-square and Fisher's exact tests, represented as $\chi^2$. P<0.05 suggests significant differences.

## Results

*Comparison of general data*

There were no statistically significant differences between the two groups in terms of age, gender, GCS, causes of injury, and types of brain injury. Thus, relevant data of two groups were comparable (P>0.05). See **Table 1**.

*Comparison of hospitalization days and in-hospital mortality rates*

Hospitalization days of the observation group were (12.7±1.1) days and the in-hospital mortality rate was 20.0% (10/50), while those in the control group were (15.4±1.3) days and 38.0% (19/50), respectively. Statistically significant differences (t=3.849, P=0.003; $\chi^2$= 3.934, P=0.047) were shown. See **Figure 1**.

*Comparison of incidence of complications*

Incidence rates of intracranial infections and extracranial complications in the observation group were 6.0% (3/50) and 44.0% (22/50), respectively. Those in the control group were 8.0% (4/50) and 60.0% (30/50), respectively, without statistically significant differences (P=0.695, P=0.109). See **Figure 2**.

*Comparison of hospitalization costs*

Hospitalization costs of patients in the observation group were obviously higher than those

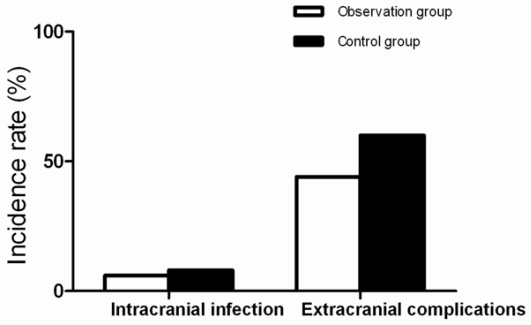


**Figure 2.** Comparison of incidence of complications in the two groups of patients.

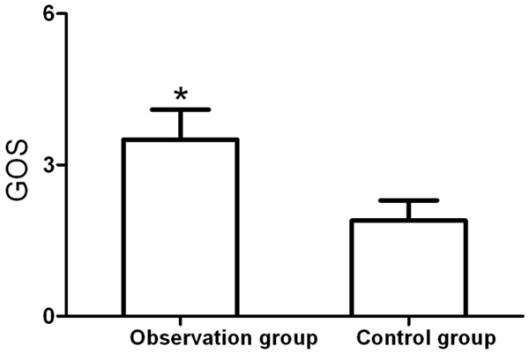


**Figure 3.** Comparison of GOS scores in the two groups of patients. Compared with the control group, *P<0.001.

in the control group ((125±32 vs 87±25) thousand Yuan). Differences were statistically significant (t=2.800, P=0.013).

*Comparison of GOS scores*

At discharge, GOS scores in the observation group ((3.5±0.6) points) were significantly higher than those in the control group ((1.9±0.4) points) (t=5.435, P<0.001). See **Figure 3**.

*Comparison of total amount of mannitol*

The total amount of mannitol in the observation group was (5.6±1.2) L, apparently lower than that in the control group ((6.9±1.4) L). Differences were statistically significant (t= 3.437, P=0.026). See **Figure 4**.

## Discussion

Traumatic craniocerebral injuries, with rapid development, high mortality rates, and poor prognosis, have become a challenging social problem, as well as a major cause of death

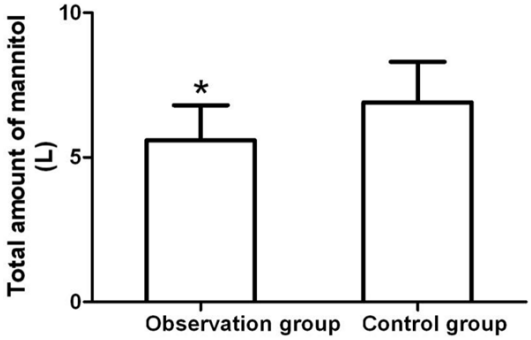


**Figure 4.** Comparison of total amount of mannitol in the two groups of patients. Compared with the control group, *P=0.026.

after cancer and cardiovascular disease [12, 13]. One epidemiological investigation showed that the mortality rate of traumatic craniocerebral injuries reached up to 30% [14]. Poor prognosis of this disease can mainly be attributed to an increase in ICP. Therefore, it is of great importance to actively prevent and control the increase of ICP.

Using invasive ICP monitoring surgery, real-time changes of ICP are monitored by the sensor probe in the brain, adjusting blood pressure in time, controlling brain edema, and keeping a balance between ICP and blood pressure. This helps in maintaining normal cerebral perfusion pressure. Thus, this method can help to better patient prognosis, improve patient survival rates, and improve quality of life [15]. Results of the current study showed that invasive ICP monitoring did not increase the risk of intracranial infections in patients. It depended upon the Codman ICP monitoring probe with the advantages of less floatability and swing, more sensitivity, and increased accuracy in recording ICP values. In addition, brain parenchyma placement of the ICP probe, instead of ventricular type pressure monitoring, reduced risks of infection [16]. Moreover, intraoperative aseptic techniques were strictly conducted with gentle movements, avoiding new brain injuries because of ICP probe insertion. Daily medication changes, postoperatively, were conducted to keep the wounds clean and dry. Finally, the probe was withdrawn timely after patient conditions were stabilized. This reduced the possibility of implantation and retrograde infections. Differences in incidence rates of extracranial complications between the two groups of patients were not statistically significant. This

may be due to the severe primary disease and lack of timely intervention.

One retrospective study showed that ICP monitoring could effectively improve in-hospital survival rates of patients with craniocerebral injuries [17]. Results of a mortality analysis of patients with brain injuries after 2 weeks of hospitalization, as reported by Farahvar et al., illustrated that, in comparison with patients without monitoring, the risk of death in those receiving ICP monitoring was effectively reduced [18]. Results of this study elucidated that hospitalization days and in-hospital mortality rates in patients with invasive intracranial monitoring were notably lower than those in the control group. Moreover, GOS scores at discharge were markedly higher than those in the control group, with statistically significant differences. With ICP monitoring, patient conditions could be effectively treated, with the prognosis of patients showing improvement. During the treatment of craniocerebral injuries, treatment regimens were adjusted in time according to changes in ICP. Results were basically consistent with those reported by Cnossen et al. [19].

The study demonstrated that factors, such as the increase of cerebral blood flow by reducing ICP, inappropriate use of antidiuretic hormones, overuse of tranquilizers and muscle relaxants, and excessive drainage of cerebrospinal fluid, could increase patient mortality rates [20]. Although it is one of the main methods for reduction of ICP, the use of mannitol for osmotic diuresis has been suggested to increase mortality rates of patients with brain injuries, as it resulted in insufficient blood volume and further lowered the blood pressure [21]. Results of this study illustrated that, compared with the control group, the total amount of mannitol in the observation group was significantly reduced. This indicates that the amount of mannitol can be controlled with the help of invasive ICP monitoring, avoiding complications, such as cerebral hypoperfusion, caused by overuse of mannitol. Additionally, in patients with ICP monitoring, hospitalization costs were obviously higher than in those without ICP monitoring, in accord with findings reported by Zapata-Vazquez et al. [22]. On one hand, the high costs of ICP monitoring, including consumables and nursing, accounted for a certain proportion of hospitalization costs. In contrast, timely adjustments of medications according to real-time monitoring of ICP could lead to an increase in drug use and hospitalization costs. There were several limitations to the present study, including an insufficient sample size. It was also and a single-center study. Larger sample sizes and multi-center trials are warranted for future studies.

In conclusion, ICP monitoring in the brain parenchyma does not increase incidence rates of intracranial infections in patients. Moreover, it significantly reduces hospitalization days, in-hospital mortality rates, and total amount of mannitol. Furthermore, it prominently increases GOS scores, at discharge, and improves patient prognosis. These factors are important in guiding the clinical treatment of patients with severe craniocerebral injuries.

## Disclosure of conflict of interest

None.

**Address correspondence to:** Xu Yang, Department of Neurosurgery, The First People's Hospital of Guiyang, Guiyang 550002, No. 97 Boai Road, Guizhou Province, China. Tel: +86-13985151610; E-mail: yangxugy1h@163.com

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