# Trauma and burns in children

Mairi Crawford
Jon G McCormack

## Abstract
Trauma is the leading cause of death and disability in children, most often resulting from blunt trauma. An immediate co-ordinated and pathology-focussed resuscitation will contribute to improved morbidity and mortality outcomes. This article discusses the principles of the primary and secondary survey in injured children and outlines the management of children suffering from burns. A multi-professional approach to the treatment of critically injured children should be adopted; where the primary survey aims to identify and manage catastrophic haemorrhage followed by management of life-threatening injuries to airway, breathing and circulation. The secondary survey includes a detailed examination to identify and manage other subtle or less severe injuries. Attention to fluid therapy, analgesia, thermoregulation, blood coagulation and glucose homeostasis form important aspects of this secondary survey. Children injured in fires may have suffered from smoke inhalation or sustained burns to the upper airway, with rapid swelling of mucosal tissue, which can make immediate control of the airway very challenging. Both flame burns and scalds can cause significant fluid losses and are associated with a significant risk of mortality.

**Keywords** Airway; burns; emergency anaesthesia; fluid resuscitation; paediatric; trauma

**Royal College of Anaesthetists CPD Matrix:** 1B04, 2D01, 2D02, 3A01, 3A10, 3D00, 3H00

## Learning objectives

After reading this article, you should be able to:
- understand the components of a primary and secondary survey
- understand the principles of initial management in paediatric trauma
- understand the immediate management in paediatric burns

## Epidemiology

Trauma accounts for over 50% of paediatric mortality in the developed world, resulting in five times more deaths than childhood cancers.[1] The UK paediatric polytrauma mortality rate is approximately 3.7%, a rate that has not changed in recent years.[2] More than 80% of injuries sustained in children are the result of blunt trauma but the mechanism of injury varies with age. Non-accidental injury is the most common cause of trauma in infants in contrast to toddlers where falling tends to be their greatest risk.[3] Older children are susceptible to injury through road traffic accidents, falls, and injuries sustained through sport.

All of the mechanisms mentioned above may result in a significant cervical spine injury.

Up to 90% of children seriously injured in motor vehicle accidents may suffer traumatic brain injury (TBI), and over 75% sustain long bone fractures. The majority of these patients can be managed conservatively but chronic morbidity remains a significant issue, with 10% of children reporting permanent neurological impairment at 4 years following TBI.

The advances in managing paediatric trauma have reduced the incidence of poor outcomes over the last 20 years, such that a 50% reduction in mortality from trauma and severe burns has been observed. Some of these advances may be due to improvements in medical imaging and therapeutic interventions; however the most significant contributions have been made by preventative strategies including developments in car safety and design.[3]

## Primary survey

Assessment of the trauma victim should include the standard Airway, Breathing, Circulation (ABC) approach[4]:
- catastrophic haemorrhage with immediate management
- airway
- breathing
- circulation.

Normal vital signs in children vary with age and this must be considered when assessing clinical status (Table 1). In units that do not routinely treat injured children, a Broselow Tape may be a useful adjunct in the initial management.

### Catastrophic haemorrhage

Obvious haemorrhage should be managed immediately with direct pressure, haemostatic dressings or tourniquet prior to an airway assessment. Pelvic trauma should be managed by pelvic splinting. There are a range of paediatric splints and tourniquets

**Approximate values for heart rate (HR), mean arterial pressure (MAP, mmHg) and respiratory rate (RR) in the healthy child**

| | HR | MAP | RR |
|---|---|---|---|
| Newborn | 140–160 | 40–45 | 40–60 |
| 1 year | 110–130 | 45–50 | 25–35 |
| 5 years | 90–110 | 60–70 | 20–30 |
| 10 years | 80–100 | 70–80 | 15–25 |
| 15 years | 70–90 | 80–90 | 12–18 |

**Table 1**

***Mairi Crawford*** *MBChB FRCA AFHEA is a Specialty Registrar in Anaesthesia at the Royal Infirmary of Edinburgh, UK. Conflicts of interest: none declared.*

***Jon G McCormack*** *FRCA MRCP DipRTM is a Consultant in Paediatric Anaesthesia and Critical Care Retrieval at the Royal Hospital for Sick Children, Edinburgh, UK. Conflicts of interest: none declared.*




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commercially available and it is essential that the appropriate size is used for the injured child in order to gain successful haemorrhage control. Modifications may be required to splints and tourniquets in order to achieve this.

## Airway

The most common cause of paediatric cardiac arrest is airway compromise leading to myocardial hypoxia. Assessment and management of the airway, with concurrent cervical spine immobilization, is vital. Key points for airway management include:

- manoeuvres to open the airway
- administration of oxygen
- assessment of the presence of foreign bodies
- appropriate spinal immobilization.

All trauma patients are at high risk of a cervical spine injury so injury should be presumed until excluded. Pre-hospital care providers will have initiated spinal immobilization prior to transporting the injured child to the Emergency Department by manual in-line stabilization with or without the aid of blocks and tape. Collars are no longer recommended as there is no evidence of their benefit.[5] Initial immobilization may even include keeping an infant in a car seat to maintain spinal immobilization until a secondary survey can be carried out.[5]

Airway manoeuvres to open the airway require some adaptation during in-line stabilization to minimize pressure on the cervical spine and a carefully applied jaw thrust may be preferable to a head tilt and chin lift. If airway patency fails to improve, consideration should be given to the presence of foreign matter within the upper airway. Inspection of the oropharynx with suction *under direct vision* may clear debris, secretions or foreign bodies. It is not advised to perform blind finger sweeps or deep oropharyngeal suction without direct vision as this may exacerbate existing trauma, or dislodge a foreign body further into the airway. If suctioning fails to improve the situation, airway adjuncts such as an oropharyngeal airway, may be used. Again, cautious insertion is necessary to minimize the risk of exacerbating soft tissue trauma. Nasopharyngeal airways are no longer considered an absolute contra-indication in either adult or paediatric head trauma and the use of one or two carefully inserted soft nasopharyngeal airways may reduce the risk of severe secondary brain injury from hypoxia. A supraglottic airway device such as the laryngeal mask airway or i-Gel may also be used in those trained in their use where bag-mask ventilation is not possible or there is supraglottic airway obstruction. If simple airway manoeuvres fail to improve airway patency then endotracheal intubation will be required. Intubation should be performed by the most skilled individual available, ideally one who regularly intubates children. The oral route is preferable over the nasal route in trauma cases. The rate of complications between cuffed or uncuffed tubes in children younger than 8 years old are no different so cuffed tubes are deemed safe for use in infants and children. They may even be beneficial in some circumstances such as burns.

Pre-oxygenation should be performed as part of a rapid sequence induction as all trauma patients should presumed to have a full stomach so are at risk of aspiration. Consideration may be given to the application of high-flow oxygenation via nasal cannulae to deliver apnoeic oxygenation during intubation, a technique that has recently been shown to decrease desaturation during intubation. Capnography should be used when performing intubation in any child and the presence of a waveform for more than four breaths will provide confirmation of correct tube placement. In addition, capnography should be used at all times during the transport of an intubated child.

The exact agents and drug doses chosen should be tailored to the individual situation but consideration should be given to the risk of significant hypotension associated with propofol or thiopentone in hypovolaemic patients. Many clinicians are now using ketamine (1−2 mg/kg IV) to minimize hypotension. Neuromuscular blockade options for rapid sequence induction include suxamethonium (1−2 mg/kg) or rocuronium (0.6−1 mg/kg) and this will vary according to clinician preference.

During pre-oxygenation, manual in-line stabilization should be maintained but blocks and tape, if being used, may have to be removed in order to permit safe access to the airway and optimize the chances of a first pass successful intubation. This will require one assistant dedicated to providing manual in-line stabilization of the cervical spine. Careful consideration should be exercised with regards to the application of cricoid pressure. Whilst there will undoubtedly be a risk of gastric content regurgitation, inappropriately applied cricoid pressure will increase the risk of vomiting, may make intubation more difficult and may exacerbate a neck injury. If using cricoid pressure, the bimanual technique is recommended, where the second hand is placed behind the cervical spine to oppose any excessive downward pressure applied to the cricoid cartilage being transmitted to the spinal cord. Cervical spine protection measures should be reapplied once successful intubation has been achieved. In the extremely rare event that a surgical airway is necessary, the clinician with the most experience with surgical airways should perform this procedure. There are now clear guidelines about which children are at higher risk of cervical spine injury but in the acute trauma setting where the exact mechanism is often unclear, all major trauma patients should be deemed at high risk until further information is obtained.

## Breathing

Children have increased oxygen consumption and reduced functional residual capacity. They are prone to airway collapse due to their softer, more pliable tissues and these physiological and anatomical differences can rapidly lead to hypoxia and respiratory acidosis in the trauma patient. Respiratory examination includes assessment of effort and specifically examining for nasal flaring, grunting, in-drawing of intercostal spaces or suprasternal notch, abdominal ‘see-saw’ movements and added sounds, all of which may indicate respiratory distress. An irregular respiratory pattern may be a sign of impending respiratory arrest and must be managed immediately. High-energy blunt force trauma may cause pulmonary contusions without rib fractures that will contribute to a persisting respiratory acidosis despite satisfactory airway management. There may be practical difficulties in obtaining arterial blood gases in the initial resuscitation phase and it is worth remembering that acid-base status can be measured on a capillary or venous sample during the acute resuscitation phase. Empirical ventilation strategies tend toward mild hyperventilation, assuming some degree of acidaemia. Oxygen 100% should be used in the initial resuscitation of the child




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