Pediatric traumatic brain injury

Epidemiology

Pediatric traumatic brain injury is significantly smaller than the corresponding adult.

When divided further by specific ages, injury types, and other sources of heterogeneity, properly powered clinical research is likely to require large data sets that will allow for stratification across variables, including age.

Head trauma is the leading cause of mortality and morbidity in children [1].

Minor head trauma (MHT) constitutes a significant proportion of head injuries in children, about 90% [2] [3].

In the presence of signs and symptoms of severe head injury like decreased GCS score, focal deficit/s, and deteriorating consciousness, the diagnosis of this pathology is relatively easy.

However, in MHT, which constitutes about 90% of childhood head trauma, the management of these patients is not so easy and there are some controversial points especially in appropriate diagnostic assessment.

Despite its very high prevalence, only 3–5% of children with MHT have traumatic brain injury and only less than 1% of them need emergent neurosurgical intervention.

Previous reports from different countries about pediatric minor head trauma indicated various results in clinical practice and examination of hospitalization rates [4].

Classification

Classification of head injury in children can be organized according to severity, pathoanatomic type, or mechanism. Response to injury and repair mechanisms appear to vary at different ages, and these may influence optimal treatment; however, much work is still needed before investigation leads to clearly effective clinical interventions. This is true both for the more severe injuries as well as those at the milder end of the injury spectrum, the latter of which have received increasing attention.

see Severe pediatric traumatic brain injury

Etiology

Injuries to children caused by falling televisions have become more frequent during the last decade. These injuries can be severe and even fatal and are likely to become even more common in the future as TVs increase in size and become more affordable. To formulate guidelines for the prevention of these injuries, Cusimano et al. systematically reviewed the literature on injuries related to toppling televisions. The authors searched MEDLINE, PubMed, Embase, Scopus, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Cochrane Library, and Google Scholar according to the

Cochrane guidelines for all studies involving children 0-18 years of age who were injured by toppled TVs. Factors contributing to injury were categorized using Haddon's Matrix, and the public health approach was used as a framework for developing strategies to prevent these injuries. The vast majority (84%) of the injuries occurred in homes and more than three-fourths were unwitnessed by adult caregivers. The TVs were most commonly large and elevated off the ground. Dressers and other furniture not designed to support TVs were commonly involved in the TV-toppling incident. The case fatality rate varies widely, but almost all deaths reported (96%) were due to brain injuries. Toddlers between the ages of 1 and 3 years most frequently suffer injuries to the head and neck, and they are most likely to suffer severe injuries. Many of these injuries require brain imaging and neurosurgical intervention. Prevention of these injuries will require changes in TV design and legislation as well as increases in public education and awareness. Television-toppling injuries can be easily prevented; however, the rates of injury do not reflect a sufficient level of awareness, nor do they reflect an acceptable effort from an injury prevention perspective [5].

Pediatric patients represent a significant proportion of the neurosurgical patient volume at field medical hospitals in the Iraqi theater. The mature medical theater environment present in 2007 allowed for remarkable diagnostic evaluation and treatment of these patients. Penetrating and closed craniospinal injuries were the most common indication for consultation. Disease and nonbattle injuries were also encountered, with care provided when deemed appropriate. The deployed environment presents unique medical and ethical challenges to neurosurgeons serving in forward medical facilities [6].

Pediatric patients account for approximately 10% of all combat support hospital (CSH) admissions in Afghanistan and Iraq. Burns and penetrating head injury account for the majority of pediatric mortality at the CSH [7].

Diagnosis

The distribution of CT findings was significantly different. Pediatric patients with traumatic brain injury (TBI) were more likely to have skull fractures (OR 3.21, $p < 0.01$) and epidural hematomas (OR 1.96, $p < 0.01$). Pediatric TBI was less likely to be associated with contusion, subdural hematoma, subarachnoid hemorrhage, or compression of the basal cisterns ($p < 0.05$). Rotterdam CT scores were significantly lower in the pediatric population (2.3 vs 2.6, $p < 0.001$).

There are significant differences in the CT findings in pediatric versus adult TBI, despite statistical similarities with regard to clinical severity of injury as measured by the GCS. These differences may be due to anatomical characteristics, the biomechanics of injury, and/or differences in injury mechanisms between pediatric and adult patients. The unique characteristics of pediatric TBI warrant consideration when formulating a clinical trial design or predicting functional outcome using prognostic models developed from adult TBI data [8].

MRI

After having divided the subjects into mild presentation (GCS 14-15) and moderate-to-severe presentation groups (GCS ≤13), we can divide the patients into three subgroups:

Subgroup I, hemorrhagic foci observed only on SWI and not on FLAIR;

Subgroup II, hemorrhagic foci observed on both Susceptibility weighted imaging (SWI) and FLAIR in the same brain regions;

Subgroup III, any cases with additional foci on SWI in other brain regions. We investigated the clinical course and compared lesion numbers and distributions of hemorrhagic lesions on SWI among the subgroups.

Three clinical variables (hospitalization period in intensive care unit, total days of hospitalization, and outcome based on Pediatric Cerebral Performance Category Scale score) showed significant relevance to the three subgroups. Subgroup I showed the fewest lesions followed by Subgroups II and III, respectively. In all three subgroups, lesions were most abundant in cortical regions. Lesion in the thalamus, basal ganglia, corpus callosum, and brainstem was least in Subgroup I and gradually increased in Subgroups II and III. Such distinction was more significant in the moderate-to-severe group when compared with the mild group.

In cases of pediatric traumatic brain injury, categorizing patients into one of the above three subgroups based on hemorrhagic lesions on SWI and FLAIR is a promising method for predicting patient's clinical outcome [9].

CT scan

As a general rule, in pediatric trauma patients with a Glasgow Coma Scale (GCS) less than 13, focal neurological deficits, and deteriorating consciousness should receive CT scan. However, for children with milder head injury, there is no clear consensus about requesting CT [10].

Most of the children with minor head trauma attend the emergency department nonsymptomatically or with minimal symptoms. Neurological examination is difficult in children, especially in newborns, infants (between one month and 12 months), and those under 3 years of age. Also, concern of the parents for their children and fear of malpractice litigation may force the physicians to request radiological imaging, especially the CT. The rate of requesting CT scans in children with minor head trauma (MHT) is between 5 and 50% [11].

There is a need for further prospective, multicentered studies with a large number of patients to make decision rules especially for children in this age group.

The fear of malpractice litigation should be reduced by various measures which will protect physicians such as robust departmental guidelines [12].

Complications

Seizures

Seizures may cause diagnostic confusion and be a source of metabolic stress after pediatric traumatic brain injury.

Continuous EEG monitoring (cEEG) significantly improves detection of seizures/SE and is the only way to detect subclinical seizures/SE. cEEG may be indicated after pediatric TBI, particularly in younger children, AHT cases, and those with intraaxial blood on computerized tomography (CT) [13].

A routine protocol for continuous EEG monitoring (cEEG) was initiated for all patients with moderate or severe TBI at a Level 1 pediatric trauma center. Over a 3.5-year period, all patients with TBI who underwent cEEG monitoring, both according to protocol and those with mild head injury who underwent cEEG monitoring at the discretion of the treating team, were identified prospectively. Clinical data were collected and analyzed.

Over the study period, 594 children were admitted with TBI, and 144 of these children underwent cEEG monitoring. One hundred two (71%) of these 144 children had moderate or severe TBI. Abusive head trauma (AHT) was the most common mechanism of injury (65 patients, 45%) in children with cEEG monitoring. Seizures were identified on cEEG in 43 patients (30%). Forty (93%) of these 43 patients had subclinical seizures, including 17 (40%) with only subclinical seizures and 23 (53%) with both clinical and subclinical seizures. Fifty-three percent of patients with seizures experienced status epilepticus. Age less than 2.4 years and AHT mechanism were strongly correlated with presence of seizures (odds ratios 8.7 and 6.0, respectively). Those patients with only subclinical seizures had the same risk factors as the other groups. The presence of seizures did not correlate with discharge disposition but was correlated with longer hospital stay and intensive care unit stay. CONCLUSIONS Continuous EEG monitoring identifies a significant number of subclinical seizures acutely after TBI. Children younger than 2.4 years of age and victims of AHT are particularly vulnerable to subclinical seizures, and seizures in general. Continuous EEG monitoring allows for accurate diagnosis and timely treatment of posttraumatic seizures, and may mitigate secondary injury to the traumatized brain [14].

Treatment

see Pediatric traumatic brain injury treatment.

Outcome

see Pediatric traumatic brain injury outcome.

Guidelines

see Pediatric traumatic brain injury guidelines

Case series

Pediatric traumatic brain injury case series.

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