Review Article

Nursing Management of Adults with Severe Traumatic Brain Injury: A Narrative Review

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Abstract

Effective nursing management strategies for adults with severe traumatic brain injury (STBI) are still a remarkable issue and a difficult task for neurologists, neurosurgeons, and neuronurses. A list of justified indications and scientific rationale for nursing management of these patients are continuously evolving. The objectives of the study are to analyze the pertinently available research and clinical studies that demonstrate the nursing management strategies for adults with STBI and to synthesize the available evidence based on the review. A comprehensive literature search was made in following databases such as Google Scholar, Cochrane, J-Gate, ProQuest, and ScienceDirect for retrieving the related studies. In the included studies, data were extracted and evaluated according to the objective. Narrative analysis was adopted to write this review. Patients with STBI have poor prognosis and require quality care for maximizing patients' survival. With a thorough knowledge and discernment of care of such patients, nurses can improve these patients' neurological outcomes.

Keywords: Narrative review, nursing management, severe traumatic brain injury

Introduction

Traumatic brain injury (TBI) is an injury which results from trauma to head due to external physical forces. The estimated annual burden of TBI on the United States economy is >$76 billion, with the costs for disability and lost productivity outweighing the costs for acute medical care.[1] The CDC approximates that in the US, around 52,000 people die every year due to severe TBI (STBI). Falls is the major cause of TBI, with maximum rates in children with age 0–4 and adults with age 75 and older. The second most common injury is motor vehicle related with the excessive rates in adults of age 20–24 years. Adults of 75 years of age and above have the elevated rates of TBI-related hospitalization and death. Males are higher rates than females.[2]

Each year, India produces approximately 1.5–1.7 million individuals who are neurologically disabled due to TBI.[3] The primary injury in the brain can give rise to severe disability due to neuronal destruction. Further deterioration results due to cerebral ischemia from brain swelling, hematoma formation, hypoxia, and hypotension and then leads to secondary brain injury.[4]

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Nurses are the health professionals who see the full impact of TBI and have the skills that can alter the course of a patient's recovery; it is important for nurses to have a valuable resource with evidence-based recommendations on nursing activities to help them achieve the best possible outcomes. Nurses require knowledge and skills to provide quality care to the adults with STBI. Nurses play a vital role in the management of patients with STBI.

Significance of This Review

Guidelines that promote interventions of proved benefit and discourage ineffective ones have the potential to reduce morbidity and mortality and improve quality of life, at least for some conditions. Guidelines can also improve the consistency of care.[5] Clinical management has become much more structured and evidence based since the publication

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of guidelines covers many aspects of care. Over the past 10 years, much of the treatment of TBI has evolved toward standardized approaches that follow international and national guidelines.[6] However, there are many recommendations on the management of STBI; there is an insufficiency of adequate facts regarding the nursing management of patients with STBIs. Even though all recommendations and activities are not individually performed by nurses, they are accountable for implementing and evaluating the results of these activities. In spite of the several existing published guidelines on the care of patients with STBI, new data and recommendations regarding the role of nursing management of STBI patients are limited.[7]

An understanding of medical complications during the care from injury to rehabilitation and discharge is important for the care of patients, for healthcare planning, and for formulating interventions that could improve outcome.[8] The most commonly encountered medical conditions in patients with TBI are eyes, ears, nose, and throat problems, psychiatric or behavioral disturbances, hypertension, and musculoskeletal injury at mild-to-moderate severity.[9] If left untreated, patients can develop certain complications such as posttraumatic seizures, hydrocephalus, deep vein thrombosis (DVT), heterotopic ossification, spasticity, gait abnormalities, agitation, and chronic traumatic encephalopathy.[10] This article outlines the nursing approaches for patients with STBI.

Methods

A comprehensive literature search was made in following databases: Google Scholar, Cochrane, J-Gate, ProQuest, and ScienceDirect from 2000 to 2016 for retrieving the related studies. In the included studies, data were extracted and evaluated as per the objective, and narrative analysis was adopted to write this review. The eligibility of the papers to be included was determined by a reviewer. The inclusion criteria included publication in peer-reviewed journals, guidelines, pathways, studies published in the last 16 years, clinical trials, studies with full-version available, and studies written in English only [Table 1]. Different combinations of search terms were used to collect the available literature and relevant data were retrieved. Search terms included nursing management, severe traumatic brain injury, severe brain injury, head injury, and management.

Results and Discussions

The evidence obtained out of 38 reviewed literature on the management of patients with STBI is beneficial for all the neuronurses who care for the STBI patients. This descriptive synthesis adds to the scientific evidence in the field of nursing care. The nursing care of TBI patients starts from the initial management to the rehabilitative care.

Prehospital management

The main goals of prehospital management are to prevent hypoxia and hypotension because these systemic insults lead to secondary brain damage. When assessed before hospital admission, oxygen saturation <90% is found in 44%–55% of cases and hypotension in 20%–30% of cases. Hypoxia and hypotension are strongly associated with poor outcome. In various settings, the introduction of a prehospital system capable of normalizing oxygenation and blood pressure (BP) has been associated with improved outcome. However, ensuring adequate training of paramedics is vital because intubation by poorly trained paramedics has been associated with worse outcome. Arterial hypotension is best prevented by early and adequate fluid resuscitation with normotonic crystalloids and colloids. No benefits have yet been shown for hypertonic solutions, or for albumin, which has been associated with worse outcome.[6]

Emergency room management

Initial management in the emergency room starts with recognizing TBI and involves assessment of the level of consciousness of the patient, securing the airway with an endotracheal tube for patients with Glasgow Coma Scale (GCS) score of ≤8,[11,12] ensuring adequate oxygenation (PaO_2 >60 mmHg) and BP (systolic BP >90 mmHg),[11] inserting peripheral intravenous (I.V) canulas, cardiac monitoring, pulse oximetry, and continuous waveform capnography if needed. A neurologic examination should be done as soon as possible,[12] and a GCS score ≤8 is considered an STBI.[11,13] A complete blood count, electrolytes, glucose, coagulation parameters, blood alcohol level, and urine toxicology should be checked.[11,14] In STBI, noncontrast head computed tomography (CT) scan is the right tool of choice. Proton neurospectroscopy is a safe, noninvasive, and fast method of predicting the end results after a TBI.[15] Intracranial pressure (ICP) monitoring is advised for all patients with STBI, patients at risk of ICH,[16] GCS score <9, and an abnormal CT scan. The target should be to maintain ICP <20 mmHg[17] and cerebral perfusion pressure (CPP) range is 60–70 mmHg.[2] A ventricular catheter connected to an external strain gauge transducer is the most appropriate method for monitoring ICP.[16,18] Draining cerebrospinal fluid (CSF) decreases ICP.[17] Hyperventilation therapy can reduce ICP,[11] but there is no strong evidence which indicates whether this improves outcomes.[19] Correction of hypotension[20] and hypoxia helps in improving patient outcomes.[16]

The management of patients with head trauma should always consider C-spine motion restriction.[21] Hold the neck immobile in line with the body, apply a rigid or semirigid cervical collar, and (unless the patient is very restless) secure the head to the trolley with sandbags and tape. Cervical spine injury can be difficult to diagnose in the unconscious patient and should be assumed to be present until it can confidently be excluded. The priority in TBI must always be to secure, maintain, and protect a clear airway. Remove secretions and foreign bodies by manual extraction or suction, giving oxygen by mask (10–12 1/min). The adequacy of ventilation can be assessed clinically and by arterial blood gas analysis. A tension pneumothorax is a life-threatening emergency which should be diagnosed clinically and treated promptly. An indwelling arterial cannula allows serial blood gas measurement and

Table 1: The literature from 2000 to 2016 retrieved for the review on nursing management of adults with severe traumatic brain injury

Author and year	Research design	Objective of the study	Sample and sample size	Outcomes measures	Study findings
American College of Surgeons, 2015[1]	Guideline	To provide recommendations regarding care of the TBI patients	-	-	Recommendations based on the best available evidence and consensus opinion of the expert panel
Lump, 2014[2]	Guideline	Management of patients with STBI	-	-	Primary and secondary brain injuries, nursing assessment and initial treatment, medical and surgical management, postoperative care, and long-term management
Das *et al*., 2012[3]	Article	To review on neurological disability in India	5 literatures	Trends, response, and burden	Neurologic disability is a public health priority in India and mandates urgent changes in national health policy
Murthy *et al*., 2005[4]	Review	To outline the importance in early diagnosis and aggressive treatment of secondary brain injury	25 literatures	-	Managing head injury is a challenging task and requires dedicated efforts and good team-work round the clock for better outcome
Woolf *et al*., 1999[5]	Clinical guidelines	To analyze the potential benefits, limitations, and harms of clinical guidelines	16 literatures	-	Clinical guidelines are an increasingly familiar part of clinical practice They have potential benefits and harms Rigorously developed evidence-based guidelines minimize the potential harms Clinical guidelines are the only one option for improving the quality of care
Maas *et al*., 2008[6]	Review	To outline the moderate and STBI in adults	Searches of PubMed up to May 2008	-	New developments and current knowledge and controversies, focusing on moderate and STBI in adults
Özztekin and Serpil Yüksel, 2013[7]	Review	To review data on literature for STBI in adults	Works in English published between 2000 and 2012, adults with STBI	Prehospital nursing approaches for patients with STBI	Initial management of the patients with STBI
Godbolt *et al*., 2015[8]	Original research	Mapping of medical complications in the subacute period after STBI and the impact of these complications on 1-year outcome to inform health care planning and discussion of prognosis with relatives	Patients aged 18-65 years with STBI and acute GCS 3-8, who were admitted to neurointensive care	GOS extended	Subacute complications occurred in two-thirds of patients. Presence of a tracheostomy or epilepsy at 3 weeks, and of PEG feeding and weight loss at 3 months, had robust associations with unfavorable outcome that were incompletely explained by acute injury severity

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Author and year	Research design	Objective of the study	Sample and sample size	Outcomes measures	Study findings
Holcomb *et al*., 2012[9]	Original research	To provide descriptive findings regarding the overall health status and prevalence of medical comorbidities experienced by TBI patients	Adults (n=258) with moderate to STBI	The Modified Cumulative Illness Rating Scale is a 14-item rating scale used to indicate health status by rating impairment across 14 different domains	The TBI sample had lower rates of comorbidities compared with other rehabilitation populations, including stroke and orthopedic samples. The most commonly encountered medical conditions within our sample were eyes, ears, nose, and throat problems, psychiatric or behavioral disturbances, hypertension, and musculoskeletal injury at mild-to-moderate severity
Pangilinan, 2017[10]	Review	To discuss classification and complications of traumatic brain injury	86 literatures	-	Classifications and complication of TBI
Claude Hemphill and Nicholas Phan, 2016[11]	Literature review	To discuss the management of acute STBI	192 literatures	-	Patients with STBI are most optimally managed with neurosurgical and neurocritical care support and the use of guidelines-based standardized protocols
Rusticali and Villani, 2008[12]	Guideline	To identify scientific evidence that defines the role of diagnostic and therapeutic procedures in adult patients with TBI, paying attention to the early stages To develop recommendations	Reviewed literature from 2000 to December 2005	-	Guidelines and recommendations for management of STBI patients
Sheriff and Hinson, 2015[13]	Review	To discuss the developments in therapeutic strategies aimed at optimizing ICP and CPP and minimizing cerebral hypoxia	76 literatures	-	The management, prognosis of medical and neurologic complications peculiar to TBI
Liao *et al*., 2009[14]	Guideline	To provide concepts and recommendations to promote the quality of care for STBIs in Taiwan	Relevant information from 1996 to 2006 on the Medline database	ER treatment, ICP monitoring, CPP, fluid therapy, use of sedatives, nutrition, intracranial hypertension, seizure prophylaxis, and second-tier therapy	Evidence-based, clinical practice guidelines for STBI
Puri, 2011[15]	Article	The role of proton neurospectroscopy in the assessment of brain function, estimation of coma duration, and prediction of outcome in STBI	6 literatures	Proton neurospectroscopy, coma duration, and outcome in STBI	In addition to GCS, clinicians should seek to obtain the neurospectroscopy measurements of the three resonances assigned to NAA, Cho, and Cr
Brain Trauma Foundation, 2007[16]	Guidelines	To address the key topics useful for management of STBI patients	-	-	Guidelines and recommendations for management of STBI patients

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Author and year	Research design	Objective of the study	Sample and sample size	Outcomes measures	Study findings
American Association of Neuroscience Nurses, 2012[17]	Guideline	To provide recommendations based on current evidence To offer evidence-based recommendations on nursing activities	Adults with a brain injury incurred by a traumatic mechanism of injury with a resultant level of consciousness categorized by a GCS score of 8 or lower	GCS score, ICP, CPP, brainstem herniation, complications of treatment, DVT, disability, mortality, duration of institutionalization	Recommendations
Zeng and Gao, 2010[18]	Case report	To evaluate the effect of the treatment modality guided by intraventricular ICP monitoring on patients with STBI	136 severely brain-injured patients	Management of patients with STBI guided by intraventricular ICP monitoring	ICP monitoring via ventriculostomy facilitate an early and accurate intervention for severely brain-injured patients
Roberts *et al*., 2009[19]	Cochrane review	To quantify the effect of hyperventilation on death and neurological disability following head injury	One trial with 113 participants	-	Not enough evidence on whether hyperventilation therapy improves outcomes for people with TBI
Protheroe and Gwinnutt 2011[20]	Review	To identify measures to manage head injuries	108 literatures	-	Management of head injuries supports the avoidance of hypoxia, hypotension, and hyperventilation, coupled with control of blood glucose
Jung, 2015[21]	Review	To discuss the airway management of patients with TBI/C-spine injury	69 literatures	-	A video-laryngoscope assists airway management in TBI patients with C-spine injury
Gentleman *et al*., 1993[22]	Guideline	To resolve the potential conflict between the need for rapid referral and transfer of selected patients to the neurosurgical unit and the need for thorough assessment, resuscitation, and monitoring before and during transfer	25 literatures	-	Guidelines for resuscitation and transfer of patients with serious head injury
Talsky *et al*., 2011[23]	Review	To discuss the pharmacological interventions for TBI	54 literatures	-	Pharmacological interventions can play a role in managing the neuropsychiatric, neurocognitive, and neurobehavioral sequelae of injury to the brain
Haddad and Arabi, 2012[24]	Review	To discuss the critical care management of STBI with focus on monitoring, avoidance, and minimization of secondary brain insults, and optimization of cerebral oxygenation and CPP	132 literatures	Hemodynamic support, respiratory care, fluid management, preventing secondary brain insults, maintaining an adequate CPP, and optimizing cerebral oxygenation	The management of STBI centers on meticulous and comprehensive intensive care that includes multimodal, protocolized approach
Bachman, 2006[25]	Article	To describe the careful balance of intervention and vigilance, hallmarks of neuroscience nursing care, in terms of patient positioning	12 literatures	Patient positioning	Neuroscience nurses must balance the basic standards of nursing practice with evidence based and esthetic aspects of caregiving

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Author and year	Research design	Objective of the study	Sample and sample size	Outcomes measures	Study findings
Spiotta *et al*., 2010[26]	RCT	To determine whether $PbtO_2$ based therapy or ICP/CPP-based therapy is associated with improved patient outcome after STBI	123 patients with STBI	$PbtO_2$-based therapy	$PbtO_2$-based therapy results in reduced patient mortality and improved patient outcome after STBI
Care, 2005[27]	Prospective observational study	To determine whether the addition of a PO_2 monitor in the treatment of TBI was associated with an improved patient outcome	53 patients	ICP and brain tissue PO_2 monitoring	The use of both ICP and brain tissue PO_2 monitors and therapy directed at brain tissue PO_2 is associated with reduced patient death following STBI
Carlier and Penrod, 1993[28]	RCT	To assess the use of moderate therapeutic hypothermia for patients with severe head injuries	40 consecutively treated patients with severe closed head injury	ICP and CBF	Therapeutic moderate hypothermia is safe and has sustained favorable effects on acute derangements of cerebral physiology and metabolism caused by severe closed head injury
Wang *et al*., 2013[29]	Systematic Review	To compare the effects of different nutritional support modalities on clinical outcomes of TBI patients	13 RCTs and 3 NPSs	-	After TBI, early initiation of nutrition is recommended. Parenteral nutrition is superior to enteral nutrition in improving outcomes. The use of small-bowel feeding and immune-enhancing formulae in reducing infectious complications
Scrimgeour and Condlin, 2014[30]	Review	To highlight four promising nutritional interventions and to provide an up-to-date summary regarding their apparent efficacy for affecting TBI	162 literatures	-	The nutritional treatment for TBI
Carney *et al*., 2016[31]	Guideline	To synthesize the available evidence and to translate it into recommendations	45 literatures	-	This document provides recommendations only when there is evidence to support them. As such, they do not constitute a complete protocol for clinical use
Khajavikhan *et al*., 2016[32]	Descriptive and correlation study	To assess the correlation between hyperglycemia with neurological outcomes following STBI	83 patients with STBI	Neurological function after severe head trauma	Hyperglycemia after STBI (RBS ≥200) is associated with poor outcome
Marek *et al*., 2016[33]	Retrospective cohort analysis	To evaluate the impact of tracheostomy on hospital mortality in patients with moderate or severe isolated TBI	279,937 patients admitted to an ICU between 1998 and 2010	Tracheostomy	Patients with isolated TBI who underwent tracheostomy had a lower risk-adjusted mortality than patients who remained intubated
Roberts and Sydenham, 2012[34]	Cochrane review	To assess the effects of barbiturates in reducing mortality, disability and raised ICP in people with acute TBI To quantify any side effects resulting from the use of barbiturates	Data from seven trials involving 341 people	Mortality, disability, raised ICP, side effects of barbiturates	There is no evidence that barbiturate therapy in patients with acute severe head injury improves outcome

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Author and year	Research design	Objective of the study	Sample and sample size	Outcomes measures	Study findings
Majdan *et al*., 2013[35]	Retrospective review	To analyze the use of barbiturates in patients with STBI in the European centers where INRO introduced guideline-based TBI management and to analyze barbiturate effects on ICP, use of vasopressors, and short- and long-term outcome of these patients	1172 patients with STBI were collected in 13 centers located in five European countries	ICP, use of vasopressors, and short- and long-term outcome	Low doses of thiopental and methohexital were used for sedation of patients without side effects. Phenobarbital was probably used for prophylaxis of posttraumatic seizures
Kirmani *et al*., 2013[36]	Review article	To discuss the role of intravenous levetiracetam in seizure prophylaxis of STBI patients and the need for future studies	24 literatures	Intravenous levetiracetam	Further larger, prospective, randomized double-blind multicenter trials are needed to further define the role of this anticonvulsant in short- and long-term seizure prophylaxis
Lemke, 2007[37]	Clinical Article	To discuss the causes of agitation in brain injured patients, to describe the pathophysiological process of sympathetic storming, to discuss the current medical management pertaining to sympathetic storming	-	Agitation in brain-injured patients, pathophysiological process of sympathetic storming, medical management	Patients with sympathetic storming must be treated promptly
Baltopoulos, 2015[38]	Prospective study	Neuroprotective function of Epo in patients with STBI	42 adults with TBI	Age, GCS, and pupil reactivity	Lower mortality and better neurological outcome for the patients who received Epo
Zhang *et al*., 2014[39]	Systematic review	To evaluate the current evidence regarding the clinical efficiency and safety of naloxone as a treatment for STBI in mainland China	Nineteen RCTs including 2332 patients	Overall mortality, prevalence of abnormal heart rates, abnormal breathing and the level of ICP; awakening time, GCS score, prevalence of verbal and physical dysfunction and severe disability rate	Naloxone in the early stage for STBI patients might effectively reduce mortality, control ICP, and significantly improve the prognosis
Gouello *et al*., 2014[40]	Single-center, retrospective, descriptive study	To evaluate the results of all decompressive craniectomies performed between 2005 and 2011 for refractory intracranial hypertension after STBI	60 patients with STBI	Complications, clinical outcome, and early and long-term GOS	Decompressive craniectomy is useful for the management of refractory intracranial hypertension after STBI
Sahuquillo and Arikan, 2006[41]	Cochrane review	To assess the effects of secondary decompressive craniectomy on outcomes and quality of life for patients with STBI	One trial with 27 participants	Quality of life for patients	There is no evidence from RCTs that supports the routine use of secondary decompressive craniectomy to reduce unfavorable outcomes in adults with STBI and refractory high ICP
Lee and Goh, 2010[42]	Review	Neuromonitoring for TBI in neurosurgical Intensive Care	105 literatures	-	Multimodal monitoring can potentially improve outcomes in patients with TBI
Aries *et al*., 2015[43]	Review	To discuss neuromonitoring of patients with STBI at the bedside	55 literatures	-	The evidence for ICP monitoring, CPP calculation, and ICP/CPP-guided therapy after STBI

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Author and year	Research design	Objective of the study	Sample and sample size	Outcomes measures	Study findings
Ristic *et al*., 2015[44]	Review	To review the current neuromonitoring techniques in critical care medicine	40 literatures	-	Early detection of secondary events is a major target of neuromonitoring in critically ill patients. The benefit of ICP monitoring has not been established by an RCT, and the efficacy of ICP-guided management has indeed been challenged
Schlosser *et al*., 2009[45]	Observational research	To determine whether prediction of outcome in the early phase after STBI is possible by means of vestibule ocular monitoring	Twenty-seven patients with STBI	Vestibulo-ocular monitoring	Vestibulo-ocular monitoring with galvanic labyrinth polarization performed during the 1st days after TBI helps to predict favorable or unfavorable outcome
Sonneville, 2014[46]	Review	To discuss the prevention of pneumonia after STBI	15 literatures	-	Various aspects have been discussed
Manju *et al*., 2013[47]	Prospective longitudinal study	To assess the factors associated with development of pressure ulcer in patients with STBI and study its prognostic significance with respect to neurological outcome at 3 months	Eighty-nine patients of TBI in age group 20-60 years admitted with GCS 4-8	Patient characteristics, hemoglobin, serum albumin levels, daily assessment for the presence of pressure ulcer, telephonic interview	The factors influencing pressure ulcer in patients with TBI were poorer GCS, delayed enteral feeding, >10% fall in hemoglobin, and >10% fall in albumin. Pressure ulcer had significant association with mortality at 21 days and recovery status at 3 months
Cooper, 2013[48]	Review	To discuss on prevention of pressure ulcers in Intensive Care Unit	34 literatures		This article addressed risk factors, risk scales used to determine the risk of pressure ulcers, and prevention of device-related pressure ulcers in patients in the critical care unit
Lo *et al*., 2008[49]	Review	Strategies to prevent CAUTIs in acute care hospitals	51 literatures	-	Practical recommendations in a concise format designed to assist acute care hospitals in implementing and prioritizing their CAUTI prevention efforts
Salierno *et al*., 2014[50]	Article	To discuss physiotherapeutic procedures for the treatment of contractures	35 literatures	-	Various physiotherapeutic procedures for the treatment of contractures in subjects with TBI has been discussed
Abdel-Aziz *et al*., 2015[51]	Review	To review the timing for DVT chemoprophylaxis in TBI	30 literatures	-	The timing for DVT chemoprophylaxis in TBI has been discussed
Demuro and Hanna, 2013[52]	Review	To discuss the prophylaxis of deep venous thrombosis in trauma patients	62 literatures	-	Prophylaxis of deep venous thrombosis is discussed
Chelladurai *et al*., 2013[53]	Systematic review	To assess both the effectiveness and safety of pharmacologic and mechanical prophylaxis, and the optimal time to initiate pharmacologic prophylaxis in hospitalized patients with TBI	12 studies on TBI patients	-	Pharmaco-prophylaxis improves DVTs and mortality outcomes in patients hospitalized with TBI

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Author and year	Research design	Objective of the study	Sample and sample size	Outcomes measures	Study findings
Paydar *et al*.,[54] 2016	Review	To discuss the management of DVT prophylaxis trauma patients	54 literatures	-	Patients with trauma are at increased risk of DVT and subsequent PE because of coagulopathy in patients with multiple trauma, DVT prophylaxis is essential but the VTE prophylaxis strategy is controversial for the trauma patients
Wertheimer *et al*., 2008[55]	Prospective study	To examine the functional status of persons surviving a severe penetrating TBI resulting from a gunshot wound who require inpatient rehabilitation	Forty-five persons with severe penetrating brain injury and 45 persons involved in a motor vehicle crash	DRS, FIM instrument, and CIQ	Survivors of a craniocerebral GSW and who are discharged from acute care into an inpatient rehabilitation program improved functional outcome and community reintegration can be expected over time
Sinha *et al*., 2013[56]	Prospective study	To assess cognitive, functional, and psychosocial outcome in patients with STBI	77 survivors of STBI	Cognitive outcome, functional outcome, and psychosocial outcome	Patients with STBI had good recovery in functional outcome and in psychosocial outcome; however, improvement in cognitive outcome was not so optimistic
Steiner *et al*., 2016[57]	Original research	To evaluate the outcome of patients after severe brain trauma according to the course of their rehabilitation	62 patients with TBI	GOS extended, FIM, CIQ	Despite the similar level of severity of TBI and outcome prognosis, patients with early showed rehabilitation the best rehabilitation effect and long-term outcome
Parker *et al*., 2013[58]	Review	To address evidence-based rehabilitation interventions to reduce the physical and mental health impairments associated with PICS	59 literatures	-	Early rehabilitation interventions in the ICU may reduce physical and mental health complications frequently occurring in survivors of critical illness
Mercier *et al*., 2013[59]	Systematic review and meta-analysis of RCTs and observational studies	To determine the ability and accuracy of the S-100β protein in predicting prognosis after a moderate or STBI	Two RCTs and 39 cohort studies were considered eligible (1862 patients)	Mortality, score on the GOS or brain death	After moderate or STBI, serum S-100β protein concentrations are significantly associated with unfavorable prognosis in the short-, mid-, or long-term
Goyal *et al*., 2013[60]	Prospective cohort study	To evaluate S-100β as a prognostic biomarker in adult subjects with STBI	218 subjects	S-100β temporal profiles generated from both CSF and serum samples across a 6-day time course	S-100β levels are highly predictive of mortality and global outcome
Egea-Guerrero *et al*., 2013[61]	Prospective study	To assess the value of including acute S-100β levels in standard clinical data as an early screening tool for BD after STBI	140 patients with STBI	S-100β concentrations and pupillary responsiveness	Pupillary responsiveness at admission, as well as 24 h serum S-100β levels, could serve as screening tools for the early detection of patients at risk for brain death after STBI
Stenberg *et al*., 2015[62]	Prospective, multicenter, observational study of STBI	To assess the clinical course of cognitive and emotional impairments in patients with STBI from3 weeks to 1 year after trauma and to study associations with outcomes at 1 year	114 patients aged 18-65 years with acute GCS 3-8	GOS extended and Rancho Los Amigos Cognitive Scale-Revised	Cognition improves over time after STBI and appears to be relatively stable from 3 months to 1 year

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Author and year	Research design	Objective of the study	Sample and sample size	Outcomes measures	Study findings
Jourdan *et al*., 2016[63]	Large prospective inception cohort study	To assess brain injury outcome for subjects with TBI	Among 245 survivors at 4 years	International classification of functioning, disability and health	Management of late brain injury needs to focus on cognitive difficulties, particularly social skills, to enhance patient participation in life
Kalmar *et al*., 2012[64]	RCT	To assess whether amantadine promotes functional recovery	184 patients who were in a vegetative or minimally conscious state	The rate of functional recovery on the DRS	Amantadine accelerated the pace of functional recovery during active treatment in patients with posttraumatic disorders of consciousness
Gardani *et al*., 2015[65]	Cross-sectional study	To explore the presence and types of sleep disorders in chronic patients with STBI undergoing inpatient rehabilitation using formal diagnostic criteria based on the International Classification of Sleep Disorders	Chronic in patients with STBI	Sleep, mood, fatigue, pain, and daytime sleepiness	High levels of sleep-wake cycle disturbances in patients with STBI undergoing rehabilitation, which was associated with anxiety, fatigue, and daytime sleepiness

STBIs: Severe traumatic brain injuries; PEG: Percutaneous endoscopic gastrostomy; CPP: Cerebral perfusion pressure; ICP: Intracranial pressure; ER: Emergency room; GCS: Glasgow Coma Scale; DVT: Deep vein thrombosis; RCTs: Randomized controlled trials; $PbtO_2$: Brain tissue oxygen; PO_2: Brain tissue oxygen tension; CBF: Cerebral blood flow; NPSs: Nonrandomized prospective studies; RBS: Random blood sugar; Epo: Erythropoietin; GOS: Glasgow Outcome Scale; CAUTI: Catheter-associated urinary tract infection; PE: Pulmonary embolism; VTE: Venous thromboembolism; DRS: Disability Rating Scale; FIM: Functional Independence Measurement; CIQ: Community Integration Questionnaire; GSW: Generalized spike wave; ICU: Intensive Care Unit; CSF: Cerebrospinal fluid; PICS: Post-Intensive Care Syndrome

continuous recording of BP. Pulse oximetry is valuable for indirect measurement of how well the patient is being oxygenated. Hypotension is a late sign of hypovolemic shock. Pulse rate, respiratory rate, and capillary refill time are the more useful ways of assessing the circulation after injury. Peripheral I.V infusions should be considered for decreased blood volumes. Early direct monitoring of arterial pressure and central venous pressure is helpful for assessing the adequacy of resuscitation.[22] When managing the immediate and long-term consequences of TBI, many pharmacological options, including psychostimulants, antidepressants, antiparkinsonian agents, and anticonvulsants can be used. These can play a role in managing the neuropsychiatric, neurocognitive, and neurobehavioral sequelae of injury to the brain.[23]

Conservative and operative management

Positioning

The patient should be positioned properly with the neck in neutral position and the head end of the bed elevated to 30°. This facilitates cerebral venous drainage.[2,24] Head end of the bed should be elevated for patients with CSF, rhinorrhea, and otorrhea.[25] Rigid cervical collars should be loosened or removed to decrease ICP.[17]

Brain tissue oxygen-directed management

Patients who receive brain tissue oxygen therapy to maintain brain tissue oxygen tension ≥20 mmHg and treated with ICP- or CPP-guided therapy to keep ICP <20 mmHg and CPP > 60 mmHg are recognized to have a better outcome and decreased mortality. These patients should be resuscitated and managed by the following methods such as (1) earlier recognition and removal of hematomas; (2) intubation and ventilation with FiO_2 and minute ventilation adjusted to set SaO_2 >93% and to evade PaO_2 <60 mmHg; (3) $PaCO_2$ set at 35–45 mmHg unless ICP is increased when $PaCO_2$ is maintained between 30 and 40 mmHg; (4) normothermia (~35°C–37°C); (5) sedation by administering propofol during the initial 24 h, succeeded by sedation and analgesia with lorazepam, morphine, or fentanyl; (6) head end elevated to 15°–30° and knee elevated; (7) if seizures are present, administer anticonvulsants (phenytoin) for 1 week or more; and (8) euvolemia by administering a crystalloid infusion (0.9% normal saline, 20 mEq/L KCl; 80–100 ml/h).[26] The use of both an ICP and a brain tissue PO_2 monitor and therapy directed at brain oxygen reduces the mortality rate after STBI.[27]

Temperature management

Hypothermia reduces ICP (40%) and cerebral blood flow (CBF, 60%), has positive effects on cerebral metabolism, and improves outcome for 3 months after injury. Thus, it limits secondary brain injury.[28] Normothermia should be maintained with the use of antipyretic medications, surface cooling devices, or even endovascular temperature management catheters.[11]

Stress ulcer prophylaxis

Stress ulcers (Cushing's ulcer) are a very common risk factor of patients in the Intensive Care Unit (ICU). Early

enteral feeding, H_2-blockers, proton-pump inhibitors, and sucralfate are recommended for the prophylaxis of stress ulcers.[24]

Nutrition

Patients immediately after injury may experience a systemic and cerebral hypermetabolic state.[13] Early enteral feeding should be initiated within 72 h of injury.[2] By day 7 of postinjury, these patients should be given full caloric replacement.[11] After TBI, early initiation of nutrition is recommended. Parenteral nutrition is superior to enteral nutrition in improving outcomes.[29] Evidence-based guidelines include the provision of early (within 24 h of injury) nutrition (>50% of total energy expenditure and 1–1.5 g/kg protein) for the first 2 weeks after the injury.[30] Feeding patients to attain basal caloric replacement at least by the 5th day and at most by the 7th day postinjury is recommended to decrease mortality. Transgastric jejunal feeding is recommended to reduce the incidence of ventilator-associated pneumonia.[31]

Fluid therapy

Fluid therapy helps in restoring vascular capacity, tissue perfusion, and cardiac flow rate. Hypertonic saline can be used for patients with complications of STBI and systemic shock.[14] Euvolemia can be maintained using isotonic fluids such as normal saline.[11]

Hyperventilation

Hyperventilation reduces $PaCO_2$, CBF, and ICP by the cerebral autoregulation. It can be used only if ICP >30 mmHg and CPP <70 mmHg; CPP >70 mmHg but higher ICP >40 mmHg.[14]

Transport of patients

These patients should be transported with caution and care with suitable protection. It should be done by trained and suitably equipped personnel with careful supervision, support to the vital organs, continuous monitoring, prevention of damage to the spine, and complete documentation.[12]

Hemostatic therapy

Patients with STBI develop coagulopathies. Prothrombin complex concentrate, fresh frozen plasma, and/or Vitamin K should be given for patients with warfarin-associated intracerebral hemorrhage (ICH). Platelet count should be maintained >75,000 with platelet transfusions if necessary for patients with thrombocytopenia.[11]

Glucose management

Extremes of very high or low blood glucose levels should be managed accordingly. A target range of up to 140 mg/dL or possibly even 180 mg/dL may be appropriate.[11] Patients with hyperglycemia should be managed insulin protocol in cases with value >200 mg/dl for improving the outcome.[32]

Tracheostomy

In patients with severe isolated TBI, tracheostomy might be favorable if it is performed in the 2nd or 3rd week after admission.[33]

Medical management

An increase in ICP can be prevented by administering sedation.[17] The foremost therapies after pain and agitation are mannitol or hypertonic sodium chloride solution. Propofol, I.V dexmedetomidine, and fentanyl are commonly used in mechanically ventilated patients.[2] Steroids are not recommended in TBI.[11,16] Barbiturates are commonly used to treat ICP. There is no affirmation that barbiturates reduce mortality; it also causes low BP.[34,35] Mannitol can be used to reduce ICP[16,17] and it also helps in improving CBF.[11] Phenytoin is recommended to reduce posttraumatic seizures.[16] Levetiracetam can be used as an alternative.[11,36] Sympathetic storming which includes posturing, dystonia, hypertension, tachycardia, dilatation of the pupils, sweating, hyperthermia, and tachypnea can occur within the first 24 h after injury till several weeks. This can be caused after the cessation of sedatives and narcotics in the ICUs and should be treated based on their signs and symptoms by initiating planned medications to reduce the activities of the sympathetic nervous system.[37] The patients who receive erythropoietin show lower mortality and better neurological outcome and limit neuronal damage induced by TBI.[38] Naloxone effectively reduce mortality and control ICP in TBI.[39]

Surgical management

A surgical evacuation is done on patients having GCS score ≤8 with a huge lesion on noncontrast head CT scan. Depressed skull fractures those are open or complicated need surgical repair. Decompressive craniectomy helps in positive patient outcome.[2,24,40] Still, there is no evidence to support whether decompressive craniectomy improves mortality and quality of life, but it may improve neurological outcomes in pediatric patients.[41] An epidural hematoma larger than 30 mL in volume despite a patient's GCS score should be evacuated immediately. Acute subdural hematomas greater than 10 mm in thickness or associated with midline shift greater than 5 mm on CT also should be should be surgically evacuated. If there is an evident mass effect, then a surgical evacuation is recommended in traumatic ICH. Superficial debridement and dural closure are indicated in a penetrating injury to prevent CSF leak. For depressed skull fractures, elevation and debridement are recommended.[11]

Monitoring

The primary aim of neuromonitoring in patients with TBI is early detection of secondary brain insults so that timely interventions can be instituted to prevent or treat secondary brain injury. ICP monitoring has been a stalwart in neuromonitoring.[42] Measurement of ICP and arterial BP is used to derive CPP and to guide targeted therapy of STBI necessitating ICU admission.[43,44] Cerebral oxygenation and near-infrared spectroscopy are also established as an important parameter for monitoring. Multimodal monitoring allows different parameters of brain physiology and function to be monitored and can improve identification and prediction of secondary cerebral insults.[42] Cerebral microdialysis is

an invasive laboratory device for analyzing brain tissue biochemistry. It is used to measure biochemical changes in the area of brain which are at higher risk to secondary insults and its use is very limited.[24] Vestibulo-ocular monitoring is an indicator of brainstem function. It helps identify brainstem lesions by imaging techniques.[45]

On-going management and prevention of complications

The prevention of ventilator-associated pneumonia in patients with STBI is a central challenge. In patients with trauma, persistent systemic inflammatory response syndrome increases the risk of nosocomial sepsis, and low-dose hydrocortisone might exert beneficial immunomodulatory effects rather than inducing an immunosuppressive state. The use of stress-dose steroids to prevent ICU-acquired infections is still an emerging concept.[46] Patients with STBI are prone to develop pressure ulcer. The factors influencing pressure ulcer in patients with TBI are poorer GCS, delayed enteral feeding, >10% fall in hemoglobin, and >10% fall in albumin.[47] A risk identification scale can be used each shift to identify which patients are at risk, and it should be ensured that tubing and devices are not placed between skin surfaces. It should be made sure that ventilator tubing is not causing tension on tracheostomy tube and faceplate and pressure-relief devices including specialty mattress surfaces, padded cervical collars, heel lift devices, and pillows, skin barrier creams, topical or indwelling fecal containment devices can be used to prevent the pressure ulcer.[48] Around 80% of the urinary tract infections are attributable to an indwelling urethral catheter. Limiting catheter use and minimizing the duration the catheter remains *in situ* are primary strategies for catheter-associated urinary tract infection prevention. Urinary catheters must be inserted only when necessary for patient care and leave them in place only if indications persist. For its prevention, hand hygiene must be practiced immediately before insertion of the catheter and before and after any manipulation of the catheter site or apparatus. Nurses should make sure that catheters are inserted by use of aseptic technique and sterile equipment.[49] Contractures are a common complication of TBI and may occur in up to 84% of cases. The most commonly affected joints are hip, shoulder, ankle, elbow, and knee, with a significant percentage of patients developing contractures in five or more joints. Stretch is one of the most widely used techniques for the treatment and prevention of contractures. Splints, positioning programs, or casts changed at regular intervals (serial casting) can also be used. All methods involve mechanical elongation of soft tissues during varying lengths of time.[50]

Postoperative care

Postoperatively, any change in ICP, circulation of the CSF, CBF should be monitored continuously. Mechanical ventilation should be provided to maintain $PaCO_2$ between 35 and 45 mmHg, maintain normal temperature, correct cerebral perfusion pressure, and prevent secondary brain injury. Patients with STBI are at an alarming risk for DVT. This can be minimized with the range-of-motion exercises, pneumatic compression devices,[51] and drugs such as low-molecular-weight heparin if needed.[2,16,31,52,53] The detection of DVT is difficult; therefore, it is good to concentrate on preventing their development using mechanical or pharmacological methods.[54] Ventriculostomies and other ICP monitors should be placed under sterile conditions to prevent CSF infections.[16]

Initiation of early in-hospital rehabilitation

STBI is the most debilitating of all injuries and has very poor outcome.[55] The survivors of STBI suffer from multiple problems such as physical deformity, memory disturbances, functional disability, cognitive dysfunction, and difficulty in performing various activities.[56] The strategy of early rehabilitation results in better short- and long-term outcomes. To optimize and accelerate the treatment process, patients should receive rehabilitative treatment as soon as possible.[57] Potential benefits for patients participating in early rehabilitation in the ICU include improved muscle strength, physical function, and quality of life and reduced hospital and ICU length of stay, duration of mechanical ventilation, and hospital costs.[58] As a part of long-term management, cranioplasty can be done after 2–6 months of the initial injury to replace the patient's bone flap or restore the area with mesh or plastic. Patients with decompressive craniectomy need neuropsychological, physical, speech, and occupational therapy. Patients require weeks to months of TBI rehabilitation.[2] Measuring the S-100β protein could be convenient in determining the long-term prognosis in patients with severe traumatic injury.[59-61] The cognition in STBI is always related with the patient outcome. Cognition improves over time and will be stable from 3 months to 1 year; thus, early screening of cognitive function is recommended for rehabilitation planning in a clinical setting (Stenberg *et al*., 2015).[62] Amantadine is proved to be effective in accelerating the pace of recovery during acute rehabilitation.[64] Sleep problems along with anxiety, depression, daytime sleepiness, and fatigue are common in patients with STBI during rehabilitation. Nurses should use actigraphy, sleep charts, sleep diaries for the assessment and diagnosis of sleep problems.[65]

Conclusion

TBI is a major cause of death and disability throughout the world. Injury can be divided into primary and secondary injuries. For patients with TBI admitted to the ICU, the management and prevention of secondary injury are most important. There is much debate surrounding many treatments in these patients. Management of TBI patients requires multidisciplinary approach, frequent close monitoring, and judicious use of multiple treatments to lessen secondary brain injury and improve outcomes. The management of STBI includes different approaches, which clearly requires the efforts of bedside nurses along with the other healthcare team in the hospital. While such management can be challenging, nurses should have enough knowledge and skill to provide quality care and to be competent in the healthcare sector.

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Conflicts of interest

There are no conflicts of interest.

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