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Intracranial Pressure and Cerebral Perfusion Pressure against Clinical and Imagenological Monitoring in Patients with Severe Traumatic Brain Injury: Experience of a Single Cuban Hospital

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Abstract

Background: Traumatic brain injury (TBI) is one of the major causes of morbidity, disability and mortality worldwide. Ciego de Avila province in Cuba has an extension of 6 810.36km^2, with population's density of 54.8/km^2 and the gross accident mortality was 41.7/100 000 in 2013. TBI has represented the main cause of attention in the neurotrauma center located at Moron General Hospital in the last 20 years.

Method: A case-control study was carried out with all patients admitted in the Intensive Care Unit of Moron General Hospital in Ciego de Avila, Cuba, with diagnosis of severe TBI in the period between January 2010 and December 2012.

Results: The sample was constituted by 96 patients, 56 (58.33%), were assigned to Group I (ICP and CPP monitoring) and 40 (41.67%) to Group II (clinical and CT scan monitoring). The difference between groups related with satisfactory recovery was 15.36% (Group I: 36 patients, 67.86%. Group II: 21 cases, 52.5%). Conclusion: The ICP and CPP continuous monitoring had a positive influence on the results in patients with severe head trauma.

Keywords: Intracranial Pressure; Traumatic brain injury; Disability; Cerebral Perfusion

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Background

Traumatic brain injury (TBI) is one of the major causes of morbidity, disability and mortality worldwide. In the US, an estimated 1.5 million people sustain TBI, resulting in over 50,000 deaths and 500,000 individuals with permanent neurological sequelae [1]. In Cuba don't exist data about the mortality for TBI, but the gross accident mortality was from 44.3/100 000 in 2000 to 44.2/100 000 in 2013 [2]. The Ciego de Avila province has an extension of 6 810.36Km^2, with population's density of 54.8/km^2 and the gross accident mortality was 41.7/100 000 in 2013 [2]. TBI has represented the main cause of attention in the neurotrauma center located at Moron General Hospital in the last 20 years.

Elevated intracranial pressure is one of the most common causes of death and disability following severe TBI. It is a clinical condition that can result in brainstem compression and compromised brain circulation, therefore, monitoring of intracranial pressure (ICP) is a reasonable approach to know the behavior of this parameter and to identify events of intracranial hypertension in these patients, however the efficacy of treatment based on ICP monitoring in improving the outcome has not been rigorously assessed and the guidelines for the management of severe TBI have documented the inadequate evidence related with this theme [3-5].

No clear consensus and considerable variation in practice in the management of TBI patients has been found worldwide [6]. A survey published in 2004 with the data of 17 Cuban hospitals treating patients with severe TBI looking for the use of ICP monitoring, reported that only in eight centers neuromonitoring was used to guide the treatment protocol and in five it had never been used [7].

The departments of Neurosurgery and Intensive Care Unit at Moron General Hospital are leaders in Cuba using ICP monitoring for the management of patients with severe TBI. The aims

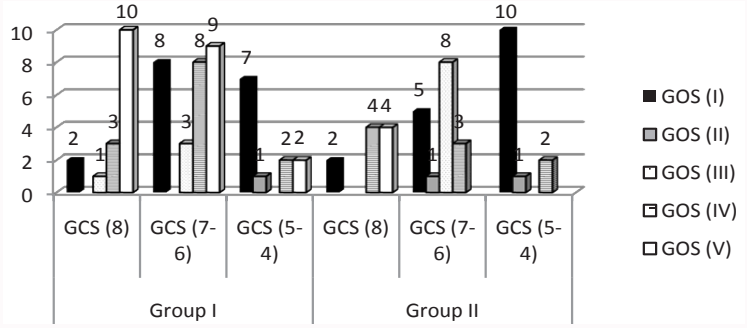

Figure 1: Relation between GCS on admission and GOS.

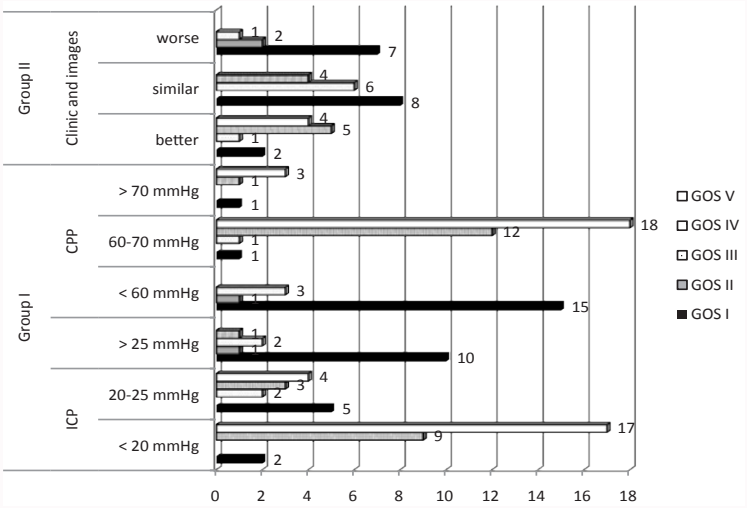

Figure 2: Relation between monitoring parameters and GOS.

of this study were to evaluate the efficacy of the analysis of the information obtained with this technique as guide for the adoption of different treatment modalities and to compare with another group of patient in those that was used clinical and sequential computed tomography (CT) scan monitoring looking for the general results.

Patients and Methods

A case-control study was carried out with all patients admitted in the Intensive Care Unit of Moron General Hospital in Ciego de Avila, Cuba, with diagnosis of severe TBI in the period between January 2010 and December 2012.

The patients were assigned to one of the two groups in accordance with the modality of monitoring used without randomization. In Group I, were included patients with clinical and CT scan monitoring plus continuous ICP and cerebral perfusion pressure (CPP) monitoring. The patients with only clinical and CT scan monitoring were assigned to Group II. The clinical status on admission was evaluated by the Glasgow Coma Scale score (GCS).

The inclusion criteria were: Patients older than 18 years and younger than 60. Initial Glasgow Coma Scale (GCS) scores greater than 4 and less than 9 or patients deteriorating to GCS score ≤ 8 within 48h of injury. An abnormal admission CT scan or a normal CT scan associated with two of the following three conditions: Abnormal posture, median systemic blood pressure (MSBP) ≤ 90mmHg and age >40 years old. Start the monitorization and treatment within 12 hours after trauma. Absence of associate trauma.

The study exclusion criteria were: Patients younger than 18 and older than 60. GCS score of 3 and bilateral fixed and dilated pupils and those with an injury believed to be unsurvivable. Normal CT scan. Presence of associated trauma or coagulopathy (prothrombin time > 12.2 seconds, platelet count < 100 × 103/μl. Patients taking anticoagulation medications or antiplatelets or with liver cirrhosis were also excluded. Patients who did not have a follow-up at 6 months were all excluded too.

All patients in the study were treated in the ICU with the availability of continuous ICP monitoring with the use of either an external ventricular drain or a parenchymal catheter. Patients received treatment for intracranial hypertension whenever the intracranial pressure was greater than 20mmHg.

In all patients a CT scans was obtained at baseline, 72 hours, and 7 days. A CT scan was emergently obtained in patients with ICP value ≥20 mmHg refractory to medical treatment for 15 minutes and in patients with progressive neurological deterioration ≥ 2 point of GCS. The images evaluation was carried out in accordance with Marshall´s classification.

Standard supportive care was provided for each patient, with care to include cardiovascular and respiratory monitor, artificial mechanical ventilation, sedation, and analgesia.

The care for patients assigned to the clinical and imaging examination group was provided in accordance with the hospital protocol for patients with severe TBI. After intracranial mass

lesions were evacuated or in the absence of intracranial mass lesions requiring surgery, patients always were treated with elevation of the head 20ºC, hemodynamic stabilization, intravenous administration of mannitol 20% in intermittent boluses (0.25g/kg/dose/4hours), controlled mild hyperventilation ($PaCO_2$:30-35mmHg), muscle relaxation if indicated. Decompressive craniectomy (DC) was performed in patients with progressive neurological deterioration (GCS≥2 point) refractory to medical therapy with postural or pupillary alterations and associated with sequential CT scan showing imagenological worsening with midline shift≥5mm and effacement of perimesencephalic cistern. Barbiturate medication was used only after DC in patients with refractory clinical and imagenological intracranial hypertension.

Patients assigned to the pressure-monitoring group had an intraventricular or intraparenchymal monitor placed as soon as possible and were treated to maintain an intracranial pressure of less than 20mmHg and CPP greater than 60mmHg. The general therapies were the same for two groups. Drainage of cerebrospinal fluid was the first treatment option in this group and the others therapies were used for ICP ≥20mmHg, as it has been proposed in the guidelines for the management of severe TBI [3,4]. The administration of hyperosmolar agents and mild to moderate hyperventilation depended of the jugular oxygen saturation (SjO_2), obtained through a catheter in the jugular bulb. Patients with hyperemic pattern were treated with hyperventilation and those with ischemic pattern with mannitol. DC was used in the group considering clinical-imagenological status but with ICP ≥20mmHg for more than 15 minutes refractory to medical therapies.

The age, interval from traumatic event to surgery or starting the treatment, clinical examination, side and location of the intracranial lesions, number of affected lobules, morbidity and mortality were recorded as primary end points. Mortality and functional outcome was defined by Glasgow Outcome Scale (GOS) at five years after hospital discharge. The results were dichotomized in satisfactory recovery (Grades III, IV, V) and non-satisfactory recovery (Grades I, II).

The Chi squared test was used to determine the presence of statistical association among categorical variables. The U of Mann-Whitney test was also applied for the comparison of medians in quantitative variables for the case that the variables don't follow a normal distribution; the technique of ANOVA was also applied to find statistical differences among medians.

Results

The sample was constituted by 96 patients, 56 (58.33%), were assigned to Group I and 40 (41.67%) to Group II. The median age for all patients was 53.2 years old.

The GCS on admission and its relation with GOS is showed in Figure 1. The percentages of patient in different categories, keep a great similarity to each other for both treatment groups, what was corroborated when analyzing the result of the U of Mann-Whitney test: -0,961 p = 0,336 (p ≥0,05), what indicates that the distribution of patient according to the categories is not significantly different for one or another study group. The biggest frequency in both groups was the category GCS 6-7 points, 28 (50%) in Group I and 17 (42.5%) in Group II. In Group I, 16 patients (28.57%) were admitted with GCS 8, 14 (87.5%) survived, 10 (62.5%) had GOS V and two cases died (12.5%). Patients with GCS 7-6, 20 (71.43%) survived, nine (32.14%) had GOS V, and eight (28.57%) died. The worst results were found in patients admitted with GCS 5-4. 12 (21.43%) cases were in this category, seven (58.33%) died (more than half of the cases), and only two patients had GOS V. In Group II, 10 (25%) were admitted with GCS 8, eight (80%) survived and fourth (40%) had GOS V, two (20%) died. Patients with GCS 7-6, 11 (64.71%) survived, none of them had GOS V and five (29.41) died. 13 (32.5%) were admitted with GCS 5-4, 10 (76.92%) died and only three (23.08%) survived.

Table 1: Marshall´s classification of CT scan images on admission.

Classification of images	Group I		Group II		Total	
	No.	%	No.	%	No.	%
DAL grade II	7	12,5	0	0,0	7	7,29
DAL grade III	12	21,43	7	17,5	19	19,79
DAL grade IV	13	23,21	9	22,5	22	22,92
Non evacuated mass lesion	24	42,86	24	60,0	48	50,0
Evacuated mass lesion	-	-	-	-	-	-
Total	56	100,0	40	100,0	96	100,0

Note: DAL (Diffuse Axonal Lesion), Chi-squared of Pearson (Statistical exact of Fisher): 7,004; p = 0,133 (p > 0,05).

Table 2: Results in both groups according with GOS.

GOS at six month of discharge	Group I		Group II		Total	
	No.	%	No.	%	No.	%
Grade I	17	30,4	17	42,5	34	35,4
Grade II	1	1,8	2	5,0	3	3,1
Grade III	4	7,1	8	20,0	12	12,5
Grade IV	13	23,2	9	22,5	22	22,9
Grade V	21	37,5	4	10,0	25	26,0
Total	56	100,0	40	100,0	96	100,0

U of Mann-Whitney: -2,644; p = 0,008 (p < 0,05).

The acquired images on admission are summarized in Table 1, where is observed that the predominant images were not evacuated mass lesions for both groups, 24 patients (42.86%) in Group I and 24 (60%) in Group II.

The relation between the monitoring parameters in both Groups with GOS is summarized in Figure 2. In Group I: 28 (50%) had ICP < 20mmHg after treatment implementation, 26 of them (92.86%) (p≤0,000) survived with satisfactory recovery and 2 patients died (7.14%). 14 (25%) had ICP 20-25 mmHg, 9 of them (64.29%) survived with mortality of 5 (35.71%). 14 patients (25%) had ICP > 25mmHg and mortality, 10 (71.43%) was higher than survivors 4 (28.57%), unsatisfactory recovery prevailed in 11 patients (78.57%). The behavior of CPP showed a hard relation between values<60mmHg and mortality. 19 patients (33.93%) was in that category, 15 of them (78.95%) (p≤0,000) died. 37 patients (66.07%) had CPP > 60mmHg, 35 of them (94.59%) (p≤0,000) survived with satisfactory recovery. In Group II, the patients that showed improvement in clinical exam and sequential CT scan images 12 (30%), were related with satisfactory recovery 10 (83.33%) and only two patients (16.67%) died. In 18 cases (45%), the clinical exam and the images stayed without changes with regard to the characteristics shown in the admission. The number of survivors 10 (55.56%) and dead 8 (44.44%) were equivalent. 10 patients (25%) showed worsening in clinical exam and sequential CT scan images, 9 of them (90%) were related with unsatisfactory recovery, 7 (70%) died and only one (10%) survived.

The behavior of the median ICP and its relation with GOS in

Group I was investigated too. It was observed that for the Grade II category of GOS, it was not carried out median calculation because of the presence of only one patient. The medians of the Grade III, Grade IV and Grade V of GOS, showed very similar values to each other (15.3, 14.1 and 14.5 respectively), while the median of the Grade I (30.8), duplicates the rest of the categories. When analyzing the result of the ANOVA test for one factor ($p \leq 0.05$) it indicates that at least two of the four evaluated medians, are significantly different to each other. The post hoc Scheffé test showed that the median of the Grade I of GOS was significantly different from the medians of the Grade III, Grade IV and Grade V, and that these were not statistically different to each other. The relation between high values of ICP and death was proven.

The mean duration of intracranial pressure monitoring was 4.44 ± 6.67 days. The complications related with the monitorization system were few, 45 cases (80.36%) didn't show complications, six (10.71%) had bad functioning of the monitoring system, small hemorrhage of the catheter trajectory was seen in 4 (7.14%) and the infection of the system occurred in only one patient (1.79%).

The results according with GOS in both groups are shown in Table 2. In Group I the biggest frequency of patients was registered in the Grade V of GOS while in Group II the Grade I of GOS prevailed. The difference between groups related with satisfactory recovery was 15.36% (Group I: 36 patients, 67.86%. Group II: 21 cases, 52.5%).

When analyzing the U of Mann-Whitney test, we found a significant relationship between the continuous intracranial pressure monitoring and Grade V of GOS with a value of $p \leq 005$.

Discussion

Continuous monitoring of ICP has been increasingly used in neurosurgical and neurocritical care practice for the last four decades and today is a routine procedure worldwide in patients with severe TBI. It is generally viewed as the cornerstone of care in these patients, and is recommended in all modern guidelines for treatment of TBI[3,4], however some studies have found no association or a negative association between monitoring-based treatment and outcome [5,8-10].

Since the studies carried out by Guillaume and Janny at the beginning of the 50´s decade [11,12], it is known that in many cases with severe TBI the clinical status is not a completely reliable indicator of the behavior of some intracranial parameters like ICP and CPP, mainly if the patient is under sedation regime or neuromuscular blockade with mechanical ventilation.

The prognostic value of CT scan in severe TBI has been study [13,14]. The value of the status of the basal cisterns as an indicator for presence of increased ICP has been confirmed in many studies. Lobato et al (2005) [14], reported that over 50% of patients with severe TBI showing initial type I-II diffuse axonal lesions developed new CT changes and nearly 50% showed intracranial hypertension during the acute posttraumatic period, however discordance between CT and ICP monitoring changes were observed in 30.3% of the cases.

CT is considered as the standard examination of the patient with severe head trauma, for the diagnosis of intracranial lesions, which appear both on admission and during clinical evolution. Sequential CT is an essential test even when monitoring ICP, PPC or other intracranial parameters, since the findings will facilitate the evolutionary follow-up of intracranial lesions and will guide the surgeon to the correct behavior at the precise moment [13].

In this study, although monitoring of the PIC and PPC were the main variables to be monitored in Group I, patients were also subject to the use of the information provided by the CT images, showing a superlative importance in those cases that showed high values of the PIC for periods of time higher than those established in the work protocol. In Group II, the analysis of the information provided by the CT images showed a high correlation between the clinical evolution and the imaging pattern, which demonstrates the value of this study to diagnose the existence or persistence of intracranial hypertension in this type of patient.

Currently, there are many reports that recommend the use of clinical and imaging monitoring to replace invasive ICP monitoring and other intracranial parameters derived from it, with the rationale that there is no full acceptance of its benefits by neurosurgeons and intensivists, in addition to the absence of the necessary scientific evidence to justify its benefits over other non-invasive methods [5,13,15].

Our position in this regard is that all the variants of monitoring must be complemented, that the information obtained from each of them does not replace the other. Our team considers that the information offered by the continuous monitoring of the PIC, the PPC and other intracranial parameters is of great value in the management of these patients, as well as that obtained from the clinical examination and the series of CT images, criteria that are shared by other authors [5,7,16,17].

When analyzing the results of this study we found that there was a difference of 12.1% in the mortality between the groups and of 15.3% for the satisfactory results, in both cases favorable to the Group I, which shows the positive influence of the continuous monitoring of the PIC and the PPC on the results in patients with a severe head trauma.

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