REVIEW ARTICLE

PEDIATRIC HEAD INJURY

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Abstract
Minor trauma to the head is common in childhood and does not require any medical or surgical treatment. Nevertheless, head injury in infancy and childhood is the single most common cause of death and permanent disability. Measurable deficits occur even after mild to moderate head injury but are markedly greater after severe injury. They include impaired cognition, motor impairments, disruption of attention and information processing, and psychiatric disturbances. Despite the frequency of the sequelae of head injury in childhood, there is relatively little information about the structural basis of the clinical deficits. Classical literature suggests that the immature brain and its coverings, at a time when it is rapidly acquiring new information, respond differently from the adult brain when subjected to an equivalent amount of mechanical force, whether mediated by contact or inertial loading. Identification of different patterns of injury in different age groups has resonance in clinical practice and now provides a reference point for future clinical and neuropathological studies. This work not only provides the basis for the future management of patients, but also serves to remind us of the continuing value of the autopsy and the proper examination of retained organs using modern standardized techniques.
Keywords: Pediatric, Trauma, Brain, Head Injury

Introduction

Accidents are the leading cause of death in children younger than 15years of age. In this group, head injury is the most common cause of mortality (1). It is twice as common as cancer and congenital diseases combined. Head trauma is one of the most common childhood injuries, annually accounting for more than 500,000 emergency department visits, 95,000 hospital admissions, 7000 deaths, and 29,000 permanent disabilities; hospital care costs alone exceed $1 billion annually. The annual brain injury rate per 100,000 children is approximately 185, with boys being twice as likely to be injured as girls (2).Common causes of injuries are falls (35%), recreational activities (29%),and motor vehicle accidents (24%) (3). Child abuse is the most common cause of head injury in infants younger than 2 years. (4)We define mild head injury as a Glasgow Coma Scale score (GCS) of 13 to 15, moderate head injuries as a GCS of 9 to 12 and a severe head injury as a GCS of 8 or less. The outcome in head injury, in many cases, is directly related not only to the severity of injury, but also to how well the injury is managed(5). Traumatic head injury continues to be a major problem in pediatrics, despite efforts to reduce its incidence. Both minor and major head injuries result in significant morbidity and mortality. Physicians who care for children must understand the need for timely evaluation

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and treatment of head injuries and the possible long-term problems. Appropriate management of patients suffering from head trauma is important to minimize complications. Despite increased understanding of the pathophysiology of traumatic brain injury, no new pharmacotherapies have been developed, and supportive care continues to be the mainstay of therapy. In the field of traumatic brain injury there are very few researches performed specifically on the pediatric population. As there are a lot of differences between the brain of adults and children, the results obtained by studies on adult patients cannot be generalized to the pediatric population. So it is of utmost importance to perform more specific studies in various aspects to obtain evidence based guidelines for diagnosis and management of pediatric head injury.

Pathophysiology

One of the unique characteristics of the pediatric brain is that it is undergoing a process of maturation and development. Because of this process, the brain of the child reacts differently to similar injuries, depending on the age of the child when the injury occurs. There are variations in the amount of white and gray matter, brain water content, and the consistency and size of the skull (6). The skull is initially a one-layered structure in infants and neonates with open sutures and small diploic spaces. However, by the age of 4 years, it has become a rigid, closed system. Because of the more compressible brain and pliability of the calvarium in the younger child, there are fewer mass lesions, with more white matter shear injuries. As the child ages, the incidence of mass lesions becomes more like that of the adult(7). Another unique aspect is the relationship of the size of the head of the infant to the body, which changes with age. In the newborn, the brain constitutes15% of the total body weight, compared with 3% in the adult. The physiology of the young child's cerebral vasculature is also different than that of the adult. It is thought that the cerebral perfusion pressure is lower in the child because mean arterial blood pressure is lower in children (8).

Patient Management Considerations

Many factors may influence how management strategies influence outcomes for children with minor closed head injury. These factors include: 1) the prevalence of intracranial injury, 2) the percentage of intracranial injuries that need medical or neurosurgical intervention, 3) the relative accuracy of clinical examination, skull radiographs, and CT scans as diagnostic tools to detect such intracranial injuries that benefit from medical or neurosurgical intervention, 4) the efficacy of treatment for intracranial injuries, and 5) the detrimental effect on outcome, if any, of delay from the time of injury to the time of diagnosis and intervention. To our knowledge no known evidence suggested that immediate neuroimaging of asymptomatic children improved outcomes for these children, compared with the outcomes for children managed primarily with examination and observation (9).

Initial Management of the Child with Mild Head Injury

Among these children, loss of consciousness is uncommon but is associated with an increased risk for intracranial injury. Studies performed since the advent of CT scanning suggest that children with loss of consciousness, or who demonstrate amnesia at the time of evaluation, or who have headache or vomiting at the time of evaluation, have a prevalence of intracranial injury detectable on CT that ranges from 0% to 7% (10). Although most of these intracranial lesions will remain clinically insignificant, a substantial proportion of children, between 2% and 5% of those with minor head injury and loss of consciousness, may require neurosurgical intervention(11). The differences in findings among studies are likely attributable to differences in selection criteria, along with random variation among studies with limited sample size. Although these findings might have been biased somewhat if more seriously injured patients were preferentially selected for CT scans, even studies in which patients were explicitly stated to be neurologically normal and asymptomatic found children with clinically significant injuries that required intervention(12). In past studies of children with minor head injury, patient selection may have led to overestimates of the prevalence of intracranial injury. Many of these studies looked at patients referred to emergency departments or trauma centers, patients brought to emergency departments after examination in the field by emergency personnel, or patients for whom the reason for obtaining CT scans was not clearly stated. These factors may have led to the selection of a patient population at higher risk for intracranial injury than the patients specifically addressed in this practice parameter.

As evidence of this, population-based studies before the widespread availability of CT scanning found the prevalence of clinically significant intracranial injury after minor closed head injury to be far less than estimated by the aforementioned studies. One study found a prevalence of intracranial injury that required neurosurgery to be as low as 0.02%. This discrepancy is consistent also with the fact that many lesions currently identified with cranial CT were not recognized before the availability of this technology. Because most of these lesions do not progress or require neurosurgical intervention, most would not have been diagnosed in studies before the availability of CT scan (13).

Management Algorithm

A. Observation in the clinic, office, emergency department, or home, under the care of a competent caregiver.

B. Cranial CT scanning along with observation in children with minor closed head injury with brief loss of consciousness.

C. If imaging is desired by the health care practitioner and if both CT and skull radiography are available, CT scanning is the imaging modality of choice.

D. In some studies, MRI has been shown to be more sensitive than CT in diagnosing certain intracranial lesions but CT is more quickly and easily performed than MRI, and the costs for CT scans generally are less than those for MRI. Because of this, the cranial CT offered advantages over MRI in the acute care of children with minor closed head injury.

E. Neurologically normal patients with a normal cranial CT scan are at very low risk for subsequent deterioration. Patients may be discharged from the hospital for observation by a reliable observer if the post injury CT scan is normal.

F. If the cranial CT reveals abnormalities, proper disposition depends on a thorough consideration of the abnormalities and, when warranted, surgical treatment is performed (9).

Management of the Children with Moderate and Severe Head Injury

When a child sustains a moderate or severe head injury, it must be decided where to take the child for care. Initial attempts are directed at stabilization of the patient's vital signs ensuring an adequate airway, good venous access, a normal blood pressure, and evaluation of life threatening injuries. After the vital signs have been ascertained, and there is an adequate airway, a complete neurological examination is performed, the components of which are the GCS assessment, pupillary reaction, determination of the presence or absence of the oculocephalic response, and some assessment of motor power bilaterally. Several pediatric coma scores have been devised to take into account a young child's maturation process (19).

After the vital signs are stabilized, the airway is secure, and there are no life-threatening injuries, the next determination is whether there is a mass lesion. This is accomplished with computed tomography (CT). If the CT scan results are negative, the patient is taken to the intensive care unit. If the patient has a mass lesion, mannitol is given in a dose of 1 to 2 g/kg, and the patient is taken immediately to the operating room. If at any time it is suspected that the patient may be harboring a mass lesion, mannitol should be given if the blood pressure is stable. The issue of hyperventilation is one of moderate controversies. There is overwhelming evidence that hyperventilation in the presence of ischemia worsens ischemia and causes a lack of adequate blood flow to the brain. The best course of action is to prevent significant hyperventilation and to maintain the Paco2 above 30 mm Hg (15).

Mass lesions

Mass lesions account for a fairly small portion of intracranial pathology in childhood trauma. The incidence of mass lesions in pediatric head injuries increases with age. Epidural hematomas occur in 1% to 2.5% of neonates and infants and occur in 1.5% to 5% of older children and adolescents. Subdural hematomas in the pediatric population vary from 3.5% to 10.8%, whereas the risk of sustaining an intracerebral hemorrhage is less than 1% to approximately 4% (16).

Extradural Hematoma

There are many reasons why extradural hematomas are relatively uncommon in neonates. The dura is attached tightly to the periosteum, preventing formation of epidural fluid collections. The middle meningeal artery groove is shallow, and the artery is not encased in bone; it is therefore less susceptible to tearing during a fracture of the soft cranium, which also dissipates energy. The most common cause of epidural hematoma in neonates is bleeding due to birth trauma. Injury can be located anywhere in the cranium but most commonly is in the temporoparietal and frontal regions (17).

Treatment of extradural hematomas can frequently be accomplished by needle aspiration. If this is not successful, a craniotomy is necessary. If the patient shows any sort of neurological findings or deterioration, the epidural hematoma should be removed immediately. Some series in the literature show that these hematomas can be observed while they spontaneously regress. However, if the physician anticipates observing an epidural hematoma, the patient must have a GCS of 15 and be essentially neurologically normal. The patient can have headaches, but if there are any signs of neurological impairment or deterioration, the epidural hematoma must be removed emergently. The procedure is fairly benign, and if there is any hint of a problem, the epidural hematoma should be removed at once (18), (fig 1).

Subdural Hematoma

Subdural hematomas are uncommon in the neonate, but they occur with increased frequency during the following years (19). Radiographically, posterior fossa hematomas are usually located near the falx and tentorium cerebri. Supratentorially, the hematomas can occur over the hemisphere or in the interhemispheric fissure. Posterio interhemispheric subdural hematomas usually do not require surgery and can be closely observed. Any acute subdural hematoma with large displacement of the midline in the patient who is comatose or who has a focal neurological deficit requires an emergency open craniotomy. However, the child with minimal neurological deficits and a small subdural hematoma can be observed. The child with neurological impairment who has a significant amount of shift; a small, thin rim of subdural hematoma; and fairly significant brain swelling presents a problem, It can be difficult to decide whether to operate on these children, In general, it is probably wise to at least operate on the child and open the dura a small amount to allow evacuation of the hematoma, Many of these hematomas can be larger than indicated on CT. Multiple small openings in the dura can be accomplished in a slitlike fashion, and the subdural hematoma can be at least partly decompressed, In this way, the surgeon avoids the terrible situation of a tremendously swollen brain herniating through a large dural opening, preventing adequate closure of the scalp, In most cases, the bone flap is left out (20), (fig 2).

Fig1 : CT Scan of a patient with epidural hematoma.

Fig 2: CT Scan of a patient with subdural hematoma.

Intra parenchymal Hematoma

These hematomas are frequently caused by acceleration or deceleration injuries, resulting in hemorrhagic contusions, as in the adult, Most common sites are the subfrontal and temporal lobes, Contrecoup injuries occur in increasing frequency as the child gets older. Little concluding literature exists about management of these lesions. Overall, the same rules apply as for the previously described subdural hematomas. If the child is neurologically intact and there is only minimal mass effect from a small intraparenchymal hematoma, close observation in an intensive care unit setting may be appropriate,Otherwise, a craniotomy should be performed for lesion removal (21), (fig 3).

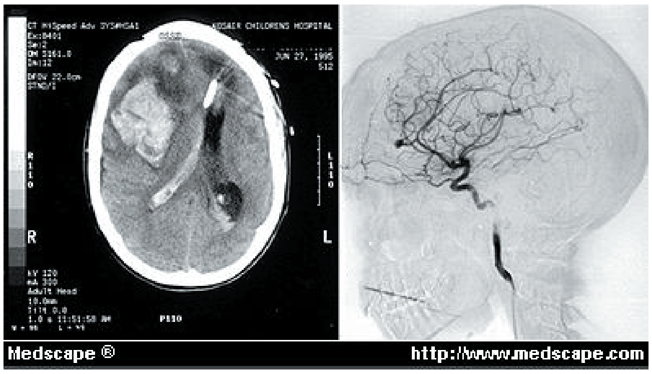

Fig3 : CT Scan of a patient with traumatic intracranial hemorrhage.

Traumatic Subarachnoid Hemorrhage

It is relatively common in the postnatal child after significant head trauma. If imaging studies reveal a significant amount of blood in the subarachnoid spaces in a child who fails to improve after aggressive management, a cerebral angiogram is warranted to exclude a traumatic arterial aneurysm, Traumatic aneurysms typically arise at the skull base or from distal anterior or middle cerebral arteries. Pediatric traumatic cerebral aneurysms may manifest early or late, Once diagnosed, these aneurysms should be treated immediately with a surgical or endovascular approach (22).

Outcomes

Traumatic brain injury is one of the leading causes of death and disability of children. Unfortunately, a myth exists that the pediatric population has a much better outcome than adults. However, studies have shown that children involved in motor vehicle accidents are just as likely to die of severe head injury as adults (23). Many of the poor outcomes observed are best prevented by preventing the initial impact or the second insults that typically occur after traumatic brain injury.

Very young and preschool children have worse outcomes in terms of mortality and long-term disability than older children and adolescents. Evidence is available that the immature brain is far more vulnerable to apoptotic neurodegeneration and therefore contributes in an age-dependent fashion to neuropathologic outcome after head trauma. This explains the unfavorable outcomes of very young pediatric head trauma patients (24). Even more so than in the adult population, many factors influence prognosis in the head-injured pediatric population. The age at injury, disproportionate cranial size to trunk in infancy, mechanism of injury, injury severity (GCS score), multiple trauma, second insults, early childhood injury, and the extent of secondary injury can all impact the final outcome. Other risk factors that worsen outcome include brain edema, midline shift, intracranial hemorrhage, hyperglycemia, hypokalemia, coagulopathy, and focal neurological deficits.

The outcome is in part related to the nature of mass lesions. Epidural hematomas in the pediatric population have a relatively better outcome than subdural hematoma(25).

Post-traumatic hydrocephalus is a common phenomenon with a clearly adverse outcome. It can develop as late as 2 to 3 years after the initial injury, and previously head injured children who arrest or regress in their recovery should always be evaluated for increased intracranial pressure due to hydrocephalus.

Children treated at pediatric trauma centers have significantly better outcomes compared with those treated at adult trauma centers. This difference in outcome may in part be explained by the approach to operative and nonoperative management of head, liver, and spleen injuries (26).

The initial therapy given to the head-injured patient is important in improving overall outcome. Evidence shows that patients with severe headinjury who are intubated in the pre-hospital setting have better outcomes (27).

More advanced tools have been used to monitor the head-injured adult. They include microdialysis to monitor the changes in contents of the extracellular fluid such as glutamate aspartate, glucose, and lactate. This may help in therapeutic interventions and to predict outcome. In one study, increased CSF glutamate and glycine levels were associated with poor outcome.

Other tools to better assess prognosis include intraparenchymal brain oxygen, carbon dioxide tension, and pH monitoring, as well as imaging studies such as proton magnetic resonance spectroscopy (MRS) (28).

Until recently, the Kennard principle (i.e., assumption that recovery after similar lesions is greater in children than in adults) was supposed to always be true. However, if the lesions are diffuse, recovery is not better in children than adults or in younger children than older children. The prognosis depends on the remaining ability to learn new practices. Normal IQ does not mean absence of sequelae. The cognitive deficits are very similar to those found in adults during the acute phase. For instance, visuospatial neglect often is identified when systematically looked for. The severity of impairment is related to premorbid psychosocial variables (29,30).

In conclusion, sophisticated end-point measurements are available to study the head-injured child during the critical phase and during the later recovery period. These studies show more clearly that the simple myth that children do better than adults needs to be revised. There is too much at stake in treating this population for the patient and the parents, as well as from a socioeconomic standpoint.

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