PAEDIATRIC TRAUMA:
PRIMARY SURVEY AND RESUSCITATION—I

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Causes of childhood trauma

Age 0-1 years—Choking/suffocation, burns, drowning, falls

Age 1-4 years—Road traffic accidents (as occupant of vehicle), burns, drowning, falls

Age 5-14 years—Road traffic accidents (as occupant or pedestrian), bicycle injuries, burns, drowning

Trauma is the most common cause of death in childhood, with the aetiology of the injury varying with age. Road traffic accidents and falls account for 80% of injuries

Effective management in the first 20 minutes after an accident can do much to reduce morbidity and mortality in children with trauma. In those who reach emergency facilities alive the commonest causes of preventable death are errors in the management of ventilation and circulation and failure to detect hidden injuries. Therefore early participation of senior staff who are familiar with the surgical, anaesthetic, and medical management of children is essential.

Because children are small multisystem injury is common. Thoracic and abdominal injuries are most commonly due to major blunt trauma, and, unlike in adults, it is unusual to see penetrating injuries. Furthermore, appreciable damage to internal organs can occur without overlying bony fractures. Associated head trauma is more common.

Duties of the paediatric trauma team

Team leader—Primary survey; secondary survey

Anaesthetist and nurse—Control of airway and ventilation; fluid balance; monitoring of central venous pressure (if needed)

Doctor and nurse—Establish intravenous access; blood sampling; procedures as required

Nurses—Pulse oximetry; electrocardiography; automatic recording of blood pressure; core temperature; measurement of patient from head to toe then estimation of age and weight

The assessment of children with multiple injuries should follow the same protocol outlined for adults. The tasks delineated in this article and the two published in the next two issues should be performed simultaneously by team members. The basic principle of resuscitation is to begin treatment of life threatening injuries immediately and not after complete evaluation of the child.

It is vital to know the weight of the child to calculate fluid volumes and drug doses. It is often impossible to weigh an injured child, but measuring head to toe length is easy, and reference to the nomogram on the paediatric resuscitation chart enables a reasonable estimate of age and weight.

Though efficient and aggressive management is essential, the conscious but injured child will be very frightened, and a team member should be allocated to give comfort and explain what is happening.

Airway management with protection of cervical spine

Children have specific anatomical differences compared with adults that can make maintenance of a clear airway and tracheal intubation difficult. They include:

- Large head relative to body size
- Small oral cavity with a relatively large tongue
- Large angle of the jaw (infant 140°, adult 120°)
- Epiglottis is more “U” shaped than in adults
- Larynx is cephalad (glottis at C3 in infant, C5-6 in adults) with an anterior and inferior inclination
- Cricoid ring is the narrowest part of the airway
- Trachea is short (newborn 4-5 cm, at 18 months 7-8 cm)
- Infants of 6 months or less are obligate nose breathers.

After assessment of the airway supplemental oxygen should be given to all children with trauma until further assessment shows that it is not required. Infants have a high oxygen consumption, a reduced functional residual capacity, and a high closing capacity, which leads to an increased right to left (physiological) shunt. This may be exacerbated, for example, by thoracic injury or diaphragmatic splinting due to raised intra-abdominal pressure. Nasal prongs are often better tolerated than masks by children younger than school age, but in the emergency setting they should be avoided in infants of less than six months, who are obligate nose breathers and in whom the prong may cause nasal obstruction.

If there is evidence of injury above the clavicles assume that the cervical spine has been damaged. A collar of appropriate size should be applied or, in infants, sandbags placed on either side of the head with tape across the forehead and on to a trolley to stop excessive head movement.

Clearing the airway

Secretions, vomit, blood, and foreign bodies in the airway should be removed. A free airway is best maintained in children by placing the head in slight extension and pulling the mandible forward, taking care not to place the supporting fingers in the submental triangle (any pressure in this area in children results in posterior displacement of the tongue and further airway obstruction). If the patient has a gag reflex he or she should be able to maintain an airway, and insertion of an artificial airway should not be attempted as it may precipitate choking, laryngospasm, or vomiting.

Maintaining a clear airway. (Left) Supporting fingers placed in the submental triangle causing posterior displacement of the tongue and airway obstruction. (Right) Correct placement of the hand and jaw lift.

Appropriate sizes and indications for use of paediatric equipment according to the age (approximate weight) of the child

Equipment	0-6 months (1-6 kg)	6-12 months (4-9 kg)	1-3 years (10-15 kg)	4-7 years (16-20 kg)	8-11 years (22-33 kg)
Airway/breathing:					
Oxygen facepiece	0	0/1	1	1/2	2/3 (Adult)
Oral airways	000/00	0/1	0/1	1/2	2
Resuscitator	Baby	Baby	Baby/adult	Adult	Adult
Breathing system	“T” piece	“T” piece	“T” piece	“T” piece	Coaxial
Laryngoscope	Straight blade	Straight blade	Child Macintosh	Child Macintosh	Adult Macintosh
Tracheal tubes (uncuffed)	2.5-3.5	3.5-4.0	4.0-5.0	5.0-6.0	5.5-7.0
Stylet	Small	Small	Small/medium	Medium	Medium
Suction catheter (FG)	6	8	10-12	14	14
Circulation:					
Intravenous cannula (G)	24/22	22	22/18	20/16	18/14
Central venous pressure cannula (G)	20	20	18	18	16
Arterial cannula (G)	24/22	22	22	22	20
Ancillary equipment:					
Nasogastric tube (FG)	8	10	10-12	12	12-14
Chest drain (CH)	10-14	12-18	14-20	14-24	16-30
Urinary catheter (CH)	5 G Feeding tube	5 G Feeding tube/ Foley (8)	Foley (8)	Foley (10)	Foley (10-12)
Cervical collar			Small	Small	Medium

Laryngoscopes with orotracheal tubes fitted with Cardiff connectors. From left to right: Anderson-Magill, child Macintosh, and adult Macintosh.

Correct fixation of Rees modified Ayres's "T" piece, endotracheal tube, and oral airway.

Artificial airway

If there is no gag reflex or if there is any doubt as to the adequacy of the airway an artificial airway is required. A Guedel airway should be inserted and the chin supported as described above. If assisting ventilation the lungs should be gently inflated with 100% oxygen with pressures of <20 cm H₂O. Higher pressures cause gaseous distension of the stomach, thus increasing the risk of regurgitation and resulting in diaphragmatic splinting.

Tracheal intubation

Orotracheal intubation should be performed when hypoxia has been reversed by ventilation with a mask. **Do not persistently attempt to intubate the trachea of a hypoxic child without giving oxygen beforehand with a mask and airway.**

Laryngoscopes with straight blades should be used for children younger than 1 year (with the epiglottis being raised on the posterior surface); curved blades are satisfactory in older children. As a rough guide a tube of similar external diameter to the child's small finger or nostril is appropriate. Uncuffed endotracheal tubes must be used for all children who have not reached puberty, and there should be a small leak of gas around the tube as the lungs are inflated. If there is no leak the tube should be exchanged for the next smaller size. The orotracheal tube should be positioned such that 2-5 cm of it (according to age) are below the vocal cords. The tube lengths recommended in the paediatric resuscitation chart should result in an appropriate position. But inadvertent endobronchial intubation is a potential hazard, and auscultation in the axillae for bilateral breath sounds is essential. Firm fixation of both tube and breathing circuit is vital. For prolonged intubation ($>1-2$ hours) use plastic tracheal tubes.

Technique for needle cricothyroidotomy. (a) The cricothyroid membrane is pierced at an angle of 45° by a 14 G cannula. Free aspiration of air confirms correct placement, and the cannula is advanced over the needle, which is then withdrawn; (b) a 3.0 mm endotracheal tube connector fits into the female end of the intravenous cannula or a 7.0 mm tube into the barrel of a 2 ml syringe; (c) the connector is attached to the oxygen circuit.

Cricothyroidotomy

Needle cricothyroidotomy with a 14 G intravenous cannula is the preferred method of establishing airway access and control if bag and mask ventilation or intubation are unsuccessful. Tracheostomy should be undertaken only in controlled circumstances.

Gastric intubation

Acute gastric dilatation is commonly seen in the injured child. Almost all infants and children who are stressed swallow large quantities of air, and mask ventilation may add to this. Acute gastric dilatation may precipitate vomiting and aspiration, splint the diaphragm, and compress the inferior vena cava, diminishing venous return and thereby causing hypotension. A gastric tube must be passed in all injured children. If the cribriform plate is intact nasogastric intubation is the route of choice.

Breathing

Causes of inadequate ventilation

Bilateral

- Obstruction of upper respiratory tract
- Oesophageal intubation

Unilateral

- Pneumothorax
- Haemothorax
- Lung contusion
- Flail segment
- Bronchial rupture
- Foreign body in bronchus
- Rupture of diaphragm
- Endobronchial intubation

Ensure that both sides of the chest are being ventilated by inspection and auscultation. Look for central cyanosis and ensure that haemoglobin saturation measured with a pulse oximeter is above 90%. Count the respiratory rate, noting that normal values change with age.

The paediatric resuscitation chart is reproduced from the paper by P A Oakley (*BMJ* 1988;297:817-9) and was devised from the guidelines of the Resuscitation Council (UK). The line drawings depicting needle cricothyroidotomy were prepared by the department of education medical illustration services, St Bartholomew's Hospital.

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