Is Mechanical Ventilation Mandatory for the Management of Severe Head Injury? Outcome in 53 Medically Managed Severe Head Injury Patients, Without Ventilatory Support: A Prospective Study

Abstract

Background: Severe head injury (SHI) is a major cause of mortality and morbidity across the world. The current paradigm of management of SHI involves admission in Intensive Care Unit (ICU), mechanical ventilation (MV), and intracranial pressure (ICP) monitoring. Such resources are expensive and often unavailable in the developing world. **Objective:** MV or ICP monitoring was unavailable for our patients due to the scarcity of resources. Hence, other alternatives were considered to prevent secondary brain injury due to hypoxia. This study assessed the outcome after SHI when managed with an early tracheostomy (ET). **Methods:** This prospective observational study over 13 months included all medically managed SHI patients without MV or ICP monitoring. The Glasgow outcome scale (GOS) was assessed at discharge and compared with published historical data reported after treatment in an ICU environment. **Results:** Our study included 53 unoperated patients with SHI among 1862 patients with traumatic brain injury. Overall mortality was 24.5% (13/53) and compared favorably with reported mortality of 25%–40% reported from centers using intensive management. At discharge, the favorable outcome with a GOS of 4 or 5 was seen in 39.6% (21/53). **Conclusion:** With ET, the results of management of SHI in our patients were comparable to results reported after MV in an ICU environment. Hence, ET is a cost-effective alternative when resources are scarce. MV should be used if hypoxia persists after tracheostomy. Although MV effectively prevents hypoxia, it has complications. We conclude that although MV was unavailable for our patients, they did not have the complications associated with it.

Keywords: *Glasgow outcome scale, mechanical ventilation, severe head injury, tracheostomy, traumatic brain injury*

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Introduction

Traumatic brain injury (TBI) remains the most common cause of death in the first four decades of life, accounting for 15%–20% of deaths between 5 and 35 years.[1] Despite management in critical care units at great cost, the outcome is often dismal in severe head injury (SHI), which is reported to have mortality rates of 37%–51%.[2,3] The current paradigm for the management of SHI emphasizes on the prevention of secondary injury due to hypoxia, hypotension, raised intracranial pressure (ICP), infections, seizures, and metabolic derangements in an Intensive Care Unit (ICU) environment with mechanical ventilation (MV) and ICP monitoring. Monitoring jugular bulb venous oxygen saturation, brain tissue oxygen tension, and use of cerebral microdialysis have also been considered in addition to protocol-based management to improve the outcome in SHI.[4,5]

Maintenance of a proper airway support is of paramount importance to prevent hypoxia which is a major cause of secondary brain injury. At admission, patients with SHI usually undergo translaryngeal intubation and MV. Subsequently, when there is a need for prolonged intubation, a tracheostomy is done usually timed after 7 days.

At our center, due to the paucity of critical care resources, the majority of patients with SHI have been managed outside traditional ICU for the past two decades. They undergo early bedside tracheostomy which is the only available alternative for airway protection outside ICU setting. Fortuitously, even without ICU resources, we observed that a significant number of our patients improved, often remarkably, before the

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commencement of this study. Hence, this prospective observational study was undertaken to analyze the outcome of SHI managed with an early tracheostomy (ET) along with best medical management without an ICU.

Methods

This prospective observational study was conducted over a period of 13 months from January 2013 to January 2014 in a tertiary care government hospital offering comprehensive free services. The study included all medically managed patients with SHI managed with an ET for airway support without MV support. Consecutive patients with SHI were included in the study if: they had a postresuscitation Glasgow coma score (GCS) of <8, an isolated TBI without any other major life-threatening injuries and did not require any cranial procedure for a traumatic cranial lesion. Patients with other life-threatening injuries such as blunt abdominal trauma, blunt chest trauma, and cervical spine injury were not included in the study. Patients who underwent any cranial procedure for the SHI were excluded from the study. Consent for the administered management was obtained from the immediate relative(s) of the patients.

All patients were managed according to the protocol described in Table 1 in a neurosurgical ward without ICU resources such as MV and ICP monitoring. ET with best available medical treatment was the only option at our institution for the management of SHI. None of the patients in the study had translaryngeal intubation for any significant period except during initial emergency resuscitation.

The patients in the study were divided into 3 groups: Group I with GCS of 3 and 4; Group II with GCS of 5, 6, and 7; and Group III with GCS of 8. Glasgow outcome scale (GOS) was assessed at the time of discharge from the hospital. For the purpose of analysis, the management outcome was grouped as: favorable (good recovery/moderate disability), unfavorable (severe disability/persistent vegetative state), and death. The outcome was analyzed and compared to available published reports of outcome in SHI managed with MV in a critical care environment.

Table 1: Protocol followed for medical management of severe head injury

CT imaging
First CT brain: Immediately after transfer into emergency services
Follow-up CT brain
At 6 h from trauma if the 1st CT was done within 6 h after trauma
After 24 h from trauma if there was no improvement in sensorium
On clinical worsening at any time leading to drop in GCS score by >2 points which could not be accounted for any other conditions such as seizures, electrolyte/metabolic imbalance
After 1 week from admission if there was no improvement
Airway care
Early elective bedside tracheostomy was performed soon after transfer to the ward in all patients with GCS <7
For patients with GCS=8, tracheostomy was carried out only if there were signs of aspiration or airway obstruction
Airway suction was carried out periodically, and tracheostomy tube was changed on alternated days
Weaning of tracheostomy was commenced once there was brisk localizing response or spontaneous eye opening response
Antiedema measures
For all adults: *Mannitol 100 ml intravenous-Q8 hourly for 3 days followed by tapering of mannitol over 3 days
Addition of *Furosemide 20 mg Q12 hourly in patients with GCS of 4 and 5
Oral glycerol started usually after 5 days from trauma if CT imaging continued to show significant cerebral edema
Prophylactic anticonvulsants
Injection phenytoin calculated at 18 mg/kg given as slow bolus over 30 min at admission followed by phenytoin 5 mg/kg/day, given 8th hourly
Phenytoin administered through nasogastric tube once enteral feeding commenced
Nutrition support
Enteral feeding initiated 24 h from trauma through nasogastric tube or orogastric tube if significant skull base fractures were present
Patient monitoring**
Monitoring of parameters: blood pressure, pulse, temperature, respiratory rate, and pupillary response by nursing staff
Monitoring of GCS and neurological status by medical personnel
Electrolytes, intake-output, and other metabolic parameters monitored
Blood gas monitoring when signs of respiratory distress were present
Nursing care for the unconscious patient
Care of back and pressure points, indwelling urinary catheter, and bowel care
Chest physiotherapy
Physiotherapy for limbs for prevention of contractures
Elastic stockings for prevention of deep vein thrombosis

*Doses adjusted by body weight for pediatric patients, **No patient had mechanical ventilation, invasive blood pressure measurement, or ICP monitoring. CT – Computed tomography; ICP – Intracranial pressure; GCS – Glasgow Coma Score; GOS – Glasgow Outcome Scale

Results

During the 13 months study period from January 2013 to January 2014, 1862 patients with TBI were admitted in our center. Among them, 1467 had mild TBI; 243 had moderate TBI; and 152 had SHI. Of the 152 patients with SHI, 88 patients were operated and 11 had major associated injuries to the chest, abdomen, and cervical spine and were not included in the study.

Among the 53 patients in the study, there were 48 males and 5 females and the mean age was 35.8 years. The age distribution of the patients is shown in Table 2 and the distribution of patients across different GCS scores in Table 3. In our study, the overall mortality was 24.5% (13/53). The outcome of management is shown in Table 4. Mortality was 100% in the 7 patients with GCS of 3. None of the 5 patients with GCS of 4 died. Mortality in 29 Group II patients with GCS of 5, 6, or 7 was 17.2% (5/29). Only one patient (1/12, 8.3%) with GCS of 8 expired.

Table 2: Age distribution of 53 patients with severe head injury (total=53)

Age	Number of patients (%)
0-10	2 (3.8)
11-20	5 (9.4)
21-30	14 (26.4)
31-40	17 (32.1)
41-50	5 (9.4)
51 and above	10 (18.9)

Table 3: Distribution of patients with severe head injury across different Glasgow Coma Score (total=53)

GCS at admission	Number of patients (%)
3	7 (13)
4	5 (9)
5	7 (13)
6	9 (17)
7	13 (24.5)
8	12 (23)

GCS – Glasgow Coma Score

Table 4: Outcome after severe head injury in 53 patients

	Total number	Death, *n* (%) GOS-1	Unfavorable, *n* (%) GOS-2 and 3	Favorable, *n* (%) GOS-4 and 5
Group-I				
GCS-3, 4	12	7 (58.3)	2 (16.7)	3 (25)
Group-II				
GCS-5, 6, 7	29	5 (17.2)	12 (41.4)	12 (41.4)
Group-III				
GCS-8	12	1 (8.3)	5 (41.7)	6 (50)
Total	53	13 (24.5)	19 (35.8)	21 (39.6)

GCS – Glasgow Coma Score; GOS – Glasgow Outcome Scale

Overall favorable outcome at the time of discharge from hospital was seen in 39.6% of patients (21/53) including full recovery in 22.7% (12/53). Among the 5 patients (5/53) with GCS of 4 at admission, 1 patient (20%) made a full recovery and 2 (40%) had moderate disability at discharge. Favorable outcome was seen in 41.4% (12/29) of patients of Group II and 50% (6/12) of Group III.

Discussion

TBI with a postresuscitation GCS score of 3–8 is defined as SHI and causes significant mortality and morbidity. Whereas primary brain injury occurs at the time of trauma, secondary brain injury (SBI) is a complex process triggered by the primary injury and involves intracranial and extracranial mechanisms. Intracranial mechanisms include intracranial hematomas or cerebral edema causing raised ICP and herniation syndromes, seizures, infection, hydrocephalus, and vascular injuries. Extracranial mechanisms include systemic hypotension, hypoxia, metabolic abnormalities, and hyperthermia. Outcome after SHI depends not only on the severity of the primary injury but also on the severity of SBI. The management of SHI is focused on controlling and treating SBI.[5] Systemic causes of SBI are managed by prevention of hypotension, hypoxia, and metabolic abnormalities. SHI patients are generally admitted in an ICU environment with MV and often with ICP monitoring. Protocol-driven therapy (PDT) is being increasingly used to bring down the mortality and improve the functional outcome in these patients. However, there remains a significant variation across institutions in the management of SHI.

Bulger *et al.*[6] analyzed the institutional variations in the management of SHI. They enrolled 34 university hospitals in the United States, of which 28 were Level I and 6 Level II trauma centers. Their retrospective analysis of 182 SHI patients (mean age 40 years, 75% of males) showed considerable variation in the rates of prehospital intubation, ICP monitoring, ICP-directed therapy, and computed tomography (CT) imaging utilization across centers. There was variation in ICP monitoring from 0% to 100% across institutions with ICP monitoring being done in 58% (105/182) of all patients. Significantly, only 76% of their patients had a neurosurgical consultation. They defined centers as aggressive if ICP monitoring was undertaken in >50% of patients, meeting the brain trauma foundation criteria. The remaining centers were called nonaggressive. They reported an overall mortality rate of 27% (20 of 74) at the aggressive centers against 45% (48 of 106) at nonaggressive centers despite the use of MV in both groups. There was no significant difference in the functional status of survivors in the two groups at the time of discharge.

The emphasis of treatment paradigm for the management of SHI is in the use of intubation and MV in a critical care setup. In a retrospective study[7] of 285 patients with TBI, with at least one reactive pupil and in need of endotracheal intubation and MV, the patients belonged to two time epochs; one with and the other without facilities for neurocritical care based on protocol-driven therapy targeted at ICP and cerebral perfusion pressure (CPP). Almost all patients receiving neurocritical care had ICP monitoring and an ICP-CPP algorithm directed management. This study included a subgroup of 182 (182/285) patients with SHI of whom, 129 patients (129/182) received neurocritical care with ICP monitoring in 95.8% and invasive blood pressure monitoring in 98.8%. In this group, which excluded all patients with bilateral fixed pupils, there was an overall mortality of 21.9% and favorable outcome of 59.6% at 6 months after injury.

A meta-analysis[8] used data from 70 case series reported from the United States (67,750 cases), 65 series reported from other developed countries (37,967 cases), and 19 series from the developing countries (15,868 cases). Among the 69 studies from the USA, the reported mortality in several studies is between 25% and 40%. Several studies from other developed countries reported mortality of more than 30%.

Neurocritical care is not available for most SHI patients in developing countries. Using data from 46 countries, De Silva *et al*.[9] reported that patients in low and middle-income countries have more than twice the probability of dying after SHI when compared with patients in high-income countries. The authors cited quality of care as the primary reason for the association between a country's income and mortality rate.

Despite the lack of neurocritical care, our results compare favorably with published reports of treatment in critical care units. We achieved SHI mortality comparable to that obtained in the developed world. The overall mortality was 24.5% even when we did not use MV or ICP monitoring and did not exclude patients with fixed pupils, especially since the mortality was 100% in the seven patients with GCS of 3 and fixed pupils in our study. None of the five patients with GCS of 4 died. Mortality was 17.2% in 29 Group II patients with GCS of 5, 6, or 7 and 8.3% in Group III with GCS of 8. We believe that an ET is an effective way to bring down mortality after SHI even when MV is unavailable. Another factor that contributed to better results was the admission of all the patients under neurosurgical care with daily continual monitoring by qualified neurosurgeons. We assessed the GOS at discharge and noted an overall favorable outcome 39.6%. Patients assigned to Group II and III had a favorable outcome in 41.4% and 50%, respectively. In patients with GCS of 4, 60% had a favorable outcome, but the numbers in the 3 groups were small to test for statistical significance.

The patients in our study were admitted in a regular ward. All patients with GCS <8 (41/53) underwent ET after admission which helped to maintain a proper airway. Patients assigned to Group III with GCS-8 (12/53) generally did not have airway obstruction and hence tracheostomy was required only in 2 patients (2/12). ET was preferred over translaryngeal intubation which is more prone for bacterial colonization, tube occlusion with secretions, and inadvertent extubation. Unlike tracheostomized patients, intubated patients are restless and need sedation. An unsedated, spontaneously breathing patient is easier to monitor for any neurological deterioration and to shift for repeat CT imaging.

Our patients did not have prehospital intubation, which made them prone for aspiration. ET also helped to clear tracheal secretions and aspirated content. It reduced the physiological dead space and decreased the work of breathing. Maintaining tube patency and change of tube is much simpler with tracheostomy than an endotracheal tube. A regular tracheostomy care and absence of MV-induced lung injury decreased the risk of infections.

All patients underwent at least one repeat CT imaging between 24 and 48 h after admission or earlier if clinical worsening occurred. They received medical management for raised ICP, seizure prophylaxis, and any intercurrent infection. All patients were started on enteral nutrition by tube, generally between 24 and 48 h after trauma which has been noted to decrease the incidence of septicemia.

Although clinical intuition suggests that aggressively correcting hypotension and hypoxia with a protocol-driven therapy (PDT) would improve outcome, clinical studies have failed to provide the supporting data.[4] We admit that MV has several advantages such as decreasing the effort of respiration, prevention of hypoxia, and hypercapnia for the management of SHI, but it was unavailable to our patients. This, however, did not impact the result. MV has complications such as ventilator-associated pneumonia, impaired cardiac performance, and difficulties associated with sedation and paralysis. Moreover, application of pressure to the lung, whether positive or negative, can cause damage known as ventilator-associated lung injury.[10] Several complications such as barotrauma, volutrauma, atelectrauma, and biotrauma are known to occur after MV.[11] Mechanical stresses caused by MV can affect cellular and molecular processes in the lung leading to biotrauma triggering a systemic inflammatory response and sometimes multiple system organ failures.[12]

We admit that this is not a comparative study but a descriptive study born out of necessity. However, it is possible to estimate the impact of new management protocols on outcomes by comparison with historical control data.[4] Our patients had no access to ICU treatment but nevertheless did not suffer for the lack of it as our results compare well with reports after aggressive ICP-directed therapy.

Even after costly neurocritical care, the outcome after SHI is often dismal. Eynon[13] ponders, "Perhaps it is better if we do nothing, don't contact the neurosurgeons, don't admit them to specialist units, don't treat the pneumonia that develops – keep them comfortable, allow them some dignity." We, however, have been successful in implementing a very low-cost management protocol for SHI which may be useful for other centers lacking resources. If similar studies establish the role of ET as a viable alternative for MV, then perhaps, it could pave the way for a comparative study.

Conclusion

SHI is reported to have mortality rates of 37%–51% and is a major cause of morbidity and mortality in young adults. Patients with SHI are usually managed in critical care units with MV. Such treatment is expensive and unavailable to most patients of SHIs in the developing world which are facing an increasing burden on account of SHI. In our study, we could achieve an overall mortality of 24.5% and favorable outcome at discharge in 39.6% among 53 consecutive patients with SHI, by adopting ET for airway management without MV.

We conclude that the management of SHI with a tracheostomy is an effective alternative when MV is unavailable. Our patients did not suffer complications associated with MV and hence could get comparable outcomes reported in other centers with MV. When hypoxia persists despite ET, MV is necessary.

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Conflicts of interest

There are no conflicts of interest.

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