Our Experience with Management and Outcome of Isolated Traumatic Brain Injury Patients Admitted in Intensive Care Unit

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Abstract

Introduction: Traumatic brain injury (TBI) is a major cause of death and disability throughout the world. Commonly used predictors of outcome both individually or in combination include age, Glasgow Coma Scale score, pupillary reactivity, early hypoxia, and hypotension. Most of the studies previously done to examine risk factors for mortality in severe TBI were done in the setting of polytrauma. Aims and Objectives: The aim and objective of this study was to do an in-depth analysis of various factors associated with the management and outcome of patients with isolated TBI admitted in an Intensive Care Unit (ICU). Materials and Methods: A total of seventy adult patients who were admitted to Intensive Critical Care Unit (ICU) with isolated TBI were selected during a 12-month period from January 2016 to December 2016. This is a prospective analytical study and parameters studied included age, sex, cause of admission classified by type of trauma, premorbid functional status, acute and chronic comorbidities, brain noncontrast computed tomography scan data, Glasgow Coma Scale (GCS), hemodynamic status, respiratory status, and mechanical ventilation, blood gases, serum electrolytes, serum glucose, hemoglobin, leukocyte and platelet counts, renal function, and urinary output. Results: The study population consisted of 46 (65.7%) males and 24 (34.2%) females. The mean age was 35.5 years (range, 18–65 years). The most common mode of trauma was road traffic accident (43.6%) followed by fall from height (35.7%). Statistically insignificant relationship (P < 0.05) was seen with sex and mode of injury among survivors and nonsurvivors; however, 61.9% of patients with age ≥40 years died (P < 0.005). Among clinical parameters at admission to ICU, low GCS, hypotension (mean arterial pressure ≤80 mmHg), hypoxia (pO2 ≤60 mmHg, spO2 ≤90 mmHg), and nonreacting pupils were significantly associated with increased mortality (P < 0.05). Conclusion: Isolated TBI still continues to have a good amount of morbidity and mortality which perhaps can be reduced by strict adherence to guidelines of management.

Keywords: Brain, injury, Intensive Care Unit, trauma

Introduction

Traumatic brain injury (TBI) is a major cause of death and disability throughout the world. It is estimated that 1.5–1.7 million people experience TBI annually in the USA.1,2 The burden is even greater globally with 10 million cases estimated each year.3 Commonly used predictors of outcome both individually or in combination include age, Glasgow Coma Scale Score, pupillary reactivity, early hypoxia, and hypotension.10 Most of the studies previously done to examine risk factors for mortality in severe TBI were done in the setting of polytrauma.11 There is a pathophysiological difference between isolated TBI and TBI in the setting of polytrauma.6,7 Earlier literatures have clearly demonstrated that better hospital processes of care, such as adherence to guidelines, can contribute to decreased complications and improved outcomes in hospitalized patients.6-10 Better understanding of factors influencing mortality in TBI will help improve process of care and risk stratification in severe isolated TBI in resource-poor country like ours.11 Based on this, the aim of this work is to identify the factors associated with the mortality in TBI to promote cost reduction and reduction of secondary brain injury that generates functional disability.

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Materials and Methods

The study was conducted in Sheri Kashmir Institute of Medical Sciences (SKIMS), a 700-bedded tertiary care cum referral facility in Kashmir, North India. Our center is only a referral center for neurosurgical patients in Kashmir province equipped with a 14-bedded Intensive Critical Care Unit. Adult patients who were admitted to Intensive Critical Care Unit with isolated TBI were selected during a 12-month period from January 2016 to December 2016; patients with age below 18 years or those who had other associated injuries, patients admitted as polytrauma, and patients with GCS 3 postresuscitation were excluded from the study. The study was designed as a prospective analytic study that enrolled seventy patients with TBI admitted to the Intensive Critical Care Unit of SKIMS. For each patient, the following data were obtained at admission: age, sex, cause of admission classified by type of trauma, premorbid functional status, acute and chronic comorbidities, brain computed tomography (CT) scan data, Glasgow Coma Score, hemodynamic status, respiratory status and mechanical ventilation, blood gases, serum electrolytes, serum glucose, hemoglobin, leukocyte and platelet counts, renal function, and urinary output. Additional data were collected on a daily basis: serum electrolyte levels (all values, if more than one value was available), serum glucose, administered medications and fluids, including vasopressin and osmotic therapy (defined as the use of 3% or 5% saline or mannitol to treat cerebral edema or raised intracranial pressure [ICP]), urinary volume, mechanical ventilation, and ICP when available. Finally, data concerning Intensive Care Unit (ICU) complications, ICU mortality, and in-hospital mortality were also collected.

Data analysis

Data were analyzed with the help of descriptive statistics, namely, means, standard deviations, and percentages. For univariate analysis of categorical variables, Chi-square test or Fisher’s exact test, whichever appropriate, was employed. Continuous variables were analyzed with the help of Student’s t-test. Independent variables associated with outcome in the univariate analysis were used in multivariate logistic regression. Statistical analysis was performed with the help of SPSS software (version 16.0) and Microsoft Excel (SPSS; Statistical Pacage for social sciences SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. Chicago, SPSS Inc. Microsoft Excel version 13). P < 0.05 was considered statistically significant.

Results

The baseline characteristics of the patients are shown in Table 1. The study population consisted of 46 (65.7%) males and 24 (34.2%) females. The mean age was 35.5 years (range, 18–65 years). Majority of our patients were males (65.7%), and the most common mode of trauma was road traffic accident (RTA) (43.6%) followed by fall from height (FFH) (35.7%). Various clinical and radiological factors were compared among survivors and nonsurvivors using univariate and multivariate analyses [Table 2]. Statistically insignificant relationship (P < 0.05) was seen with sex and mode of injury among survivors and nonsurvivors; however, 61.9% of patients with age ≥40 years died (P < 0.005). Among clinical parameters at admission to ICU, low GCS, hypotension (mean arterial pressure [MAP] ≤80 mmHg), hypoxia (pO2 ≤60 mmHg and spO2 ≤90 mmHg), and nonreacting pupils were significantly associated with increased mortality (P < 0.05). CT brain findings were compared among survivors and nonsurvivors. Compressed basal cistern and midline shift of >5 mm were independently associated with increased mortality. A mortality of 55.10% was seen in patients who were not operated (managed conservatively) as compared to 28.57% of patients who were subjected to some surgical interventions (P < 0.05).

Table 1: Demographic and clinical characteristics

| Characteristics | n (%) |
|-----------------|-------|
| Age (median)    | 39    |
| Age (mean±SD)   | 35.5±9.87 |
| Gender          |       |
| Male            | 46 (65.7) |
| Female          | 24 (34.2) |
| Mode of injury  |       |
| RTA             | 34 (43.6) |
| FFH             | 21 (35.7) |
| Hit by object   | 10 (14.3) |
| Assault         | 5 (0.07) |

SD: Standard deviation, RTA: Road traffic accident, FFH: Fall from height

Discussion

TBI is one of the major health problems all over the world, especially in developing countries, its incidence has risen in the recent past due to increased number of RTAs.

In general, TBI is divided into two discrete periods: primary and secondary brain injury. The primary brain injury is the physical damage to parenchyma (tissue, vessels) that occurs during traumatic event, resulting in shearing and compression of the surrounding brain tissue. The secondary brain injury is the result of a complex process, following and complicating the primary brain injury in the ensuing hours and days. Numerous secondary brain insults, both intracranial and extracranial or systemic, may complicate the primarily injured brain and result in secondary brain injury. Secondary, intracranial brain insults include cerebral edema, hematomas, hydrocephalus, intracranial hypertension, vasospasm, metabolic derangement, excitotoxicity, calcium ion toxicity, infection, and seizures. It is now clear that only part of the damage to the brain during head trauma is from the primary brain injury, which is not amenable to alteration and cannot be reversed. However, secondary brain insults are often amenable to prevention or reversal.

The intensive care management of patients with severe TBI is a dynamic process, which starts in the prehospital period, at the scene of the accident. The continuum of acute care, during...
the “GOLDEN HOUR,” from the time of injury through the start of definitive care, should be ensured and based on the guidelines and recommendations mentioned time to time.\[15\]

It can affect all the ages and ethnicities but is more seen in productive age group. In this present age of evidence-based medicine, prognosis is an important factor to be determined in a disease so that our diagnostic and therapeutic modalities are more focused toward the factors that can improve the prognosis of a disease.\[16,17\]

Our study was more focused toward the immediate mortality of TBI as delayed mortality may be related to many other factors such as ICU complications, subsequent injuries such as pneumonia, sepsis, pulmonary embolism, and multiple organ dysfunction syndrome.\[18\] Our study was an ICU-based study where patients with severe TBI (GCS ≤8) were admitted.

Schirmer-Mikalsen et al. during their 5-year (2004–2009), prospective study of 133 patients with severe TBI (Glasgow Coma Scale [GCS] score ≤8) concluded that age, GCS score, pupil dilation, injury severity score, ICP >25 mmHg, hyperglycemia, and pneumonia predicted a worse outcome.\[19\]

Opondo and Mwangombe studied 87 adult patients including 73 men (83.9%) and 14 women (16.1%) with a mean patient age of 34 ± 17 years with severe TBI admitted between April and September 2005 and observed that severe TBI accounted for 14.3% of all ICU admissions. Motor vehicle accidents were the main cause (58.6%). Forty-six patients (54.0%) died. Twenty-nine percent of patients had persistent vegetative state or severe disability. Factors that were associated with poor outcome on univariate analysis were Glasgow Coma Scale <5, diffuse axonal injury and intracerebral mass lesions, and blood sugar >10 mmol/L.\[20\] Tobi et al. in their retrospective, case–control study of 182 patients of TBI admitted to the ICU observed that male: female ratio was 3:1, but females had a better outcome with \( P = 0.026\).

### Table 2: Clinical and computed tomographic prognostic factors for mortality

| Prognostic factors | Subgroup | \( n \) | Survived | Died | Mortality (%) | \( P \) |
|--------------------|----------|--------|----------|------|---------------|--------|
| **Age**            | <40      | 28     | 20       | 8    | 28.5          | <0.001 |
|                    | ≥40      | 42     | 16       | 26   | 61.9          |        |
| **Sex**            | Male     | 46     | 22       | 24   | 52.1          | >0.05 (NS) |
|                    | Female   | 24     | 14       | 10   | 41.6          |        |
| **Mode of injury** | RTA      | 34     | 18       | 16   | 47.06         | >0.05 (NS) |
|                    | FFH      | 21     | 9        | 12   | 57.14         |        |
|                    | Hit by object | 10  | 6        | 4    | 40.00         |        |
|                    | Assault  | 5      | 3        | 2    | 40.00         |        |
| **Hypotension (MAP ≤80 mmHg)** | Present | 21 | 4 | 17 | 80.90 | <0.005 |
|                    | Absent   | 49     | 33       | 16   | 32.65         |        |
| **Hypoxia**        | Present  | 15     | 3        | 12   | 80.00         | <0.05  |
|                    | Absent   | 55     | 35       | 20   | 36.37         |        |
| **GCS**            | 3-4      | 26     | 7        | 19   | 73.07         | <0.0001|
|                    | 5-6      | 12     | 6        | 6    | 50.00         |        |
|                    | 7-8      | 32     | 24       | 8    | 25.00         |        |
| **Pupillary reflex** | Normal   | 61     | 35       | 26   | 42.62         | <0.001 |
|                    | Anisocoria | 5   | 1        | 4    | 80.00         |        |
|                    | Dilated  | 4      | 1        | 3    | 75.00         |        |
| **Treatment**      | Nonoperative | 49 | 22 | 27 | 55.10 | <0.05 |
|                    | Operative | 21     | 15       | 6    | 28.57         |        |
| **Midline shift**  | Absent   | 36     | 23       | 13   | 36.11         | <0.005 |
|                    | ≤5 µm    | 21     | 9        | 12   | 57.14         |        |
|                    | >5 µm    | 13     | 5        | 8    | 61.53         |        |
| **EDH**            | Absent   | 56     | 27       | 29   | 51.78         | >0.05  |
|                    | ≤10 µm   | 12     | 8        | 4    | 33.34         |        |
|                    | >10 µm   | 2      | 2        | 0    | 0             |        |
| **SDH**            | Absent   | 45     | 24       | 21   | 46.67         | >0.05  |
|                    | ≤10 µm   | 19     | 10       | 9    | 47.37         |        |
|                    | >10 µm   | 6      | 2        | 4    | 66.67         |        |
| **Basal cistern**  | Effaced  | 52     | 25       | 27   | 51.92         | <0.05  |
|                    | Uneffaced | 18  | 12       | 6    | 33.34         |        |
| **SAH**            | Present  | 56     | 30       | 26   | 46.42         | >0.05 (NS) |
|                    | Absent   | 14     | 6        | 8    | 57.14         |        |

RTA: Road traffic accident, FFH: Fall from height, GCS: Glasgow Coma Scale, EDH: Extradural hematoma, SAH: Subarachnoid hemorrhage, NS: Not significant, MAP: Mean arterial pressure, SDH: Subdural hemorrhage.

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between 1 and 7 days were >4 times more likely to die in the ICU compared with those who stayed for >7 days. In addition, TBI patients who had blood transfusion had a better outcome ($P = 0.004$). Furthermore, TBI patients who received ventilatory support had higher mortality compared with those who did not ($P = 0.006$). \cite{21}

Gender difference in TBI has been seen in almost all the studies. Our study also showed a male predominance of TBI. Younger age was seen with better outcome as has been shown by studies done by Saini et al.\cite{22} and Tjahjadi et al.\cite{23} RTA was the most common mode of presentation which may be because of reasons such as poor traffic planning of Kashmir province and less number of people wearing seat belts. FH was the second most common presentation, and falls from buildings, stairs, and trees, especially walnut tree, were seen in most of these patients. Increasing age was associated with poor outcome as has been shown by various other studies like the studies done by Livingston et al.\cite{24} and Lewin et al.\cite{25} GCS on arrival was significantly associated with prognosis, a Glasgow Coma Score (GCS) <4 was a significant factor for mortality (odds ratio = 2.2). Hypotension and hypoxia were the two important factors determining the prognosis in TBI. Both these factors result in secondary brain injury and a worse outcome. Our finding was consistent with most of the previous studies but is in contrast to what was seen in the study done by Saini et al.\cite{22} Abnormal papillary response in the form of anisocoria and dilated pupils was significantly associated with poor outcome. Our study clearly documented CT scan findings in the form of basal cistern compression and midline shift which were found to be associated with increased mortality in TBI. Management has an impact on the outcome of TBI; the patients managed conservatively by one reason or the other has poor outcome as compared to patients in whom a surgical intervention was done.

Cerebral perfusion pressure (CPP), bispectral index (BIS), and transcranial oxygen saturation (StCO2) monitoring are intended to assess global intracranial blood flow, regional cerebral cortical function, and local cortical oxygen extraction, respectively. The associations of BIS and StCO2 with ICU outcomes (survival, neurological outcome, ICP, CPP, Cranial-Arterial Pressure Index [ICP/(MAP−ICP)], CAP Index, and interventions to lower ICP indicate that BIS and StCO2 are clinically discriminate parameters. The independent associations of BIS, StCO2, and ICP or CPP with outcomes indicate that BIS, StCO2, and ICP values are complementary. Apropos, the noninvasiveness of BIS and StCO2 is appealing. ICP and CPP monitoring is limited by nondistinct targets and need for expertise with monitor insertion. The study findings indicate that cerebral hypoxia occurs and brain wave patterns are altered when ICP increases, CPP decreases, or CAP Index increases. BIS ≥60 or StCO2 ≥70 suggests that patients with severe brain injury are likely to have an acceptable ICP and CPP. Future studies will define the role of BIS and StCO2 monitoring with TBI. They will determine if select patients with BIS ≥60 or StCO2 ≥70 can be managed without ICP monitoring. Such investigations may prove that an ICP of 16–25 mmHg does not need to be lowered with BIS ≥60 or StCO2 ≥70. An increased CAP Index is a harbinger of poor outcome. Further studies may show that, when the CAP Index is increased and ICP cannot be reduced, raising MAP will enhance CPP.\cite{26}

TBI is a devastating injury and often patients with TBI would require monitoring and treatment in ICU. Management of TBI patients requires multidisciplinary approach, frequent close monitoring, and judicious use of multiple treatments to lessen secondary brain injury and improve outcomes. There are a lot of opportunities for further research in TBI, including but not limited to multimodal monitoring, and therapeutics to further improve outcomes in this very common mechanism of brain injury.\cite{27} There is also a need to develop some evidence-based protocols for the health-care sectors, in which there is still a lack of specific management related to monitoring methods, equipment, and other technical resources. Optimization of physiological parameters, understanding of basic neurocritical care knowledge as well as incorporation of newer guidelines would certainly improve the outcome of the TBI patients.\cite{28}

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**Conflicts of interest**

There are no conflicts of interest.

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