Role of Intracranial Pressure Monitoring in Management of Patients with Severe Traumatic Brain Injury: Results of a Large Level I Trauma Center in Southern Iran

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■ OBJECTIVE: **To determine the role of intracranial pressure (ICP) monitoring in management of patients with severe traumatic brain injury (TBI) admitted to a large level I trauma center in Southern Iran.**

■ METHODS: **This was a cohort study performed during a 2-year period in a level I trauma center in Southern Iran including all adult patients (>16 years) with severe TBI (Glasgow Coma Scale [GCS] score, 3–8) who underwent ICP monitoring through ventriculostomy. The management was based on the recorded ICP values with threshold of 20 mm Hg. Decompressive craniectomy was performed in patients with intractable intracranial hypertension (persistent ICP ≥25 mm Hg). In unresponsive patients, barbiturate coma was induced. Patients were followed for 6 months and Glasgow Outcome Scale Extended was recorded. The determinants of favorable and unfavorable outcome were also determined.**

■ RESULTS: **Overall, we included 248 patients with mean age of 34.6 ± 16.6 years, among whom there were 216 men (87.1%) and 32 women (12.9%). Eighty-five patients (34.2%) had favorable and 163 (65.8%) unfavorable outcomes. Those with favorable outcome had significantly lower age ($P = 0.004$), higher GCS score on admission ($P < 0.001$), lower Rotterdam score ($P = 0.035$), fewer episodes of intracranial hypertension ($P < 0.001$), and lower maximum recorded ICP ($P = 0.041$). These factors remained statistically significant after elimination of confounders by multivariate logistic regression model.**

■ CONCLUSIONS: **Age, GCS score on admission, Rotterdam score, intracranial hypertension, and maximum recorded ICP are important determinants of outcome in patients with severe TBI. ICP monitoring assisted us in targeted therapy and management of patients with severe TBI.**

INTRODUCTION

Traumatic brain injury (TBI) is among the most important public health problems associated with high health care and social burden and significant mortality and morbidity.[1,2] Motor-vehicle accidents are the most common cause of trauma-associated mortality in Iran, with an annual incidence of 42.0 per 100,000 population higher than developed and other developing countries.[3] TBI remains the main cause of trauma-associated mortality and morbidity in Iran.[2,4] The TBI-associated annual costs in Shiraz (Southern Iran) have been estimated to be 511,000 US dollars, 6390 potential years of life lost, and 20 million US dollars of productivity. The TBI-associated costs were equivalent to 0.00011% of Iran's gross domestic product in 2013.[5] Overall, low-income countries have the highest TBI-associated mortality and morbidity.[6] The incidence of TBI is also associated with long-term disabilities such as impaired cognitive function, reduced quality of life, and psychiatric disorders such as posttraumatic stress disorder and depression.[7,8]

The primary aim of the surgical and critical care management of patients with TBI is early diagnosis and treatment of secondary brain injuries including ischemia, herniation, infection, and brain swelling. The mainstay of the treatment of patients with TBI is to

Key words
- Cerebral perfusion pressure
- Intracranial pressure monitoring
- Prognosis
- Traumatic brain injury
- Ventriculostomy

Abbreviations and Acronyms
CI: Confidence interval
CT: Computed tomography
CPP: Cerebral perfusion pressure
CSF: Cerebrospinal fluid
GCS: Glasgow Coma Scale
ICP: Intracranial pressure
RR: Relative risk

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preserve cerebral perfusion in the normal range to prevent ischemia and irreversible brain injury.[9] Intracranial hypertension is an important cause of secondary brain injury, and its degree and duration are associated with outcome after TBI.[10-15] Monitoring of intracranial pressure (ICP) using different devices is the most widely used intracranial monitor because prevention and control of increased ICP and maintenance of cerebral perfusion pressure (CPP) are fundamental therapeutic goals after TBI.[9] The guideline for management of patients with severe TBI (3rd edition) recommends ICP monitoring in all patients with severe TBI (Glasgow Coma Scale [GCS] score, 3–8) with abnormal findings on computed tomography (CT) (hematomas, contusions, swelling, herniation, or compressed basal cisterns) (evidence level II) and age more than 40 years, unilateral or bilateral motor posturing, or systolic blood pressure <90 mm Hg.[16] The guideline also recommends ventriculostomy as the best method of ICP monitoring in accordance with the Virginia staircase of intracranial hypertension management in patients with severe TBI.[17] Although the subject is well established in the international literature, data from Iran are scarce, and thus, the aim of the current study was to report the results of management of patients with severe TBI using ICP monitoring via ventriculostomy in a large level I trauma center in Southern Iran.

METHODS

Study Population

This prospective cohort study was conducted in a 2-year period from March 2010 to March 2012 in Rajaei Hospital, a large level I trauma center in Southern Iran. A level I trauma center is defined according to the American College of Surgeons as a comprehensive regional resource that is a tertiary-care facility central to the trauma system. A level I trauma center is capable of providing total care for every aspect of injury, from prevention to rehabilitation, education, assessment, and research.[18] Shahid Rajaei is a level I trauma center according to this definition.

We included all patients with severe TBI (GCS score, 3–8) who underwent ICP monitoring in our center during the study period. The indications for ICP monitoring included severe TBI and any abnormal finding on brain CT (hematomas, contusions, swelling, herniation, or compressed basal cisterns) and age more than 40 years, unilateral or bilateral motor posturing, or systolic blood pressure <90 mm Hg according to the guideline for management of patients with severe TBI.[16] We excluded those who died during the first 48 hours and those who were lost to follow-up. Patients with a GCS score of 3 and bilateral fixed and dilated pupils and those with an injury believed to be unsurvivable were excluded. The institutional review board and medical ethics committee of Shiraz University of Medical Sciences approved the study protocol before recruitment. Because ICP monitoring is considered the standard of care, no informed written consent was required and obtained from the patients.

Study Protocol

All patients referring to our center during the study period were evaluated and examined by a neurosurgery resident on admission and the indications for ICP monitoring were considered. The demographic information and clinical findings were recorded in a data-gathering form on admission. This information included age, gender, mechanism of injury, baseline GCS score, Injury Severity Score, and CT findings according to the Rotterdam classification.[19] ICP was monitored in all patients via ventriculostomy, which was inserted in the anterior horn of the lateral ventricle through the left or right Kocher point. The ventriculostomy was connected to an external pressure transducer in the intensive care unit and the ICP was monitored. The ICP was continuously monitored and the CPP was calculated by subtraction of ICP from the mean arterial pressure. ICP higher than 20 mm Hg was considered high for which therapeutic procedures were considered according to the Virginia staircase of ICP control,[17] including 30° head elevation, cerebrospinal fluid (CSF) drainage through ventriculostomy, muscle-relaxant and sedative agents in agitated patients, hyperventilation to reduce the P_{CO_2} to 30 mm Hg, and administration of osmotic agents such as mannitol or hypertonic saline. Patients with intractable intracranial hypertension (ICP >25 mm Hg) underwent decompressive craniectomy. ICP monitoring was continued after the operation and in those with high postoperative ICP (>25 mm Hg), barbiturate coma with sodium thiopental (a loading dose of 500 mg followed by 150 mg/hour intravenous infusion until burst suppression) was induced. The number of episodes of high ICP and duration of high ICP (>20 mm Hg) and low CPP (<70 mm Hg) were recorded. The CSF sample was analyzed daily for detection of infection. Meningitis was diagnosed based on a high number of white blood cells and high protein and low sugar levels. Results of CSF cultures were also recorded. Patients were classified as having culture-positive and culture-negative meningitis based on the culture results. Ventriculostomy and ICP monitoring were discontinued 48 hours after recording normal ICP values. The patients were followed for 6 months in an outpatient setting and the Glasgow Outcome Scale Extended was recorded. Favorable and unfavorable outcome was defined as a Glasgow Outcome Scale score of 5 and higher and 4 and lower, respectively.

Statistical Analysis

All the recorded data were entered into a computer database and were further analyzed with SPSS version 16.0 (SPSS Inc., Chicago, Illinois, USA). Data are presented as mean ± standard deviation and proportions as appropriate. We investigated the determinants of favorable and unfavorable outcome by comparing the results between these 2 groups. The proportions were compared using a χ^2 test and the parametric variables with normal distribution were compared by independent t test. The parametric variables without normal distribution were compared using Mann-Whitney U test. We also used a multivariable logistic regression model to eliminate the effects of confounders. A 2-sided P value of less than 0.05 was considered statistically significant.

RESULTS

Overall, 248 patients with severe TBI underwent ventriculostomy and ICP monitoring during the study period. The mean age of the patients was 34.6 ± 16.6 years (range, 16–82 years). There were 216 men (87.1%) and 32 women (12.9%) among the patients. Road traffic accidents were the most common mechanism of injury (62.1%). The Rotterdam classification of brain CT on