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Management of Pediatric Traumatic Brain Injury: A Mini-Review

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Abstract

Traumatic brain injury (TBI) is a significant source of concern in the pediatric population. It has been estimated that close to 500,000-700,000 pediatric TBI incidents occur within the United States alone, with majority occurring in early childhood (<4 years) and early adulthood (>15 years). The management of TBI depends on its severity. It is the prevention of worsening of the secondary injury that is often targeted during the medical management. Given that TBI poses such a huge health risk, further understanding is required for adequate management of pediatric patients with TBI; especially due to the fact that their brain is still developing and has not completely matured.

Keywords: Traumatic brain injury; Fractures; Headaches; Ataxia; Rehabilitation

Introduction

Traumatic brain injury (TBI) is a significant source of concern in the pediatric population. It has been estimated that close to 500,000-700,000 pediatric TBI incidents occur within the United States alone, with majority occurring in early childhood (<4 years) and early adulthood (>15 years) [1-3]. TBI in children is associated with various different etiologies such as falls, shaken baby syndrome, motor-vehicle collisions, and sports [4,5]. TBI can range from mild to severe, with the following classification (Table 1). TBI can be divided into being primary or secondary injury in nature. Primary injuries are result of the initial insult from the accident, and include direct injury to the brain such as diffuse axonal shear and rupture, contusion, fractures of the skull [4]. Meanwhile, secondary injuries are result of the mechanism that occurs after the initial injury, and varies from having local inflammation to global ischemia. The mechanism for varied response is dependent on the presence of increased intracranial pressure (ICP) [4,6]. It is the prevention of worsening of this secondary injury that is often targeted during the medical management. Given that TBI poses such a huge health risk, further understanding is required for adequate management of pediatric patients with TBI; especially due to the fact that their brain is still developing and has not completely matured.

Classification	Gcs	Loss of Consciousness	Post-Traumatic Amnesia
Mild	13-15	0-30 minutes	<1 day
Moderate	9-12	30 min – 24 hours	1-7 days
Severe	3-8	>24 hours	>7 days

Table 1: Classification of TBI, classifying the patient based on the highest severity in any column [7]. Table usage was adapted and approved by Janich et al.

Concussion

Concussion is one of the most common pediatric injuries. It is an injury to the brain that disrupts the neurological function in an acute setting, but the symptoms can often progress at a later time [8,9]. This short-lived impairment of the neurological function has been showed to be due to alteration in ion balances, particularly sodium, potassium, and calcium in animal models [8,10]. Symptoms of concussion vary depending on the given situation and can include cognitive challenges, sleep disturbances, headaches, and ataxia. One of the most disabling symptoms that patients often complain about after a concussion is headache [9]. Even more striking is the fact that children often need a longer rehabilitation time post-concussion compared to adults [8,9]. Most concussion symptoms resolve over time; however, some patients experience post-concussion syndrome (PCS), and research has showed that personal or family history of migraine, psychiatric illness, and prior concussions are all factors that increase a patient's predisposition to develop PCS [7].

Imagings

If a head injury is suspected, then proper imaging is usually required. However, as most cases of mild TBIs do not have significant computed tomography (CT) imaging findings, there had been no significant consensus. The Canadian Head CT Rule (Table 2) assists with this problem. Under this rule, if a sign or symptom is present from the list then CT imaging is recommended. As with most guidelines, if hemorrhage is appreciated on the initial CT then repeat imaging is warranted in 6 hours of the initial scan. Magnetic Resonance Imaging (MRI) has also been studied as an imaging modality for TBI; however, its use is often best reserved for later stages of the TBI [10,11]. In a study conducted by Yuh et al., in which they directly compared CT *vs.* MRI, they found that out of the patients who had negative head CTs, 28% had abnormal MRIs [12,13]. However, given the fact that MRI is often not feasible in patients who have certain implants, requiring significant sedation, etc., CT is a much more favored initial test.

Management of mild TBI

Mild TBI is managed through supportive care, and appropriate medications are prescribed to assist with symptoms such as headache, nausea, or vomiting. It is important to emphasize the importance of cognitive and physical rest in the pediatric population with gradual progression to normal activity [14]. Also, children and parents should be provided with adequate guidelines on prevention of such injuries in the future [8]. These patients will benefit from physical, occupational, and speech therapies.

High Risk	GCS<15 after 2 hours from the time of injury
	Suspected open or depressed skull fracture
	Sign of basal skull fracture
	2 or more episodes of vomiting
	Patient is 65 years old or older
Medium risk	Amnesia of more than 30 minutes prior to impact
	Dangeous mechanism (Pedestrian struck by motor vehicle, Ejection from motor vehicle, fall from>3 feet or five stairs)

Table 2: Canadian CT Head Rules-If any of the following characteristics are present, a CT of the head is warranted. Table usage was adapted and approved by Janich et al.

Management of moderate TBI

There is minimal literature and guidelines in the management of moderate TBI. Most evidence pertaining to the management of TBI addresses the moderate TBI as either mild or severe. It was reported that 8-28% of cases with TBI were moderate [15,16]. The best treatment modality is to provide supportive care with frequent neurological exams in cases where there is no apparent mass lesion on imaging. In cases where a lesion such as epidural hematoma or subdural hematoma is appreciated, guidelines state the need for a repeat imaging within 6 hours to assess the lesion progression.

Management of severe TBI

Unfortunately, similar to the management of moderate TBI, there is not sufficient high quality evidence available in the pediatric population [17]. However, one of the primary purposes in the management of severe TBI is providing adequate oxygenation and maintaining cerebral perfusion pressure. The 2003 and updated 2012 pediatric TBI guidelines provide some guidance on the management of these patients with severe TBI. It has been stated that if the child has a severe TBI and lives in a metropolitan area, then the child should be transferred to a pediatric trauma center if available [16]. Similar to other trauma protocols, the ABCs (airway, breathing, circulation) must be first assessed and secured. Of note, management of hypoxia is extremely crucial, and supplemental oxygen must be administered if needed [17].

In addition, proper assessment for other potential injuries should also be conducted. In cases, where a patient is hypotensive (systolic blood pressure below the 5th percentile for the age), adequate resuscitation with fluids is needed. To maintain adequate perfusion pressure, one needs to have adequate control of intracranial pressure (ICP). Compared to the adult population, there is paucity in guidelines focusing on the control of ICP within the pediatric population. Of note, children are also proven to have stratified values of normal ICP: infants 2-4 mmHg while older children maintain it between 5-15 mmHg [18]. The 2012 Pediatric TBI guidelines suggest that treatment protocol for ICP management can be considered when ICP is around 20 mmHg, and one can consider the use of ICP monitoring especially when patient's GCS<8 [17]. Devices such as external ventricular drain (EVD) and fiber optic intraparenchymal probe can be employed [16].

Some studies have suggested the use of hyperventilation to decrease ICP; however, there is lack of support for hyperventilation, especially due to a possibility of ischemia at low levels of $PaCO_2$. It is not recommended to use hyperventilation as a mode to maintain adequate ICP goals especially when $PaCO_2$<30 mmHg, especially in the acute setting [17]. The use of barbiturates has also been suggested to maintain ICP; however, the use is very limited, and high dose therapy should only be employed in refractory cases [17]. Furthermore, the hyperosmolar therapy, which primarily worked by decreasing the intracellular fluid volume, has also been used to maintain ICP. The guidelines recommend the use of hypertonic saline at the dose between 6.5 and 10 ml/kg for maintaining ICP [17]. Mannitol can also be used instead of hypertonic saline and in the current Brain Trauma Foundation Guidelines, the use of mannitol is recommended to control ICP after monitoring has been initiated [16,17]. While the use of glucocorticoids was a common practice in the management of TBI, its use is no longer recommended as it has not been proven to improve outcomes [16,17].

Finally, a decompressive surgery can be conducted to manage TBI patients. Both craniotomy and craniectomy are used in setting of a hematoma after trauma (Table 3). In terms of comparing craniotomy with craniectomy, RESCUE-ASDH study is still underway. Meanwhile, a recently published study titled RESCUEicp stated that decompressive craniectomy in patients with TBI had a lower mortality rate at 6 months compared to medical treatment alone; however, the studied age groups were mostly adults, and it is difficult to generalize these results to the pediatric population [18,19].

Type of hematoma	Without respect to decline	With respect to decline
Subdural	Thickness of 10 mm or more, MLS of 5 mm or more	Thickness<10 mm and MLS<5 mm if GCS decreased by 2 points or more since presentation
Epidural	Volume is 30 cc or more	GCS 8 or less with anisocoria
Intraparenchymal	Elevated ICP refractory to medical management, signs of mass effect on CT, Lesion volume is 50 cc or more	Signs of deteroriation referable to the lesion, GCS 6-8 and >20 cc of frontal or temporal contusions and MLS of 5 mm or more and/or cisternal compression
Posterior Fossa	Mass effect in posterior fossa (evidence of 4th ventricular distortion, effacement of basal cisterns, hydrocephalus)	Any deterioration that may be attributed to the hematoma

Table 3: Indications for surgical evacuation of intracranial hematomas with respect to decline in mental status (GCS). Thickness is in regard to the maximum thickness on CT of the head. MLS, midline shift. Table usage was adapted and approved by Janich et al.

Conclusion

The management of TBI depends on its severity. Most TBI patients would benefit from physical, occupational, and speech therapies. Outside of the management of mild TBI, no significant high quality evidence of support exists for managements of moderate and severe TBI. Further research is needed to evaluate the efficacy of various treatment modalities in TBI for the pediatric population.

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