The management of traumatic brain injury

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Abstract

Paediatric head injury is an important clinical problem. Essential management begins with initial resuscitation supporting the airway, breathing and circulatory systems with cervical spine stabilization. Neurological assessment should include evaluation of the Glasgow Coma Score and pupil reactivity. Further imaging, admission for observation and neurosurgical referral may be indicated. This article is aimed at the general paediatrician and emergency department physician. We discuss the epidemiology, pathophysiology and general principles of paediatric head injury management from the time of injury through to discharge from hospital.

Keywords Glasgow Coma Scale; head injury; intracranial pressure; neurosurgery

Introduction

Most childhood head injuries are minor, but severe head injuries can be devastating for patient and family. Childhood incidence peaks at around 15 years in both sexes but it is more common in males of all ages. Causes include falls, road traffic collisions, sport, firearms, deliberate assault and, specific to paediatrics, 'non accidental injury' which is the cause of injury in 25–30% of children under the age of 2 years who are hospitalized after head trauma. According to the NICE head injury guidelines (2014), 1.4 million people attend emergency departments in England and Wales annually with a head injury, of which between 33% and 50% are children.

Head injury pathophysiology

The damage in head injury occurs in two phases. Primary, or 'impact injury', is the neurological damage sustained *at the time of injury* and is a direct result of forces applied to the cranium at the moment of trauma. The effects of primary injury include diffuse axonal injury (DAI), skull fractures, brain parenchymal contusions and lacerations. Secondary injury describes the neurological damage that develops over the minutes, hours and days following the initial insult. Doctors have the potential to intervene to prevent secondary injury but have little control over primary injury which can only be improved by avoiding or lessening the accident.

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Causes of secondary injury interlink and include hypoxia, ischaemia and raised intracranial pressure (ICP). For this reason, hypoxia and hypovolaemia should be corrected urgently following head injury, as these can be major determinants of neurological outcome. Management of raised ICP is usually carried out on a specialist neuro-intensive care ward and may involve neurosurgery to evacuate a mass lesion.

Initial assessment and management of the severe paediatric head injury

Optimal head injury care is streamlined with management of other injuries in accordance with Advanced Trauma Life Support (ATLS) principles. The primary survey and initial history should be succinct and directed at resuscitation along with injury severity stratification; assessing whether the patient can be discharged immediately, or requires a further period of observation and investigation, or direct referral to specialist services.

National Institute of Clinical Excellence (NICE) guidelines state that all patients presenting with head injury should have an initial assessment within 15 minutes of presentation, the focus of which should be establishing whether or not the patient is at high risk for clinically important brain or cervical spine injury. A clinician with training in safeguarding should be involved in the initial assessment of a child admitted to the emergency department following a head injury and any concerns should be documented and local protocols followed.

Structured approach to a child with head injury – ABCDER

It is important to be thorough and structured in the approach to a child with traumatic head injury. Following an ABCDER approach is vital to optimize outcomes. The initial approach is separated into the primary (see Box 1) and secondary surveys.

Radiological investigations

A patient over the age of 10 years presenting with a significant injury history should have a 'trauma series' carried out, which includes X-rays of the cervical spine, chest, pelvis and any long bones in which a fracture is suspected.

To reduce the radiation exposure children <10 years may have more limited views undertaken but require particular imaging to exclude cervical spine injuries. Children <10 with GCS ≤8 or strong clinical suspicion of cervical spine injury should have CT imaging of the cervical spine within one hour of presentation or when they are sufficiently stable for transfer to the CT scanner.

In addition to the routine trauma scans, children who have suffered traumatic head injury may need a CT head scan to indicate whether or not there is intracranial pathology which requires treatment. Indications for an immediate CT head (within 1 hour), according to NICE guidelines are:

- Suspicion of non-accidental injury
- Post-traumatic seizure with no history of epilepsy
- On initial ED assessment, GCS of <14 or for children <1 year, paediatric GCS of <15
- At 2 hours after injury, GCS <15
- Suspected open or depressed skull fracture or tense fontanelle

The primary survey

A 'look, listen, feel' approach should be continued throughout the primary survey.

Airway and cervical spine

Look: is the cervical spine stable? If not sure stabilize it until stability is proven radiologically. Is there cyanosis? Does the patient have an obviously reduced conscious level? (If the GCS is <8, an anaesthetist should be called to help intubate).

Listen: is there gurgling or stridor? Check for sources of airway obstruction and use suction. If a chin lift improves breathing a naso- or oropharyngeal may be of use.

Breathing

Look: is the patient tachypnoeic? Is there accessory muscle use or unequal chest expansion? Observe the rate and depth of respirations. Inspect for flail segments.

Listen: for breath sounds and heart sounds.

Feel: feel for expansion, subcutaneous emphysema and check the trachea is midline.

Manage: breathing with high flow oxygen via a face mask and reservoir bag and pulse oximetry. Address reversible causes of breathing problems, e.g. pneumothorax, haemothorax or flail segment.

Circulation

Look: is there skin pallor or evidence of external haemorrhage?

Feel: assess the rate and quality of the pulse, and take a blood pressure. Feel the extremities, checking temperature and capillary refill (which should be <2 seconds).

Manage: Obtain vascular access (using the intra-osseous route if necessary) and give fluid resuscitation if required (10 ml/kg in trauma). If the patient's circulation does not respond appropriately, consider occult blood loss requiring immediate attention.

The aim at this stage should be to have the patient pink, warm and stable. Only at this stage consider neurological investigation.

Disability

Only after stabilization of airway, breathing and circulation, should the neurological status be investigated. Assessment of neurological status in the trauma setting requires an assessment of the Glasgow Coma Score (GCS), pupils and limb movement. GCS should be assessed and documented in terms of its 'E', 'V' and 'M' component, using the paediatric scale in pre-verbal children (see Tables 1 and 2). Pupil diameter (in mm) and reactivity should also be documented. If the GCS is less than eight or the patient appears to be unable to maintain their airway, and this issue has not been addressed at an earlier stage, an anesthetist must be available for urgent intubation.

Exposure

The patient should be fully exposed and a full survey for other injuries performed. This will include a log roll, where the spine can be palpated and a rectal examination performed to assess anal sphincter tone if spinal injury suspected. Temperature should be checked, and warming blankets provided to maintain the core temperature if necessary. Pain can increase intracranial pressure, and appropriate analgesia and anti-emetics should be therefore provided, avoiding morphine and other sedating agents to maintain an optimal conscious level. For similar reasons, the bladder should be decompressed with a urinary catheter, the stomach with a naso-gastric tube if necessary and fractures should be splinted.

Box 1

- Any sign of basal skull fracture (e.g. haemotympanum, 'panda' eyes, leakage of cerebrospinal fluid from the ear or nose, Battle's sign)
- Focal neurological deficit
- For children <1 year, presence of bruise, swelling or laceration of more than 5 cm on the head

A provisional CT report should be made available within one hour of the scan being performed. For children with none of the above risk factors but more than one of the risk factors listed below, a CT within an hour of admission is also indicated:

- Loss of consciousness for >5 minutes
- Abnormal drowsiness
- Three or more episodes of vomiting
- Dangerous mechanism of injury (high-speed road traffic accident as pedestrian, cyclist or vehicle occupant, fall from a height of greater than 3 m, high-speed injury from projectile or other object)
- Amnesia (antegrade or retrograde) lasting more than 5 minutes

If a child presenting with a head injury has none of the indications on the first list above, but one on the second list, they should be observed for 4 hours. If, over the period of observation they develop any of the features below, they should have a CT scan:

- GCS less than 15
- Further vomiting
- A further episode of abnormal drowsiness

The NICE guidelines also state that if none of the above features develop during the period of observation, it is up to the

Child >2 and adult Glasgow Coma Score (maximum score 15)

	Eyes	Verbal	Motor
1	Does not open eyes	No verbal response	No motor response
2	Opens eyes in response to painful stimuli	Incomprehensible sounds	Decerebrate response (extensor posturing)
3	Opens eyes in response to voice	Inappropriate words	Decorticate response (abnormal flexion to pain)
4	Opens eyes spontaneously	Confused speech	Withdraws/flexes in response to painful stimuli
5	—	Oriented speech	Localises painful stimuli
6	—	—	Obeys commands

Table 1