CHAPTER 1
MEDICAL EMERGENCIES

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CARDIORESPIRATORY ARREST

Cardiorespiratory arrest may occur in a wide variety of conditions that cause hypoxaemia or hypotension, or both. Examples include trauma, drowning, septicaemia, sudden infant death syndrome, asthma and congenital anomalies of the heart and lung.

The initial cardiac rhythm discovered during early resuscitation is usually severe bradycardia or asystole. The spontaneous onset of ventricular fibrillation in children is uncommon, but it may occur with congenital heart conditions or secondary to poisoning with cardioactive drugs. Respiratory arrest alone is more common.

Diagnosis and initial management

- Cardiorespiratory arrest may be suspected when consciousness is lost, or the patient appears pale or cyanosed. Call for help.
- Assess airway and respiration by observing movement of the chest, as well as listening and feeling for expired breath while positioning the head and neck to open and maintain an airway. Movement of the chest without expiration indicates a blocked airway.
- Assess circulation by palpation of the carotid, brachial or femoral pulse and by other signs of circulation (breathing, movement, consciousness).
- Whenever possible, treat in a treatment room. Carry the patient there if necessary. If this is not possible, fetch the resuscitation trolley from a treatment room.
- Cardiopulmonary resuscitation (CPR) must commence with basic techniques and be continued using advanced techniques (Figure 1.1).

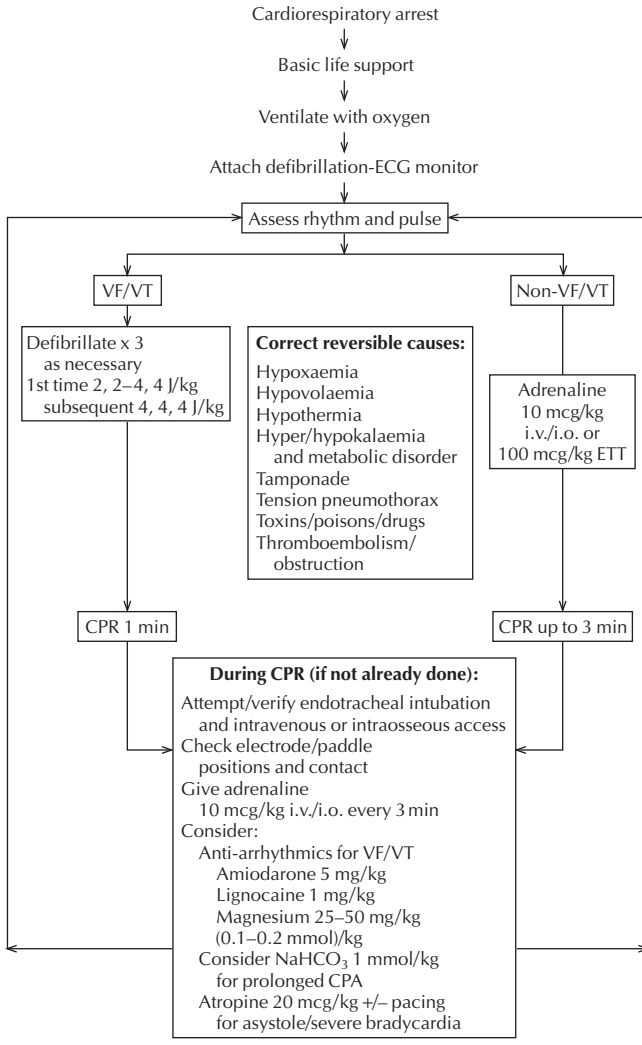


Fig. 1.1 Management of cardiorespiratory arrest. Key: CPA; cardiopulmonary arrest: ECG; eletrocardiograph: ETT; endotracheal tube: i.o.; intraosseus: i.v.; intravenous: J; Joules: kg; kilogram: mg; milligram: mcg; microgram: VF; ventricular fibrillation: VT; ventricular tachycardia.

Airway maintenance and ventilation

- If an airway obstruction is present, quickly inspect the pharynx. Clear secretions or vomitus by brief suction using a Yankauer sucker.
- Maintain the airway with backward head tilt, chin lift or forward jaw thrust.
- If adequate respiration does not resume, ventilate the lungs with a self-inflating resuscitator (e.g. Laerdal, Ambu, Air-viva) with added oxygen 8–10 L/min. If ventilation cannot be achieved with the resuscitator, use a mouth-to-mask technique. Give 5 initial breaths.
- **Whatever technique is used, ensure that ventilation expands the chest adequately.**
- Intubate the trachea via the mouth if able to do so, but do not cause hypoxaemia by prolonged unsuccessful attempts. Select the tube and insert it a depth appropriate to the patient's age in years.

ETT Size and position

- Tube size (internal diameter) = (age/4) + 4 mm (for patients over 1 year of age)
- Depth of insertion is approximately (age/2) + 12 cm from the lower lip

Secure the tube with cotton tape around the neck or affix it firmly to the face with adhesive tape to avoid endobronchial intubation or accidental extubation.

External cardiac compression

Start external cardiac compression (ECC) over the lower sternum if:

- A pulse is not palpable within 10 seconds.
- A pulse is less than 60 beats per minute (all ages).
- Other signs of circulation (respiration, movement, consciousness) are absent.

Place the patient on a firm surface and depress the lower sternum one-third the depth of the chest:

- Newborn infant or an infant (<1 year); two-thumb technique in which the hands encircle the chest.
- Small child (1–8 yrs); the heel of one hand.
- Larger child (>8 yrs) and adult; the two-handed technique.

Avoid pressure over the ribs and abdominal viscera.

- **Whatever technique is used ensure that compression generates a pulse.**

Compression-ventilation rates and ratios

The Australian Resuscitation Council recommends these rates and ratios. Give 5 initial breaths. Then with one or two rescuers give:

- Newborn infants (within hours of birth); give cycles of 3 compressions, followed by one breath.
- Infants and small children (up to 8 yrs); give cycles of 5 cardiac compressions followed by 1 breath. Give *at least* 60 compressions and 12 breaths per minute.
- Larger child (>8 yrs) or adult; give cycles of 15 compressions followed by 2 breaths. Give *at least* 60 compressions and 8 breaths per minute.

If bag-to-mask ventilation or mouth-to-mask ventilation is used, the rescuer giving compressions should count aloud to allow the rescuer giving ventilation to deliver efficient breaths between compressions so that a minimal pause, if any, is required. Compression may be commenced at the end of inspiration. These measures will enable near-continuous ECC and result in an optimum number of compressions and additional breaths each minute.

The *rate* of compression per minute is 100, that is one compression every 0.6 seconds, aiming to give approximately 80–100 compressions each minute.

If ventilation is given by bag and endotracheal tube, ECC may be continued during ventilation (in the recommended ratios) provided lung expansion can be achieved.

Management of cardiac dysrhythmias

- Determine the cardiac rhythm with defibrillator paddles or chest leads.
- Give DC shock if ventricular fibrillation or pulseless ventricular tachycardia is present. See Table 1.1 and Figure 1.1 for monophasic energy doses in DC shock.
- Give adrenaline if any other pulseless rhythm is present (see Figure 1.1).

Table 1.1 Table of drugs, fluid volume, endotracheal tubes and direct current shock for paediatric resuscitation

Age	*0*	*2 months*	*5 months*	*1 year*	*2 years*	*3 years*	*4 years*	*5 years*	*6 years*	*7 years*	*8 years*	*9 years*	*10 years*	*11 years*	*12 years*	*13 years*	*14 years*
*Bodyweight (kg)**	*3.5*	*5*	*7*	*10*	*12*	*14*	*16*	*18*	*20*	*22*	*25*	*28*	*32*	*36*	*40*	*46*	*50*
*Height (cm)**	*50*	*58*	*65*	*75*	*85*	*94*	*102*	*109*	*115*	*121*	*127*	*132*	*138*	*144*	*151*	*157*	*162*
	mL	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*	*mL*
Adrenaline 1 : 1000																	
10 mcg/kg	0.035	0.05	0.07	0.10	0.12	0.14	0.16	0.18	0.2	0.22	0.25	0.28	0.32	0.36	0.4	0.46	0.5
100 mcg/kg	0.35	0.5	0.7	1	1.2	1.4	1.6	1.8	2	2.2	2.5	2.8	3.2	3.6	4	4.6	5
Adrenaline 1 : 10 000																	
10 mcg/kg	0.35	0.5	0.7	1	1.2	1.4	1.6	1.8	2	2.2	2.5	2.8	3.2	3.6	4	4.6	5
100 mcg/kg	3.5	5.0	7.0	10	12	14	16	18	20	22	25	28	32	36	40	46	50
Lignocaine 1% mL																	
1 mg/kg	0.3	0.5	0.7	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.6	5.0
Sodium bicarb. 8.4% mL																	
1 mmol/kg	3.5	5	7	10	12	14	16	18	20	22	25	28	32	36	40	46	50
Fluid volume mL																	
20 mL/kg	70	100	140	200	240	280	320	360	400	440	500	560	640	720	800	920	1000
Endotracheal tube																	
Size (mm) age/4 + 4	3	3.5	3.5	4	4.5	4.5	5	5	5.5	5.5	6	6	6.5	6.5	7	7	7.5
Oral length (cm) age/2 + 12	9.5	11	11.5	12	13	13.5	14	14.5	15	15.5	16	16.5	17	17.5	18	18.5	19
Direct current shock																	
VF, VT 2 J/kg	7	10	20	20	20	30	30	30	50	50	50	50	70	70	70	100	100
VF, VT 4 J/kg	10	20	30	50	50	50	70	70	70	100	100	100	150	150	150	200	200
Unsynchronised																	
SVT 1 J/kg	3	5	7	10	10	10	20	30	20	20	30	30	30	30	50	50	50
Synchronised																	

* 50th percentiles

Source: Oakley, P., Phillips, B., Molyneaux, E. & Mackway–Jones, K. (1993) Updated standard reference chart. *BMJ* 1993; **306**, 1613.

- Insert an intravenous cannula. Although this is the preferred access to the circulation, do not waste time (>90 secs) with repeated unsuccessful attempts, because access can be achieved with the alternative techniques of bone marrow (intraosseous) infusion, (see Procedures, chapter 4) or endotracheal administration (ETT).
- All intravenous drugs and resuscitation fluids can be given via the bone marrow.
- Only adrenaline, atropine and lignocaine can be given via the endotracheal route.
- A quick reference guide to drug doses and fluid volume is provided in Table 1.1 and Figure 1.1.

Other drugs

Calcium

This is a useful inotropic and vasopressor agent but it has no place in the management of a dysrhythmia, unless it is caused by hypocalcaemia, hyperkalaemia or calcium channel blocker toxicity. It is not useful and probably harmful for asystole, ventricular fibrillation or electromechanical dissociation. The intravenous dose is 10% calcium chloride (0.2 mL/kg) or 10% calcium gluconate (0.7 mL/kg). Do not administer calcium by endotracheal tube and do not mix it with bicarbonate.

Adenosine

This is the preferred drug treatment for supraventricular tachycardia (SVT). See management of SVT in Cardiovascular conditions, chapter 18.

ANAPHYLAXIS

See also Allergy and immunology, chapter 16.

The life-threatening clinical manifestations are:

- Hypotension due to vasodilatation and loss of plasma volume due to increased capillary permeability.
- Bronchospasm.
- Upper airways obstruction due to laryngeal or pharyngeal oedema.

Immediate treatment

- Vasopressor and bronchodilator therapy. Give adrenaline 0.01 mg/kg (i.e. 0.1 mL/kg of 1:10,000 solution) by slow intravenous (i.v.) injection (over 10 min) or 0.01 mL/kg of 1:1,000

solution by intramuscular (i.m.) injection. A continuous infusion (0.1–1.0 mcg/kg per min) may be required if manifestations are prolonged.

- Oxygen by mask. Mechanical ventilation may be required.
- Intravenous volume expander. Give or 0.9% saline at 20 mL/kg. Give repeat boluses of 10–20 mL/kg until the blood pressure is restored.
- Bronchodilator therapy with salbutamol – continuous nebulised (0.5%) or i.v. 5 mcg/kg per min for 1 h, then 1 mcg/kg per min thereafter. Secondary therapy with a steroid, aminophylline and an antihistamine may be helpful for prolonged bronchospasm and capillary leak.
- Relief of upper airway obstruction: mild to moderate oedema may respond to an inhalation of nebulised 1% adrenaline (1 mL per dose diluted to 4 mL) or 5 mL of nebulised 1:1,000 solution, but intubation of the trachea may be required.
- Anaphylaxis can be biphasic and the patient may deteriorate again over the next few hours.
- All patients with anaphylaxis should be observed carefully for at least 12 h, followed up for allergen testing and provided with self-injectable adrenaline and a Medi-alert warning.

Allergic oedema causing acute larygeal obstruction

Treat with nebulised 1% adrenaline 1 mL per dose diluted to 4 mL or 5 mL of 1:1,000 solution. Refer to an intensive care specialist or anaesthetist for endotracheal intubation, or an ENT surgeon for tracheostomy.

HAEMORRHAGIC SHOCK

The normal blood volume is 70–80 mL/kg. A child may lose a substantial volume of blood without developing hypotension. Cardiac output and blood pressure are preserved by tachycardia and vasoconstriction, so hypotension is a late sign of blood loss.

- Control external haemorrhage by direct wound pressure, arterial vessel pressure or a tourniquet and elevation of the injured area.
- Administer oxygen by mask.
- Insert a large bore intravenous cannula, preferably in the upper limb. Two cannulae may be required.
- Withdraw blood for group and cross-match.

- Infuse rapidly by pressure 20 mL/kg of 0.9% saline solution. This may also be administered rapidly by syringing with the aid of a three-way tap. Titrate additional volume to the blood pressure and other indices of perfusion. Further boluses of 10–20 mL/kg 0.9% saline solution may be given.
- **If exsanguinating, transfuse urgently** with (in order of preference): (i) cross-matched blood or; (ii) uncross-matched blood of the same group as the patient or; (iii) uncross-matched O-negative blood. Warm the blood.
- Monitor blood pressure, heart rate, oxygenation and urine output.
- Measure the central venous pressure, serum calcium, serum potassium, coagulation and acid-base status if a massive transfusion is required. Calcium (10% calcium chloride 0.2 mL/kg) and fresh frozen plasma are usually needed after 1–2 blood volumes have been transfused.
- Investigate and surgically explore internal haemorrhage if necessary.

SEPTICAEMIC SHOCK

Hypotension is due to leakage of fluid from capillary beds and depression of myocardial contractility.

- Collect blood for culture, but do not delay administration of an antibiotic if a blood sample cannot be collected. If no information is available regarding the source of pathogen, give flucloxacillin 50 mg/kg (max 2 g) i.v. 4-hourly and cefotaxime 50 mg/kg (max 2 g) i.v. 6-hourly. For particular circumstances consult the Antimicrobial Guidelines. For shock due to meningococcaemia, which is usually accompanied by a purpuric rash, give cefotaxime 50 mg/kg (max 2 g) i.v. 6-hourly. Give benzylpenicillin 60 mg/kg (max 3 g) i.v. or i.m. 4-hourly if cefotaxime not available.
- Treat shock with 0.9% saline solution, 20 mL/kg initially – further boluses of 10–20 mL/kg may be needed.
- Commence infusion of an inotropic agent. Dopamine (5–20 mcg/kg per min) is preferred. Administration via a central vein is preferred but it may be given via a peripheral vein as a dilute solution (e.g. 15 mg/kg in 500 mL at 10–40 mL/h = 5–20 mcg/kg per min). Dobutamine (5–20 mcg/kg per min) may be administered into a peripheral vein.

- Give oxygen and monitor blood gases. Mechanical ventilation may be required.
- Defer lumbar puncture, if indicated, until the child has been stabilised.

NEAR DROWNING

There is a global hypoxic-ischaemic injury often associated with lung damage from aspiration of water and gastric contents.

- Adequate oxygenation and ventilation are of paramount importance. Mechanical ventilation is required for severe lung involvement, circulatory arrest or loss of consciousness. Lung hypoxic-ischaemic injury is compounded by pulmonary oedema or aspiration of water or gastric contents.
- Decompress the stomach, which is usually distended with air and water.
- Support the circulation with intravenous infusion of colloid (e.g. 4% albumin) or 0.9% saline solution and infusion of an inotropic agent (e.g. dopamine 5–20 mcg/kg per min into a central vein).
- If signs of cerebral oedema are present (i.e. a depressed conscious state) administer mannitol 0.25–0.5 g/kg i.v. once.
- Correct electrolyte disturbances; hypokalaemia is common. The differences between fresh-water and salt-water drowning are not usually clinically important.
- Administer benzylpenicillin 60 mg/kg (max 3 g) i.v. 6-hourly (to prevent the complication of pneumococcal pneumonia).
- If CPR is required, prevent hyperthermia and induce controlled hypothermia (33–34°C) for 72 h for cerebral protection.

ACUTE LARYNGEAL OBSTRUCTION

The most common cause is laryngotracheobronchitis (croup) and occasional causes are epiglottitis, an inhaled foreign body, allergic oedema and trauma. The hallmark of obstruction is stridor, which when accompanied by a barking cough, suggests croup, or when accompanied by dysphagia/drooling suggests epiglottitis. Severe obstruction stimulates forceful diaphragmatic contraction that results in a retraction of the rib

cage, tracheal tug and abdominal protrusion on inspiration. Cyanosis and irregular respiratory effort are terminal signs.

Epiglottitis

See also Respiratory conditions, chapter 33.

- Complete obstruction may occur in just a few hours. In general, tracheal intubation under anaesthesia is required. Arrange promptly.
- Keep the child as calm as possible in a seated position and administer oxygen by mask.
- If complete obstruction is imminent, summon immediate help from an intensivist or anaesthetist. If inexperienced, do not attempt intubation unless the child becomes comatose. Intubate orally initially with a relatively small endotracheal tube. It may be hard to see the larynx because of secretions in the pharynx and the swollen epiglottis. Be prepared to aspirate the pharynx with a Yankauer sucker. Cricoid pressure is very helpful to visualise the vocal cords.
- If intubation proves to be impossible, attempt to ventilate with bag-valve-mask; a good technique may achieve adequate oxygenation and ventilation. If ventilation is impossible, perform cricothyrotomy or tracheostomy (see below).
- Antibiotic therapy: Ceftriaxone 100 mg/kg (max 2 g) i.v. followed by 50 mg/kg (max 2 g) 24 h later.

Croup

See also Respiratory conditions, chapter 33.

- In severe obstruction, give an inhalation of nebulised 1% adrena line 1 mL per dose diluted to 4 mL, or 5 mL of 1:1,000 solution to obtain temporary relief.
- Give corticosteroid i.m./i.v. (e.g. dexamethasone 0.6 mg/kg).
- Obtain intensive care or anaesthetic help with a view to endotracheal intubation. If this is not available, intubate when the child is going into respiratory failure. Use an introducing stylet in an endotracheal tube of size 0.5 or 1 mm smaller than usually calculated by age in years; i.e. (age/4 + 4 mm).

Aspirated foreign body

See also Respiratory conditions, chapter 33.

- Give first-aid (back slaps, lateral chest compressions or Heimlich manoeuvre) if obstruction occurs, otherwise allow the child to cough. Do not instrument the airways if the child is coping, but summon an anaesthetist and ENT surgeon. Give oxygen.
- If complete obstruction occurs, attempt removal of an impacted laryngeal foreign body with forceps – if this is unsuccessful, perform a cricothyrotomy or tracheostomy (see below).
- If respiratory failure is due to a foreign body in the lower trachea or bronchi, attempt ventilation via an endotracheal tube while organising endoscopic removal.

Emergency relief of a totally obstructed upper airway

- Adequate oxygenation (but not normal ventilation) can be obtained by inserting a 14-gauge intravenous cannula percutaneously into the trachea via the cricothyroid membrane (which lies immediately inferior to the thyroid cartilage); the patient should be lying straight, with the cannula in the midline and angled towards the feet. Remove the needle of the intravenous cannula; connect the cannula to a resuscitator or a bagging circuit using a connector from a 3.0 mm endotracheal tube. Oxygenate with sustained 100% oxygen inspirations. Alternatively, connect the cannula to the compressed wall oxygen supply via a three-way intravenous tap (to allow expiration) and a length of plastic tubing. A length of plastic tubing that has a side hole cut may also be used to allow expiration. Aid intermittent expiration by lateral chest compression.
- Alternatively, perform cricothyrotomy. Identify and maintain stabilisation of the thyroid-cricoid region with one hand. Incise the skin over the cricothyroid membrane (between the thyroid and cricoid cartilages). Bluntly dissect into the trachea with forceps in the midline or incise vertically with scalpel. Insert a small tracheostomy or endotracheal tube.
- Alternatively, perform percutaneous mini-tracheostomy.

STATUS ASTHMATICUS

See also Respiratory conditions, chapter 33.

Critical asthma

Children unresponsive to intermittent inhalation of salbutamol should receive:

- Continuous inhalation of undiluted 0.5% salbutamol solution nebulised with oxygen.
- Methylprednisolone 1 mg/kg i.v. (max 50 mg) 6-hourly.
- Nebulised ipratropium may be added as 250 mcg/dose diluted to 2–3 mL every 20 min × 3 and then 4–6-hourly (beware anticholinergic effects).
- Intravenous salbutamol load 5 mcg/kg/min for 60 min followed by infusion 1–2 mcg/kg per min (beware hypokalaemia).
- Aminophylline (subject to prior theophylline use and serum level) 10 mg/kg (max 500 mg) i.v. over 1 h followed by infusion of 1.1 mg/kg per h (age 1–9 years) or 0.7 mg/kg per h (10 years to adult). Check level following loading dose.
- Refractory critical asthma – manage in ICU.

STATUS EPILEPTICUS

See also Neurologic conditions, chapter 30.

A convulsion involving the respiratory musculature and upper airways that does not cease within a few minutes may cause hypoventilation with hypoxaemia and hypercarbia.

- Administer oxygen.
- Be prepared to give mechanical ventilation, particularly if the child has meningitis.
- Check blood glucose, electrolytes, blood gas and septic screen.
- Some initial intravenous anticonvulsant choices include:
  - Diazepam 0.2–0.4 mg/kg (max 10–20 mg) i.v. May be given per rectum if there is no intravenous access. Midazolam 0.1–0.15 mg/kg i.v. or 0.2 mg/kg (i.m.) effective i.m. within 5–10 min.
  - Clonazepam 0.25 mg (<1 year); 0.5 mg (1–5 years); 1 mg (>5 years) i.v.
  - Phenobarbitone 20 mg/kg over 30 min; repeat doses 10–15 mg/kg every 15–30 min up to 100 mg/kg in 24 h (beware of hypotension) if required (adults – max. 600 mg/d).

- Phenytoin 15 mg/kg (max 1.5 g) i.v. over 1 h to avoid negative inotropic effect. Slow onset.
- Thiopentone: titrate dose slowly to effect (usually 2–5 mg/kg). Beware of hypotension.

Prolonged convulsions may require large and repeated doses of anticonvulsant drugs or infusions and, consequently, mechanical ventilation. Repeated doses of a single anticonvulsant such as phenobarbitone (where the serum level correlates with the effects) are preferable to using multiple anticonvulsants. Suspect hyponatraemia as the cause of convulsions in meningitis.

RAISED INTRACRANIAL PRESSURE

Acute intracranial hypertension threatens the blood supply and may cause herniation of the brain. It is recognised by (in approximate sequence):

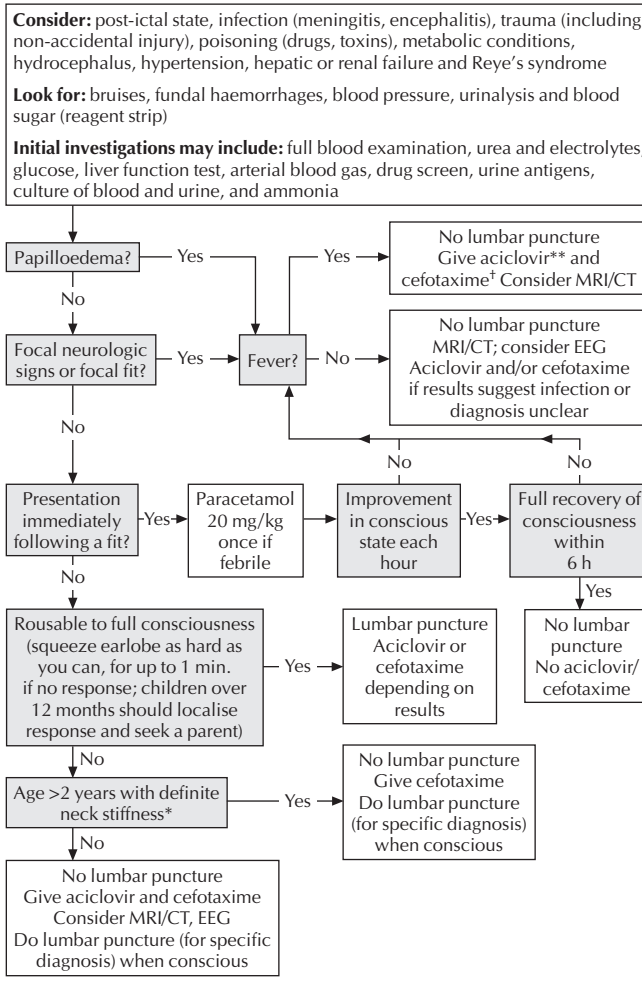
- Headache, vomiting, papilloedema, deterioration in the conscious state with diminution of spontaneous limb movements.
- Ipsilateral pupillary dilatation and contralateral hemiparesis, limb hypertonicity and spasm if there is uncal herniation into tentorial hiatus with supratentorial lesion. These can be bilateral with an extensive lesion.
- Alteration in pattern of respiration (hyperventilation; irregular respiration), bradycardia and hypertension are near-terminal events due to medullary herniation into the foramen magnum.

Common causes of intracranial hypertension are:

- Acute brain swelling due to cerebral oedema caused by trauma, infection, ischaemia or hypoxaemia.
- Space-occupying lesion, such as an intracerebral haemorrhage, tumour or abscess.
- Obstruction of cerebrospinal fluid circulation.

A neurosurgeon should be contacted immediately where indicated; e.g. in cases of trauma.

- If it is impossible to treat the cause immediately, reduce the intracranial blood volume by using mechanical hyperventilation to lower the P_aco_2 and cause cerebral vasoconstriction. (*Note*: prolonged or excessive hyperventilation to P_aco_2 of <25–35 mmHg may be harmful.)



* Neck stiffness is not a reliable sign of meningism in children <2 years
** Aciclovir10 mg/kg i.v. 8 hourly (age 2 weeks–2 years)
500 mg/m^2 i.v. 8 hourly (age 2–12 years)
† Cefotaxime 50 mg/kg (max 2 g) i.v. 6 hourly

Fig. 1.2 A guide to the role of lumbar puncture and the use of chemotherapeutic agents in the child unconscious due to unknown cause.

- Mannitol may be used to reduce cerebral oedema (0.25–0.5 g/kg, i.v.). Fluids should be restricted to avoid cerebral oedema, but not at the expense of causing hypotension. Blood pressure may be maintained with a vasopressor (e.g. dopamine up to 10 mcg/kg per min).
- Hypoxaemia and hypotension must be avoided.

A lumbar puncture should not be performed in the presence of intracranial hypertension because of risk of brain stem coning. A guide to the role of lumbar puncture and chemotherapeutic agents in the undiagnosed unconscious patient is given in Figure 1.2.