The acute management of children's brain injuries

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Abstract
Traumatic brain injury is the leading cause of death in children in the UK. The pathway of care for severely brain injured children involves ambulance services, local and regional hospitals and regional trauma, critical care and rehabilitation networks. With so many stakeholders, effective advocacy for these children requires an understanding of their whole journey. Indeed, review of the pathway provides an opportunity to reflect on how improvements may be achieved.

Keywords pre-hospital; prevention; rehabilitation; trauma network; traumatic brain injury

Introduction

In 2014, traumatic brain injury (TBI) is still the leading cause of death for children in the United Kingdom (UK) (RCPCH 2014). These deaths occur in the moderate (Glasgow Coma Score, GCS 9–12) to severe (GCS 8 or below) head injury group. In the UK, 5.6–7.3 children per 100,000 population per year require admission to a Paediatric Intensive Care Unit (PICU) as a result of TBI. This equates to approximately 750 PICU admissions per year.

This paper follows the NHS journey for children with moderate and severe TBI and provides an update on the care they require and the care they currently receive. Effectively providing acute care to brain injured children requires an understanding of their pathway of care (Figure 1). When viewing their overall NHS journey, it becomes apparent that brain injured children need a series of interventions from paediatric clinicians; delivering any one component in isolation does not provide effective advocacy.

In an ideal world, children would not be injured in the first place. However, when they are these children need:

- NHS pre-hospital care that accurately assesses their organ support requirements and optimises oxygenation and perfusion of their brains.
- NHS pre-hospital care that ideally transports them to definitive care.
- An NHS initial hospital response that continues and extends neuro-protection.
- Timely computed tomography brain imaging.
- Safe transport to definitive care if not already reached.
- Rapid neuro-surgery if required.
- Continuation of neuro-protection in a paediatric intensive care unit.
- Rehabilitation back to optimised function within a specific children's rehabilitation service.

Preventing traumatic brain injury in children

Children predominantly sustain traumatic brain injuries from falling from height, motor vehicle collisions, sporting injuries and assault. Injury prevention strategies need to target all of society, as most commonly children are injured from circumstances imposed upon them; e.g. motor vehicles in proximity to children driving at speed, open accessible windows in tall buildings. Primary and secondary prevention interventions that make a difference to children were extensively reviewed in 2001 by Towner et al. and more recently in 2012 by Mytton et al. These include education and training, development of protective devices and safety equipment, environmental change and legislation. Approaching trauma prevention in a multi-modal fashion has a synergistic effect on injury reduction.

Paediatric clinicians are in a unique position of knowledge and influence to positively effect prevention of injury. The clinicians' knowledge of the real impact of injury for children and their families can be used to effectively advocate for changes in parental and child behaviour. The extensive access to children and families through paediatric clinics in the community and in hospitals provides an opportunity for disseminating injury prevention knowledge in a participatory manner.

Principles of care once an injury has occurred

Once a child has been brain injured attention shifts to medical and surgical management to minimise the effect of damage already sustained (axonal injury, brain contusion, laceration, haemorrhage and shearing injury) and reduce ongoing damage from hypoxaemia, hypoperfusion and hypoglycaemia.

There is little robust evidence to support management options for TBI and clinicians are reliant on consensus guidelines. International consensus guidelines and NICE guidance have been published within the past 2 years. The overarching principle that an injured brain needs oxygenated blood has not changed. Therefore the main intention of acute medical and surgical activity following TBI is optimisation of brain perfusion and brain oxygenation.

Care of brain injured children before reaching hospital

From April 2012 onwards in England, 16 hospitals have been designated as children's major trauma centres (MTC) (12 combined adult and children's centres and four children's centres). MTCs have the regional responsibility of providing trauma resuscitation, surgery, intensive care and rehabilitation against an extensive national service specification. MTCs support a network of trauma units (TU), which are hospitals that accept trauma patients for initial stabilisation and will transfer patients with severe injury to an MTC.

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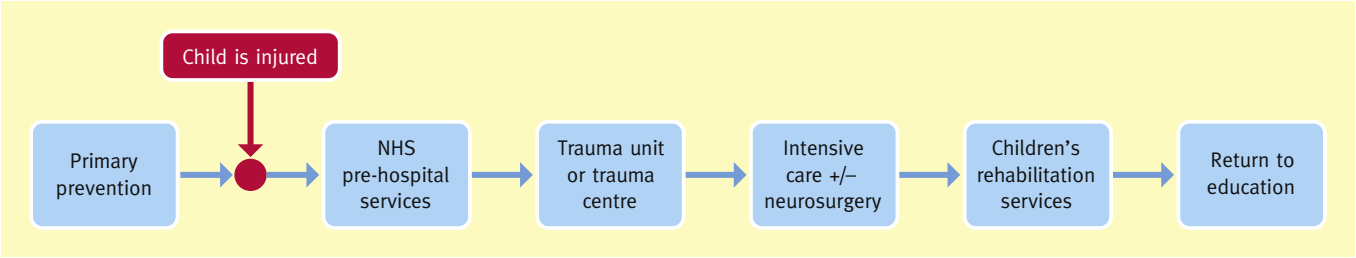

Figure 1 The pathway of care for children with traumatic brain injury.

The pathway of care for moderate and severely brain injured children has changed to support regionalised trauma care. Children with TBI and physiological or anatomical derangement are moved by English ambulance services directly to an MTC based upon prescribed criteria (Table 1). Children with brain injuries that do not fulfil the criteria are transported to the nearest TU and these children may need secondary transfer to a children's MTC.

Children typically spend close to 1 hour in the pre-hospital phase of their NHS care. The care received by brain injured children during this period was reviewed by the confidential enquiry into children's head injuries (2010) and has reported that only 70% of brain injured children with GCS less than 12 were given oxygen in the pre-hospital phase. Additionally, oxygen saturations were only recorded in 32% of 798 pre-hospital records for head injured children. Underpinning infrastructure and training may play a role in this, as in the confidential enquiry 38% of UK ambulance trusts did not have pulse oximetry probes or blood pressure cuffs suitable for children. As described above, the two factors known to change outcome in traumatic brain injury are hypoxia and hypotension. These factors cannot be avoided if supplementary oxygen is not provided or oxygen saturations and blood pressure not measured. In a review of pre-hospital care of brain injured children with GCS of 8 or less in Utah, United States of America, those children whose blood pressure was not monitored had an increased risk of in hospital death (RR 4.5, 95% CI 1.6–12.7).

Paediatric clinicians have somewhat overlooked the effect of the pre-hospital phase on children's TBI outcomes for many years. The upcoming national consensus review of children's pre-hospital care by the Faculty of Pre-hospital Care of the Royal College of Surgeons of Edinburgh may focus our gaze on this component of acute care.

The criteria used within English ambulance service trauma decision tools in order to convey children directly to major trauma centres, bypassing closer hospitals. Any of criteria 1 and all of criteria 2 are required

Criteria for transport directly to a major trauma centre	
1	Reduction in Glasgow Coma to 13 or less (or motor score to four or less)
1	Abnormally high or low respiratory rate
1	Abnormally low blood pressure or absence of radial pulse
1	Suspected open or depressed skull fractures
2	Airway and catastrophic haemorrhage are controlled
2	Major trauma centre within 45 minutes journey time

Table 1

Care within the trauma receiving hospital

Team-based paediatric trauma care

Trauma units and major trauma centres accepting injured children receive a structured pre-alert from the ambulance service (Box 1). In response to the pre-alert, a hospital paediatric trauma team is called to the emergency department. These teams are generally led by an emergency department consultant or paediatric consultant and include a variable number of the professionals listed in Box 2 (depending on location). Assembling the trauma team before the child arrives in the emergency department enables a team briefing, a check of all equipment, drugs to be drawn up, blood products to be made available and radiology to be alerted.

In almost a quarter (26%) of paediatric trauma admissions in England, children are delivered to hospital by a method other than the ambulance service. This reality of practice emphasises the need for hospital trauma teams to practice regularly, as they may be presented a severely injured child without warning.

On arrival of the child, an ordered handover is provided by the pre-hospital team using the ATMIST acronym (Box 1). The trauma team then carries out a primary assessment of the child in a parallel manner searching for immediately life threatening derangements in physiology or anatomy as per Advanced Paediatric Life Support (APLS) guidelines.

Specific management of brain injury

Derangements in the child's airway, breathing and circulation must be corrected to optimise brain perfusion and oxygenation.

ATMIST handover tool

A standardised acronym used by ambulance services to pre-alert and handover trauma patients.

A — Age of patient
T — Time of injury
M — Mechanism of injury
I — Injuries sustained
S — Symptoms/Signs on examination
T — Treatment provided

Box 1