# Prognostic Impact of Intracranial Pressure Monitoring in Patients with Severe Traumatic Brain Injury

## *Impacto prognóstico da monitorização da pressão intracraniana em pacientes com traumatismo cranioencefálico grave*

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**Abstract**

**Objectives** The aim of the present study was to analyze the prognostic impact of intracranial pressure (ICP) monitoring in patients with severe traumatic brain injury (TBI).

**Methods** An observational, retrospective and quantitative study was performed. The sample consisted of 246 patients diagnosed with severe TBI, from January 2009 to August 2017.

**Results** Out of the total sample, 43.56% of the patients were submitted to ICP monitoring. The mean time of use of the catheter was 1.7 days. In both groups, males were the most affected, and the majority of the patients were $< 50$ years old. Automobile accident was the main etiology of TBI. In the initial clinical evaluation, mydriatic pupils were related to death and normal pupil reaction at hospital discharge. The monitored group performed a larger number of computed tomography (CT) scans, with a mean of 2.6 examinations, with cerebral edema being the most common finding. Regarding the prognosis, those who used a catheter for ICP monitoring had a 47% reduction in the chance of death when compared with those who did not use the catheter. The stay duration both in the hospital and in the intensive care units was higher in patients who underwent ICP monitoring; periods $> 30$ days were related to meningitis, especially in those who used the catheter.

**Conclusion** Patients who used a catheter for ICP monitoring had a significant improvement in survival.

**Keywords**
- traumatic brain injury
- intracranial pressure
- prognosis

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## Resumo

**Objetivos** O objetivo do presente estudo foi verificar o impacto prognóstico da monitorização da pressão intracraniana (PIC) em pacientes com traumatismo cranioencefálico (TCE) grave.

**Métodos** Foi realizado um estudo observacional, retrospectivo e de natureza quantitativa. A amostra foi composta por 246 pacientes com diagnóstico de TCE grave no período de janeiro de 2009 a agosto de 2017.

**Resultados** Da amostra total, 43,56% dos pacientes foram submetidos à monitorização da PIC. O tempo médio de uso do cateter foi de 1,7 dias. Em ambos os grupos, o gênero masculino foi o mais acometido, e a idade da maior parte dos pacientes era $< 50$ anos. Acidente automobilístico foi a principal etiologia do TCE. Na avaliação clínica inicial, pupilas midriáticas relacionaram-se ao óbito, e pupilas isofotorreagentes à alta hospitalar. O grupo monitorizado foi submetido a uma quantidade maior de exames de tomografia computadorizada (TC) do crânio, com uma média de 2,6 exames, sendo edema cerebral o achado mais comum. Quanto ao prognóstico, os pacientes que utilizaram cateter para monitorização da PIC tiveram uma redução de chance de ir a óbito de 47% quando comparados aos que não utilizaram o cateter. O tempo de permanência hospitalar e na unidade de terapia intensiva foi maior para aqueles que receberam monitorização da PIC, sendo que períodos $> 30$ dias se relacionaram com meningite, principalmente naqueles que utilizaram o cateter.

**Conclusão** Pacientes que utilizaram cateter para monitorização da PIC tiveram melhora significativa da sobrevida.



**Palavras-chave**

- traumatismo cranioencefálico
- pressão intracraniana
- prognóstico


## Introduction

Traumatic brain injury (TBI) constitutes a relevant socioeconomic problem throughout the world and is considered a major cause of death and incapacity, especially in individuals $< 45$ years old.[1,2] In Brazil, the mortality rates are influenced by several factors, and may reach 37% in some regions of the country.[3]

Intracranial pressure (ICP) reflects the connection between the internal contents of the cranial cavity—which is composed primarily of cerebrospinal fluid (CSF), the brain, and blood—and the volume of the skull. When the structures that make up the skull are submitted to the same force, they respond differently, since they have different densities, which can lead to an increase of the ICP.[4–6]

According to the guidelines of the Brain Trauma Foundation (BTF), ICP monitoring should be considered as part of the standard care in patients suffering from severe TBI. In Brazil, however, the Recommendations Report of the National Commission for the Integration of Information Technology, published in 2014 by the Brazilian Unified Health System (SUS, in the Portuguese acronym) under the title CONITEC 125, does not recommend this practice because of the lack of clinical effectiveness of the procedure. – This is contrary to the international and national guidelines, as well as to the recommendations of the medical societies of the specialty.[7–11]

Therefore, the present study aimed to verify the prognosis of patients with severe TBI who underwent ICP monitoring when compared with those who did not undergo the procedure.

## Materials and Methods

An observational, retrospective and quantitative study was performed.

### Ethical Aspects

The present study only started after being approved by the Human Research Ethics Committee (CEP, in the Portuguese acronym) of the Universidade do Extremo Sul Catarinense (UNESC), under the number 2.271.904, and by the CEP of the Hospital São José, under the number 2.604.092.

### Samples and Observational Groups

The sample was collected in a hospital in Criciúma, in the state of Santa Catarina, Brazil. Patients who had been diagnosed with severe TBI ($n = 129$) and patients who used intraventricular catheters to monitor ICP due to severe TBI ($n = 134$) between January 2009 and August 2017 were selected. Patients who either had been diagnosed with pathologies different from severe TBI, were $< 18$ years old, or who needed immediate neurosurgery at admission were excluded from the study.

### Procedures

A data collection instrument was developed aiming to evaluate the main variables of interest of the research, which allowed the comparison with other studies previously performed on the same topic. The instrument evaluated four main domains: the epidemiological profile of the population,

the initial clinical evaluation, the radiological evaluation, and the outcome of the case.

At the initial clinical evaluation, patients with TBI, with Glasgow Coma Scale scores between 3 and 4 and presenting with mydriatic pupils were considered as subjects with a reserved prognosis.

### Statistical Analysis

Data analysis was performed with SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). The qualitative variables were expressed by frequency and percentage, and the quantitative variables by average and standard deviation (SD), when they presented normal and average distribution, and by interquartile range when they did not follow this type of distribution. The normality tests used were the Shapiro-Wilk and the Kolmogorov-Smirnov tests.

The statistical analysis was performed by applying the Mann-Whitney U test, the Pearson chi-squared test, and the Fisher Exact test, with a relevance level of $p = 0.05$; the analysis of residues was performed when a statistical significance was observed. The magnitude of the association found was investigated by odds ratio (OR).

## Results

The group that received ICP monitoring corresponds to 47.56% ($n = 117$) of the sample, with an average of 1.7 days of use of the catheter. Both in those who were and the ones who were not submitted to ICP monitoring, males were the most affected, with a prevalence of $> 80\%$ of the individuals evaluated ($p = 0.392$).

The age ranged between 18 and 88 years old, and 72.76% of the patients were $< 50$ years old. The group receiving ICP monitoring was younger, with an average age of 36.38 years old and a SD of 17.05 years. The average age of the other group was $39.78 \pm 18.14$ years old ($p = 0.135$).

The main cause of TBI in the present study was an automobile accident, which was also the main etiology in those who underwent ICP monitoring. In those who did not use the catheter, other trauma mechanisms, such as aggression, gunshot wounds, and being run over by a car, were more common ($p = 0.001$). (►**Fig. 1**)

In the initial clinical examination of the patients with severe TBI, the mydriatic pupillary pattern was related to death, and normal pupil reaction pupils were related to hospital discharge ($p < 0.001$). The use of the catheter was related both to the normal pupil reaction-pupils and to the miotic pupils ($p = 0.003$).

Regarding the performance of cranial computed tomography (CT) scans, the monitored group was submitted to a larger number of exams, with an average of 2.6 examinations ($p < 0.001$), and the most common finding being cerebral edema. In relation to the patients who were monitored, the finding of subdural hematoma ($p = 0.014$) and of midline deviation ($p = 0.026$) was statistically significant when compared with the other group.

Regarding the length of hospital stay, the group of patients who underwent ICP monitoring were hospitalized for a longer time ($p < 0.001$) and remained longer in the intensive care unit (ICU) than the other group ($p = 0.005$). (►**Table 1**)

When analyzing the prognosis of the patients, there is statistically significant evidence that the individuals who used the catheter for ICP monitoring have a 47% chance of dying, as opposed to the group that did not receive this monitoring (OR = 0.53; 95% confidence interval [CI] 0.31–0.90; $p = 0.009$).

Regarding the complications, a statistically significant correlation between a hospital stay $> 30$ days and the development of meningitis ($p < 0.001$) was shown, with the majority of these patients being submitted to ICP monitoring, although the expected outcome for these patients ($p = 0.018$) had no correlation with the number of days of catheter use ($p = 0.210$). In addition, no statistically significant correlation was found between the duration of catheter use, and other complications, such as infection at the place of the surgical wound, and/or ventriculitis.

The monitored group was more likely to have motor deficit at hospital discharge ($p = 0.036$) and to need to progress to decompression 24 hours after being admitted to the hospital. In contrast, unmonitored patients had a

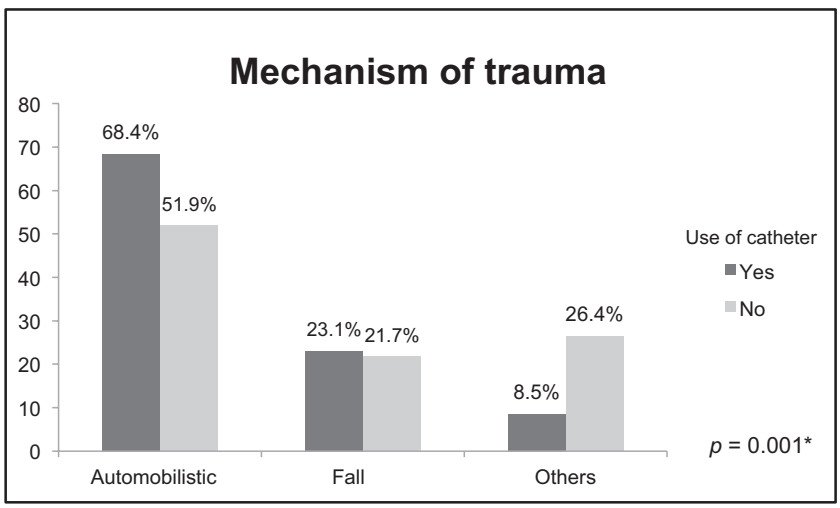


**Fig. 1** Mechanism of trauma. *Value obtained after Pearson chi-square test. Others: trampling, assault and gunshot wounds.

**Table 1** Length of hospital stay and in intensive care unit

| Variables | Use of catheter, *n* (%) | | *p*-value |
|---|---|---|---|
| | Yes | No | |
| | *n* = 117 | *n* = 129 | |
| Days of hospitalization † | | | |
| 0–10 | 14 (12.0) | 70 (54.3)[b] | < 0.001** |
| 11–20 | 35 (29.9) | 28 (21.7) | |
| 21–30 | 54 (46.2)[b] | 20 (15.5) | |
| > 30 | 14 (12.0) | 11 (8.5) | |
| Days of hospitalization †† | 10.00 (6–15.5) | 4.00 (1–13) | 0.005* |

* Value obtained after application of Mann-Whitney U test.
** Value obtained after Pearson chi-squared test.
†Days of total hospital stay.
††Days of hospitalization in the intensive care unit (values expressed in median and interquartile range).
[b]Statistically significant value after the residue analysis.

**Table 2** Characteristics of patients who were managed with and without intracranial pressure monitoring

| Variables | Use of catheter, *n* (%) | | *p*-value |
|---|---|---|---|
| | Yes | No | |
| | *n* = 117 | *n* = 129 | |
| Reserved prognosis | | | |
| Yes | 2 (1.7) | 48 (37.2) | < 0.001* |
| No | 114 (98.3)[b] | 81 (62.8) | |
| Need for decompression | | | |
| Yes | 54 (52.9)[b] | 26 (20.2) | < 0.001* |
| No | 48 (47.1) | 103 (5.2) | |
| Motor deficit at hospital discharge | | | |
| No | 103 (45.6) | 123 (54.4) | 0.036* |
| Yes | 14 (70.0)[b] | 6 (30.0) | |

*Value obtained after Pearson chi-squared test.
[b]Statistically significant value after the residue analysis.

higher predicted rate of guarded prognosis in the initial evaluation. (►**Table 2**)

## Discussion

The main outcome of the present study was that the use of the catheter for ICP monitoring is related to reduction in the mortality rate (OR = 0.53; 95% CI: 0.31–0.90) of patients with severe TBI. Intracranial pressure monitoring is indicated in all patients with severe TBI, that is, those who present a score between 3 and 8 points in the Glasgow Coma Scale and have an abnormal cranial CT scan. In some cases, even with an unchanged CT, monitoring is indicated if 2 or more of the following characteristics are observed at the time of admission: pathological posture, age > 40 years old, or systolic blood pressure < 90 mmHg.[8,12]

Increased ICP is the leading cause of death and sequelae following severe brain injury, predominantly within the first 48 hours after the injury.[13] Intracranial pressure monitoring helps to recognize these elevations in PIC, allowing for early interventions that can control secondary damage due to increasing pressure within the rigid skullcap.[2,14] In the evaluated sample, more than 50% of the patients who used the catheter for ICP monitoring evolved for decompression, confirming the efficacy of the method in interpreting pressure variations early, thus allowing for a more appropriate clinical-surgical approach.[15,16]

The present study reinforces data from other authors that have demonstrated a positive association between ICP monitoring and mortality reduction in these patients.[2,12,17,18] However, some authors question its efficacy, demonstrating negative results with ICP monitoring.[19–22] These studies have some limitations, such as the non-recognition of the cause of death and the non-measurement of the CT findings of the patients.

In the present study, more than 80% of the patients in both groups were male. Similar data have already been reported previously, even showing proportions > 3.5 men affected for each woman.[23,24] This finding can be attributed to the greater exposure of males to TBI risk factors, such as auto accidents and urban violence.[25]

Regarding the age group, a higher prevalence of severe TBI was observed in young adults, and the population < 50 years old corresponded to > 70% of the sample. This is a period of life with greater exposure to traumatic injuries, which is in line with the data that defines automobile accidents as being the main etiology of TBI in the present study, as reported by other authors.[24,26,27]

In the initial clinical examination, there was a correlation between the finding of mydriasis and the clinical outcome of death. This finding in trauma patients suggests a mechanical compression of the third cranial nerve or a decrease in the blood flow to the brainstem.[28,29] Other authors have already demonstrated this association as the worst indicator of the outcome of the patient, although the definition of the prognosis depends on other factors, such as hospital interventions and resuscitation measures.[29–31] In the present study, no difference was observed in the frequency of pupillary alterations between groups, unlike other authors who correlate abnormal pupillary reactions and greater amount of catheter insertion for ICP monitoring.[32]

Patients who undergo ICP monitoring tend to have a longer hospital and intensive care unit stay than those who are not submitted to the procedure.[6,19] In the present study, the data were reconfirmed before and after the exclusion of the patients who died, possibly due to the longer survival of these patients when compared with the non-monitored group.[12,33]

There was an association between the use of the catheter and the development of meningitis, a complication already described by other authors, who correlate it with a monitoring time > 5 days.[34] In the present study, there was no statistical significance regarding this temporal correlation,

since the patients who developed meningitis had an average time of use of the catheter of 3.53 (SD: 1.92) days. The insertion of the catheter itself is considered as an independent risk factor for the development of meningitis.[8,35] Moreover, other factors found in the present study contribute to this finding, such as prolonged hospital and ICU stay, as well as the TBI itself.[35]

The patients who received ICP monitoring underwent a larger number of CT scans, probably due to the increased hospital stay and to the necessity of severe TBI control. Cerebral edema was the most common finding, present in 59% of the CT scans performed. The literature reports that cerebral edema appears between 24 and 48 hours after the trauma, due to fluid accumulation, and it can be considered as a predictive factor of increased ICP.[36]

When comparing the two groups, we observed a higher frequency of subdural hematoma in those who received ICP monitoring. However, we did not find a relation between this finding and a worse prognosis, as has been described in other studies.[27,37] Although there is no specific correlation between CT findings and ICP value, this is the examination of choice for patients with severe TBI because it allows the etiological diagnosis and indicates findings suggestive of intracranial hypertension.

The present study has some limitations, such as the impossibility of performing a periodic follow-up of the patients after they were discharged. Although the association between catheter use and a greater amount of motor deficit at the time of the discharge was verified, it was not possible to describe the long-term clinical outcome.

Furthermore, the guidelines regarding the use of the catheter for ICP monitoring do not constitute a universal protocol, and the final decision involves multiple factors, among them the clinical condition of the patient and the judgment of the neurosurgeon. Therefore, it is possible to presume a reserved prognosis, in which the real perspective of recovery can be considered null and the use of certain procedures presents a smaller benefit than its possible complications.

We suggest new studies that contemplate protocols for a more uniform selection of patients, excluding the selection bias, which may differ greatly when indicated by different professionals, modifying the final results.

## Conclusion

In the present study, it was evidenced that the use of the catheter for ICP monitoring was associated with lower hospital mortality, suggesting that this is a predictor of improvement in the prognosis of the patients submitted to ICP monitoring. This is due to the sensitivity of the method regarding an early diagnosis of increases in the ICP, which enables a prompter intervention and reduces possible sequelae due to hypoxia or ischemia secondary to intracranial hypertension.

### Conflicts of Interest

The authors have no conflicts of interest to declare.

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