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Effects of Intracranial Pressure Monitoring on Outcome of Patients with Severe Traumatic Brain Injury; Results of a Historical Cohort Study

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ABSTRACT

Objective: To investigate the effects of intracranial pressure (ICP) monitoring on mortality rate and functional outcome of patients with severe traumatic brain injury (TBI).
Methods: This was historical cohort study being performed in Nemazee hospital of Shiraz during a 4-year period (from 2006 to 2010) including those patients with severe TBI who had undergone care based on ICP monitoring (case group) or clinical evaluation (control group).Patients and controls were matched regarding the age, sex, initial GCS, initial pupils, and CT findings. The functional outcome, complications and mortality rate were recorded and compared between those who underwent ICP monitoring and those who did not.
Results: There was no significant difference between two study groups regarding the baseline characteristics. The rate of meningitis was significantly higher in those who underwent Ventriculostomy and ICP monitoring when compared to those who were managed without ICP monitoring. [14 (23.3%) *vs.* 7 (11.6%); p=0.041]. We found that the mortality rate (28.3% *vs.* 11.6%; p=0.172) as well as the frequency of persistent vegetative state (5.0% *vs.* 5.0%; p=0.998) were comparable between two study groups. However the frequency of severe disability was higher in control group compared to case group (26.7% *vs.* 15.0; p=0.046). In the same way, the frequency of good recovery (26.7% *vs.* 15.0; p=0.046) and favorable outcome (51.7% *vs.* 33.3%; p=0.021) was significantly higher in case group.
Conclusion: Care based on ICP monitoring in patients with severe TBI was associated with increased frequency of good recovery and favorable outcome and decreased frequency of moderate disability. However higher meningitis rate was associated with Ventriculostomy and ICP monitoring.

Keywords: Traumatic brain injury; ICP monitoring; Functional outcome; Mortality rate.

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Introduction

Severe traumatic brain injury (TBI) is a major cause of mortality and morbidity as well as long term disability being responsible for more than one-third of trauma related deaths in USA and Iran [1-3]. Elevated intracranial pressure (ICP) is associated with mortality and worse functional outcome in patients with TBI, and treatment of elevated ICP has been a central component of brain-protective

strategies for many years. Accordingly, the Brain Trauma Foundation currently recommends that treatment be initiated for ICP values >20 mmHg (level II recommendation) [4]. The management of intracranial hypertension has been the matter of debate and currently ranges from medical therapy to decompressive craniectomy [5-7].

Based on the current scientific literature, there is uncertainty whether elevated ICP plays an independent role in determining the outcome of TBI patients other than as a marker of disease severity and, consequently, whether ICP monitoring and aggressive treatment improves patient outcome. The interpretation of the current literature on intracranial hypertension is limited by the lack of detailed ICP information and the failure to account for important markers of risk, such as age, severity of injury and hypoxia and temporal changes in the management of TBI patients. Likewise, limited information is available examining the effect of raised ICP on long-term neuropsychological outcome [8-12]. Currently, most of the authors believe that in patients with severe TBI, care focused on maintaining monitored intracranial pressure at 20 mm Hg or less is not superior to care based on imaging and clinical examination [8-12]. As there is still controversy regarding the issue, and the current practice is based on the Trauma Guideline which recommends ICP monitoring [3], we performed this study to investigate the role of ICP monitoring on mortality and long-term complications and functional outcome of patients with severe TBI.

Materials and Methods

Study Population

This was a retrospective cohort study being performed in Nemazee hospital, a tertiary healthcare center and level I trauma center in southern Iran affiliated with Shiraz University of Medical Sciences over a period of 4 years from March 2006 to February 2010. We included those patients with severe TBI who were older than 18 years, and were referred to our center within 8 hours of injury. Brain trauma was considered severe when the post-resuscitation Glasgow Coma Scale (GCS) score in the emergency room was ≤8 or the GCS motor score was 1-5 in the absence of pharmacological paralysis in patients with endotracheal intubation [13]. For the purpose of our study, patients needed to have ICP monitoring placed within 12 hours of injury and to have had continuous ICP monitoring maintained for the first 48 hours following placement. None of the patients had evacuable intracranial hematoma or pathology and none of them required surgical intervention. We included those with brain contusions, subarachnoid hemorrhage (SAH) or intraventricular hemorrhage (IVH). Patients were excluded if they were pregnant, prisoners or residents abroad, aged ≤18 years or died within 48 h of admission. Only those with complete and reliable medical charts were included. The study protocol was approved by both institutional review boards (IRB) and medical ethics committee of Shiraz University of Medical Sciences. As this was a retrospective study, no informed written consent was required.

Study Protocol

This was retrospective study and the data was extracted from the medical charts of the patients using a data gathering form. The patients in case groups were those who had undergone ICP monitoring during the hospital stay (n=60). Those who were managed conservatively without ICP monitoring were considered as control group (n=60). Patients and controls were matched regarding the age, sex, mechanism of injury, initial Glasgow Coma Scale (GCS), initial pupil size,

The initiation and continuation of ICP monitoring were based on clinical decisions by the attending neurosurgeon and made in accordance with the guidelines for the management of severe traumatic brain injury [14]. Therapeutic interventions were started with in a maximum of 12 h from the traumatic injury to the first ICP value. All the patients had undergone Ventriculostomy (mostly right anterior) for ICP measurement. ICP measurements were recorded using an intra-ventricular pressure monitoring catheter, with ICP values scheduled to be collected on an hourly basis and additional values to be included if there were any meaningful changes. Normal ICP was defined a san ICP of 0–20 mmHg. Patients who had continuous ICP monitoring were managed according to ICP values. In those without ICP monitoring, changes in level of consciousness, change in respiratory pattern (sustained hyperventilation, Cheyne-Stokes respiration, bradypnea, ataxic respiration), papilledema, opistotonousposture and Cushing phenomenon (hypertension with bradycardia) were considered as the signs of intracranial hypertension. Those with persistent intracranial hypertension (>25 mmHg or persistent signs of intracranial hypertension) resistant to medical therapy underwent decompressive craniectomy.

Outcome Measures

The primary endpoints were 6-month all-cause mortality and a composite endpoint of functional [Glasgow Outcome Scale (GOS)] at the 6-month follow-up. We also recorded the duration of hospital stay, complication rate and the incidence of meningitis. The favorable and unfavorable outcome was also recorded in all the patients.

Statistical Analysis

Fifty-three patients were required in each group for a study to have 90%power to detect significant differences between corresponding variables (p=0.05, two-sided). To compensate for possible

non-evaluable data, we enrolled 60 participants in each group. All statistical analyses were performed with the Statistical Package for Social Sciences version 16.0 (SPSS Inc., Chicago, IL, USA). The results are expressed as mean+standard deviation (SD) or proportions. The parametric variables were compared between two study groups using the independent t-test. The proportions were compared using chi-square test. A two-sided *p*-value less than 0.05 were considered statistically significant.

Results

Overall we included 120 patients with severe traumatic brain injury who were managed with and without continuous ICP monitoring. The baseline characteristics of the patients are summarized in Table 1. There was no significant difference between two study groups regarding the baseline characteristics.

The mean duration of ICP monitoring in case group was 4.5±2.6 days. The rate of meningitis was significantly higher in those who underwent Ventriculostomy and ICP monitoring when compared to those who were managed without ICP monitoring. [14 (23.3%) *vs.* 7 (11.6%); *p*=0.041]. We found that the mortality rate as well as the frequency of persistent vegetative state was comparable between two study groups. However the frequency of severe disability was higher in control group compared to case group. In the same way, the frequency of goof recovery and favorable outcome was significantly higher in case group. The study outcomes are summarized in Table 2.

Discussion

Role of continuous ICP monitoring in management of patients with severe traumatic brain injury is still a matter of debate [8-12]. We performed this study in order to investigate the role of continuous ICP monitoring on mortality rate and functional outcome of patients with severe traumatic brain injury. We found that Ventriculostomy and ICP monitoring was associated with higher rate of meningitis and infection. Mortality rate and persistent vegetative state was not different between two study groups. However we found that ICP monitoring was associated with lower frequency of severe disability

Table 1. The baseline characteristics of 120 patients with severe traumatic brain injury (TBI) who were managed with and without ICP monitoring.

	Case group (n=60)	Control group (n=60)	*p* value
Age (years)	28.3±12.9	29.6±10.9	0.439
Sex			
Men (%)	49 (81.6%)	52 (86.7%)	0.103
Women (%)	11 (18.4%)	8 (13.3%)	
Mechanism of trauma			
Vehicle collision (%)	24 (40.0%)	24 (40.0%)	
Pedestrian collision (%)	21 (35.0%)	21 (35.0%)	0.215
Falling from moving object (%)	9 (15.0%)	12 (20.0%)	
Falling from height (%)	4 (6.6%)	3 (5.0%)	
Assault trauma (%)	2 (3.4%)	0 (0.0%)	
Glasgow coma scale (GCS)	6.±1.3	6.4±0.9	0.689
3 (%)	1 (1.7%)	0 (0.0%)	
4 (%)	3 (5.0%)	7 (11.7%)	
5 (%)	12 (20.0%)	10 (8.3%)	0.317
6 (%)	21 (35.0%)	21 (35.0%)	
7 (%)	18 (30.0%)	15 (25.0%)	
8 (%)	5 (8.3%)	7 (11.6%)	

Table 2. The outcome of 120 patients with severe traumatic brain injury who were managed by continuous ICP monitoring or clinically.

	Case group (n=60)	Control group (n=60)	*p* value
Meningitis (%)	14 (23.3%)	7 (11.6%)	0.041
GOS[a]			
Death (%)	17 (28.3%)	21 (35.0%)	0.172
PVS[b] (%)	3 (5.0%)	3 (5.0%)	0.998
Severe disability (%)	9 (15.0%)	16 (26.7%)	0.046
Moderate disability (%)	15 (25.0%)	11 (18.3%)	0.068
Good recovery (%)	16 (26.7%)	9 (15.0%)	0.046
GOS			
Favorable outcome (%)	31 (51.7%)	20 (33.3%)	0.021
Unfavorable outcome (%)	29 (48.3%)	40 (66.7%)	

[a]GOS: Glasgow Coma Scale; [b]PVS: Persistent vegetative state

and higher frequency of good recovery and favorable outcome. Previously, Badri *et al*., [15] showed that average ICPduring the first 48 hour of monitoring was an in dependent predictor of mortality at the 6-month follow-up and as good as other ICP patterns in predicting 6-month mortality. Elevated ICP was associated with worse functional outcome and neuropsychological performance in the whole study population. Importantly, when focusing on survivors, they found that there was no association between ICP and neurobehavioral functioning at the 6-month follow-up [15].

Most of the data from non randomized, controlled trials support the association of treatment based on monitored intracranial pressure with improved recovery, which has led to there commendation of this approach in successive editions of published guidelines for the management of severe traumatic brain injury [14] (although there have been calls for a randomized, controlled trial). In two retrospective studies, there was no association [16] or a negative association [17] between monitoring based treatment and outcome, and in an older, small, low-quality study of the usefulness of monitoring in guiding mannitol dosing, monitoring was not found to be useful [18]. Farahvar *et al*., [19] found that treatment of intracranial hypertension with the use of ICP monitoring,improvesoutcome as measured by 2-week adjusted mortality. The use of initial Day 1 post-resuscitation GCS scores, CT scan parameters, or presence of arterial hypotension may not delineate patients who will benefit from ICP monitoring and treatment [19]. Similarly, in a previous study [20] these same variables did not independently predict therapeutic response to the treatment of ICP elevation.

The relationship between age and worse outcome, with a significantly higher mortality rate, has been reported before [21,22].Sorrentino *et al*., [23] found differences in cerebral autoregulation and cerebral pressure reactivity index in elderly patients with TBI. However, there is also evidence that older patients may be more responsive to intracranial hypertension treatment [20]. Farahvar *et al*., [19] found that patients with pupillary abnormalities were less likely to be monitored. Recent evidence may contradict the idea that patients with a GCS score of 3 with anisocoria have universally poor outcomes or are unsalvageable. Chamoun *et al*., [24] showed that patients with a GCS score of 3 had an overall survival rate of 50.8%. They also found that 25.5% of patients with bilateral reactive pupils and 27.6% with unilateral fixed and dilated pupils had a good outcome (Glasgow Outcome Scale score of 1 or 2) at 6 months.

We note some limitations to our study. First the study population was limited. This was because of the type of study. This was a historical cohort study which requires complete medical charts and follow-ups. We included almost all the patients who fulfilled the criteria for being included in the study. However the study has appropriate power to detect the significant differences between the primary endpoints. Second, this was a retrospective cohort study. Clearly, randomized clinical trials are preferred because of their accuracy and reliability. Overall this is among the only studies from Iran which evaluated the role of ICP monitoring on outcome of patients with severe TBI.

In conclusion, care based on ICP monitoring in patients with severe TBI was associated with increased frequency of good recovery and favorable outcome and decreased frequency of moderate disability. However higher meningitis rate was associated with Ventriculostomy and ICP monitoring.

Conflict of Interest: There isn't any conflict of interest to be declared regarding the manuscript.

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