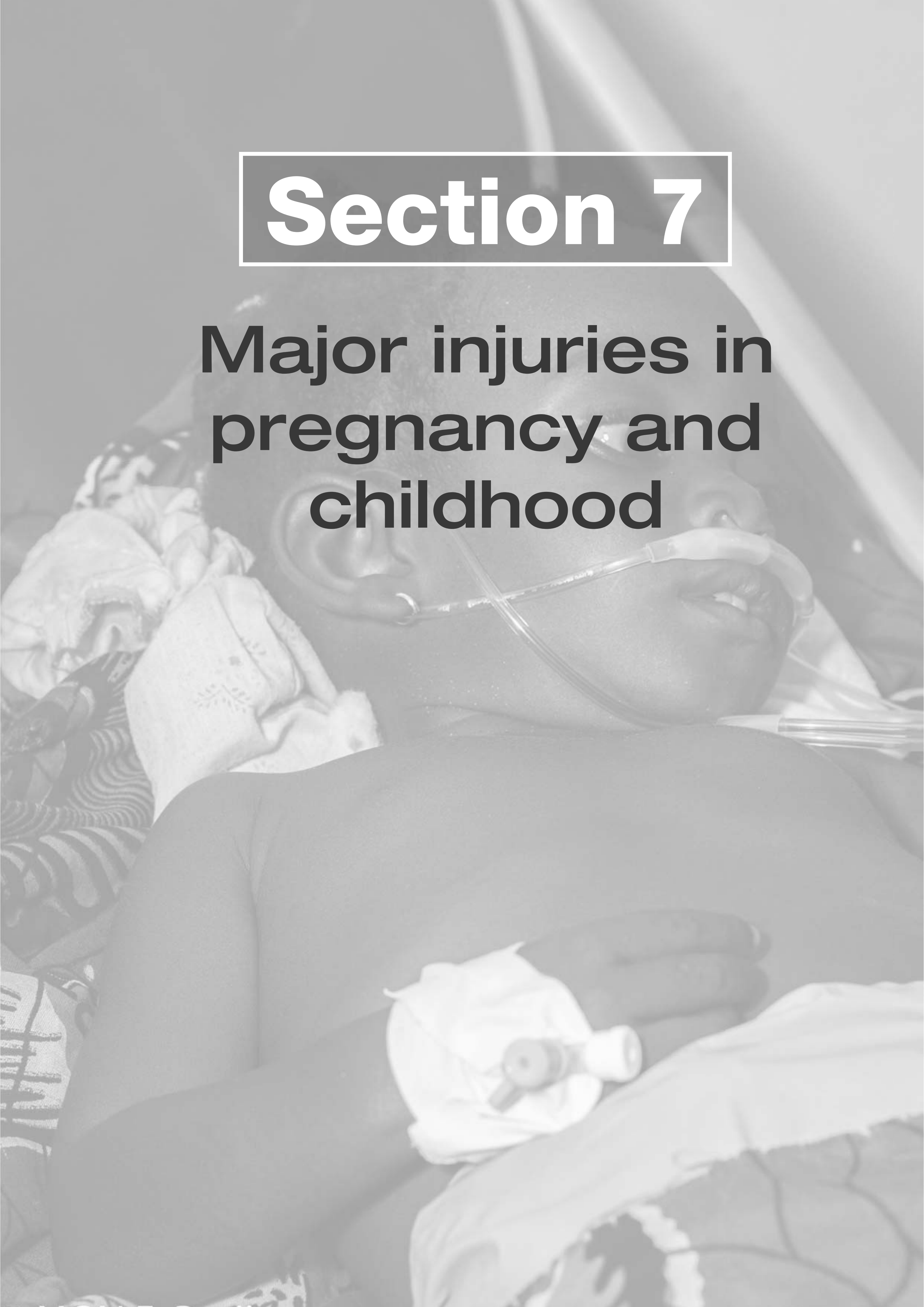

Section 7

Major injuries in pregnancy and childhood

7.1 Wounds and their management

BOX 7.1.1 Minimum standards
- Analgesia.
- Sutures.
- Adhesive strips/tissue glues.
- Human anti-tetanus immunoglobulin.
- Tetanus toxoid (or DTP, Td).
- Antibiotics.

Management of major injuries using the APLS/ATLS system

Before wounds are treated, if there are other injuries, the whole patient must be assessed according to the APLS/ATLS system (*see also* Section 1.11).

Primary survey and resuscitation

- Assess:
  - Airway and cervical spine control
  - Breathing
  - Circulation and haemorrhage control
  - Disability
  - Exposure.
- Identify and correct life-threatening abnormalities.
- Resuscitate and stabilise vital functions.

Secondary survey and emergency treatments

Remember that if simple resuscitative measures do not stabilise the child, operative intervention may be necessary before a formal secondary survey is done. In the secondary survey, determine the full extent of all injuries to the head, face, neck, chest, abdomen, pelvis, spine and extremities.

Have an emergency treatment plan to give emergency treatments in order of priority.

Definitive care

The definitive care of major injuries, which include wounds, is often carried out by teams that have not been involved in the resuscitation and emergency treatments. Good communication is essential, using:

- legible and detailed notes
- prompt and efficient transfer to a unit which can provide the definitive care (this may be an inter-hospital transfer)
- a clear handover summary.

Wounds

Definition

In a medico-legal context, to wound is to destroy, however superficially or minutely, a bodily surface, be it skin or mucous membrane. A contusion (bruise) is excluded.

Nature of injuries causing wounds

- Kinetic energy (impacts): from any object of any material purposefully or accidentally impacting.
- Heat: from any heated solid, liquid or gas.
- Cold: from any cooled solid, liquid or gas.
- Chemical: acids and alkalis predominate.
- Electrical: can cause significant internal injury.

Types of wounds

- Abrasion: friction injury, also known as graze.
- Laceration: blunt injury.
- Incision: injury from a sharp object.
- Stab: injury from a knife, scissors, screwdriver, poker, etc., usually penetrating in nature.
- Needlestick.
- Bite: human or animal (*see* Sections 6.2.H and 7.5).
- Firearm: shotgun, rifle, revolver or pistol (*see* Section 7.3.H).
- Blast (*see* Section 7.3.G).
- Burn (*see* Section 7.3.I.a and I.b).

It is important to remember that a variety of types of wounds may coexist following a single incident.

Assessment of minor wounds

Assessment of each wound should include the following:

- nature of the injury causing the wound
- type of wound
- wound site: size, shape, position and depth
- relevant motor function
- relevant sensation
- circulation distal to the wound.

Associated features include the following:

- erythema (redness)
- oedema (swelling)
- contusion (bruise)
- **surgical emphysema: this needs urgent specialist care**
- tenderness: if this extends beyond the area of the wound, a fracture may be present (*see* Section 7.2)
- pain.

General assessment includes the following:

- allergies
- immunisation status
- intercurrent illness
- medication
- past medical history
- time of last meal.

General principles

- After assessment of pain, give appropriate analgesia (*see* Section 1.15).
- If a radiopaque foreign body may be present, arrange an X-ray.
- The most important local treatment for all wounds is vigorous cleaning with sterile saline to remove dirt and possible pathogenic organisms (after analgesia).

- Local, regional or general anaesthesia may be needed to achieve optimal cleaning (*see* Section 1.24).
- Superficial palpable foreign bodies should be removed as soon as possible.
- Removal of deeper foreign bodies may need specialist advice.
- **Dead or damaged tissue must be excised.** Specialist advice is needed if this involves more than a very small area of skin or mucous membrane.
- If tendons or nerves have been damaged, specialised care is needed.

Tetanus prevention

Give tetanus prophylaxis if the patient is **not immunised** or is **not fully immunised** (full immunisation is 5 doses of tetanus toxoid: 3 for the primary immunisation in infancy, one before school entry and one before leaving school). Wounds particularly prone to tetanus are those sustained more than six hours prior to presentation, those of puncture type, those with much devitalised tissue, those that appear septic, those associated with a compound fracture or foreign body and those contaminated with soil or dung. These wounds may need human anti-tetanus immunoglobulin (HATI), 250–500 units IM, depending on the patient's tetanus status and the degree of contamination or devitalisation of the wound.

If the child has received anti-tetanus immunisation in the past, a single extra dose of tetanus toxoid IM (or, if they are due additional immunisation boosters, the relevant combination) should be given.

TABLE 7.1.1 Need for tetanus immunoglobulin and/or tetanus toxoid after a wound

History of tetanus vaccination		Type of wound	Tetanus vaccine booster (see below)	Tetanus immunoglobulin
≥ 3 doses	< 5 years since last dose	All wounds	No	No
	5–10 years since last dose	Clean minor wounds	No	No
		All other wounds	Yes	No
	> 10 years since last dose	All wounds	Yes	No
< 3 doses or uncertain		Clean minor wounds	Yes	No
		All other wounds	Yes	Yes

Note: if a patient has not completed the 5 tetanus doses when they are injured, it is likely they have also not completed other immunisation schedules. If possible give a combined immunisation comprising, for example, DTaP, DTP or DTaP – IPV for young children and Td for older children or adults according to local immunisation schedules.

Antibiotics

There is no substitute for thorough cleaning of wounds and for careful debridement of any devitalised tissue. However, in addition to cleaning and to tetanus prophylaxis, some wounds will need antibiotics. These will include wounds that have presented late and already are infected. Do not close these wounds but pack with sterile gauze dampened with sterile normal saline and review after antibiotic treatment for possible delayed primary closure after excision of the wound edges if feasible, or secondary closure.

Oral antibiotics to choose include flu/cloxacillin 25–50 mg/kg four times a day or co-amoxyclav 125/31 mg three times a day for 1–6 years or 250/62 mg three times a day for 6–12 years. Co-amoxyclav is effective in bite injuries. A five day course is usually sufficient.

Specific injuries

Abrasions

- After thorough cleaning and debridement, leave abrasions exposed or cover them for 5 days with vaseline gauze.
- If debris is left in an abrasion, epithelium will grow over it and 'tattooing' will occur.

Lacerations and incisions

- Only clean fresh wounds should be closed immediately, preferably only less than 6 hours old, certainly less than 12 hours old.
- **Distal-based flap lacerations may need specialist care if the blood supply is poor.**
- To close superficial wounds, adhesive strips and tissue glues are excellent, but these must not be used for deeper wounds, in which cavities will be created and healing will not occur.
- Close deeper wounds in layers without tension.
- Close skin with interrupted sutures, ideally using monofilament material.
- If the wound is compound (associated with a fracture), an antibiotic should be given to prevent osteomyelitis (*see* Section 5.17).
- Arrange for removal of sutures at the times shown in Table 7.1.2.
- Younger patients heal more quickly. Malnourished patients take longer to heal.

TABLE 7.1.2 Times for removal of sutures

Site	Days
Face	4
Scalp and neck	5–7
Hand (flexor surface)	5–7
Trunk and arms (not extensor surfaces)	5–7
Legs (not extensor surfaces)	7–10
Hands (extensor surfaces)	7–10
Elbows and knees	10–14

Fingertip injuries

- Preserve maximum length.
- If the tip is amputated distal to the bone, regeneration will occur if the wound is kept clean and moist under paraffin gauze dressings changed weekly.

- Other principles of treatment are the same as for lacerations and incised wounds.

Tongue lacerations
- Most stop bleeding spontaneously and do not need sutures.
- Repair under general anaesthesia if there is profuse bleeding or the full thickness of tongue is involved.
- Use absorbable sutures.

Stab wounds
- **Stabbing may cause serious penetrating injuries to deep structures, which may lead to rapid death from haemorrhage or air embolus.**
- The external dimensions of a stab wound may be deceptively small compared with the damage to underlying structures.
- Superficial stab wounds are treated in the same way as lacerations and incised wounds.
- Patients with penetrating wounds need resuscitation and emergency exploration under general anaesthesia.
- Never remove the penetrating object until the patient has been resuscitated and is in a secure surgical environment with cross-matched blood available.

Needlestick injuries
- If there is **skin puncture**, encourage bleeding and wash the wound thoroughly with plenty of soap and water. Dry the wound and apply a dry dressing if appropriate.
- If there is only **skin contact**, wash the wound with plenty of soap and water but do not scrub it. Scrubbing may damage the skin.
- If there is **splashing into the mouth**, rinse with plenty of water.
- If there is **splashing into the eye**, rinse with plenty of water. Obtain the help of a colleague to do this.
- If the identity of the donor (the person whose blood is on the needle) is known, try to find out whether that person has hepatitis B and/or HIV infection.
- Consider immunisation for hepatitis B and triple therapy for HIV if these are available.

Complications of wounds
Retained foreign body
- This will cause swelling beneath the wound.
- Secondary infection is more likely if there is a retained foreign body. If the foreign body is superficial, it must be removed by a competent surgeon under local anaesthetic. A general anaesthetic will be required if the foreign body is deeply placed and/or in an area with important structures, such as the hand or face.

Infection
- Tetanus: this is most likely to occur if the wound has been contaminated with soil and/or manure and the child is not fully immunised (see above).
- Bacterial. Prophylactic antibiotics such as flu/cloxacillin or co-amoxyclav should be considered in cases where wounds have been contaminated, **but this does not lessen the need for thorough cleaning of such wounds**.
- Antibiotic doses: flu/cloxacillin 25–50 mg/kg four times a day or co-amoxyclav 125/31 mg three times a day for 1–6 years or 250/62 mg three times a day for 6–12 years. Co-amoxyclav is effective in bite injuries. A five day course is usually sufficient.

Delayed healing
- This may be due to poor apposition of the edges, malnutrition and/or infection.
- Excision of the edges of the wound and secondary suture may be helpful, except in malnutrition.

7.2 Fractures in children

BOX 7.2.1 Minimum standards
- X-rays.
- Splints.
- Plaster of Paris bandages.
- Traction.
- External and internal fixation.
- Physiotherapy.

Introduction
As any parent knows, all children are susceptible to injury. However, children in resource-limited countries are probably more at risk than their developed-world counterparts, as they often live in less regulated and protective environments. Once injured, there may be a considerable delay in their presentation to a healthcare facility, a situation that can complicate and restrict treatment options.

Scarce X-ray resources and a limited range of treatment modalities can then further complicate treatment of paediatric fractures.

However, on a more optimistic note it can be said that paediatric fractures are often more ‘forgiving’ when compared to those of the adult; they are often easier to reduce, less requiring of internal fixation, are quicker to unite and, due to the potential for remodelling with continued skeletal growth greater degrees of mal-union can be tolerated.

Diagnosis
Certain features of the history and examination may suggest the presence of a fracture:

- history of a significant traumatic event
- swelling
- bruising
- deformity
- loss of function: inability to move or weight-bear
- bony crepitus at the fracture site
- consider the possibility of child abuse (*see* Section 7.6) if the fracture appears inconsistent with the history given or with the child's developmental status.

Open fractures

Open fractures occur where the fracture site communicates with a laceration or break in the skin relating to it. There is potential for the introduction of contaminants and resultant infection. Often open fractures are the result of a greater degree of violence than is the case for closed fractures.

Open fractures are graded according to the Gustilo classification:

- grade 1: skin wound of < 1 cm with minimal soft-tissue injury
- grade 2: skin wound of > 1 cm, with moderate soft tissue injury
- grade 3: these wounds typically involve a far greater degree of violence and energy transfer. This is further subdivided into:
  - A: extensive wound > 10 cm with crushed tissue and contamination but for which soft-tissue coverage is usually possible.
  - B: extensive wound > 10 cm, again with crushed tissue and contamination, but where it is not thought that local soft-tissue coverage is possible, and therefore a **regional** or **free** flap may be necessary.
  - C: any open fracture with an associated major vascular injury requiring repair for limb salvage.

Treatment is dictated by the extent of soft-tissue injury as reflected in the above grading system. The initial priority is a thorough debridement and copious irrigation of the fracture site in order to reduce the burden of contamination and lower the risk of infective sequelae. Once this has been done, some form of stabilisation is necessary. Internal fixation of open fractures carries a considerable risk of infection. Safer options are plaster application (with or without windowing to expose the wound) or external fixation.

It is often useful for a photograph of an open fracture to be taken by the initial assessor (perhaps on a mobile phone) so that the wound can remain covered until the patient is in the operating theatre. It helps to prevent frequent opening of the dressings and infection.

Compartment syndrome

The associated soft-tissue injury and subsequent swelling leads to an elevation of interstitial pressure within a closed fascial compartment, which results in microvascular compromise. If left untreated, tissue necrosis will occur. The commonest site is in the lower leg, but compartment syndromes can also occur in the thigh, foot and upper limb. The signs and symptoms of compartment syndrome include the following:

- a hard woody swollen extremity
- severe pain on passive movement
- tingling or burning sensations (paraesthesia) in the skin
- pain out of proportion to the severity of the fracture and not relieved by splinting or analgesia
- numbness or paralysis (loss of movement) and absent distal pulses are late signs.

Although it is possible to monitor intra-compartment pressures, such technology will rarely be available. The alternative is to have a high index of suspicion for fractures involving significant soft-tissue injury, and regularly review the clinical condition of the limb.

Treatment of compartment syndrome is by prompt surgical fasciotomies to decompress the affected compartments. In the lower leg there are four muscular compartments separated by strong fascia:

1. the lateral compartment containing the peroneal muscles
2. the anterior compartment containing the dorsiflexor muscles of the ankle and toes
3. the superficial posterior compartment containing the gastrocnemius and soleus muscles
4. the deep posterior compartment containing the deep plantar flexors of the ankle and toes.

The lateral and anterior compartments can be decompressed through the same antero-lateral longitudinal incision. A single postero-medial incision can be used for the deep and superficial posterior compartments. In each case the fascial envelope containing the muscle group must be incised along its length in order to permit swelling and prevent the build-up of pressure within the compartment.

X-rays

X-rays are the most useful and specific diagnostic modality. Where possible, two orthogonal X-rays (at 90 degrees to each other) should be obtained, ideally including the joints above and below the suspected fracture site. Terms relating to fracture appearance on X-ray include the following:

- transverse: at 90 degrees to the long axis of the bone
- oblique: other than the above
- simple: involving a single fracture line
- comminuted: involving bony fragmentation
- greenstick: visible fracture at only one cortex on the X-ray view. Greenstick fractures are only seen in paediatric fractures, due to the flexible nature of paediatric bone; this implies intact periosteum along the opposite side to the fracture and is a good prognostic sign.

Salter–Harris classification

This relates to the X-ray pattern of fractures occurring around the epiphysis, or growth plate, of a bone. Such fractures occur in about 15–20% of major long bone fractures and 34% of hand fractures in childhood.

There are five grades, with increasingly poor prognosis for fracture outcome with increasing grade because of an increasing degree of damage to the growth plate. This will lead to limb shortening as the child grows.

1. Fracture across the epiphyseal line, not extending into the epiphysis or metaphysis. This occurs when the growth plate is very thick, and thus tends to be seen in young children. Healing is rapid and complications are rare.
2. Fracture across the epiphyseal line extending into the metaphysis, but not into the epiphysis. This usually occurs in children over the age of 10 years. Healing is usually rapid and there is rarely growth disturbance.
3. Fracture extending completely across the epiphyseal line

and into the epiphysis. This type of fracture can occur at any age and is associated with a poor prognosis.

4 Fracture extending from the metaphysis through the growth plate and into the epiphysis. This type of fracture occurs when the growth plate is partially fused, and it has a poorer prognosis.

5 Crush injury to the growth plate. This is caused by severe axial loading during a fall from a height. Inevitably there is partial destruction of the epiphyseal plate, and thus a considerable risk of growth disturbance.

Treatment of fractures

- **Reduce** the fracture (if displaced).
- **Hold** the fracture while bony healing occurs.
- **Rehabilitate:** restore function and range of motion.

The potential for remodelling with continued skeletal growth is more marked in younger children. It occurs to a greater degree in the plane of movement of the affected joint. As a result of remodelling, angular deformity can gradually resolve with growth, and thus accurate initial reduction is not mandatory. In contrast, it is important to accurately reduce intra-articular fractures in order to prevent secondary arthrosis.

Children will often be unable to tolerate reduction under local anaesthesia. General anaesthetic will usually be required (*see* Section 1.24).

Once reduced, the fracture needs to be held in position while bony union occurs.

During reduction of fractures, particularly in the lower limb, rotation of the limb should be checked clinically and compared with the opposite limb. X-rays, although useful for judging angulation, length and translation, are not very helpful for judging rotation.

Splintage

Splintage of a fracture involves immobilising the fracture, thereby preventing relative motion of the bone ends. In the acute phase, this will help to relieve the pain associated with the fracture. In the longer term, the fracture stability conferred by the splint will help to promote bony union.

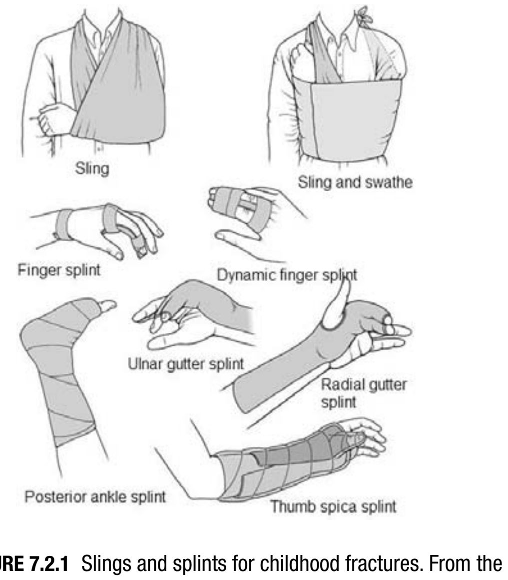

FIGURE 7.2.1 Slings and splints for childhood fractures. From the Merck Manual Home Health Handbook, edited by Robert Porter. © 2010-11 Merck Sharp & Dohme Corp., a subsidiary of Merck & Co, Inc, Whitehouse Station, NJ. Available at: www.merckmanuals.com/home/ (accessed 5/8/14).

The commonest form of splintage uses plaster of Paris bandages (see plastercraft below). If these are not available preformed, then it is possible to make them from crepe bandages and calcium sulphate. The bandages can be applied in the form of a complete (circumferential) cast or as a backslab, along only one side of the injured limb.

In any situation where swelling is anticipated, a complete cast should either be bivalved or split down to skin along its length.

In some circumstances, plaster of Paris may not be available. If this is the case, splints can often be fashioned from locally available materials. One example of this is the use of strips of bamboo and bandaging.

The splint should be applied with the limb in the position of function. Then if stiffness does occur the limb will still have some use. For the elbow, this position is 90 degrees of flexion. For the ankle, a position of neutral plantar/dorsiflexion (the sole of the foot at 90 degrees to the lower leg) is preferred.

Plastercraft

Before starting to apply a plaster, all of the necessary equipment should be ready to hand. The limb should be covered in stockinette, if available, and then cotton wool. Bony prominences (ankle malleoli, fibular head, wrist, olecranon) should be covered with extra padding to prevent pressure sores.

The plaster bandage should be immersed in water for about 5 seconds, by which time bubbles should have stopped rising from the plaster. Cold water is usually best, but hot water causes the plaster to set faster, so the temperature should be adjusted according to need.

For plaster slabs, the length required should have been premeasured and then the slab made up in readiness, most slabs requiring a thickness of between 5 and 10 layers of plaster bandage. Once dipped, the slab should be applied to the limb over the layer of cotton wool and then bandaged into place.

For circumferential casts, the bandage should be unwound half a turn before dipping, with the roll held in one hand and the free end in the other. After immersion, excess water should be allowed to fall from the plaster, but it should not be wrung or squeezed, as this will result in a plaster that is too dry to make a good cast. The plaster bandage can then be wound around the injured limb, with each turn overlapping the previous one by about two-thirds. Twists and turns in the plaster should be avoided, as these can constrict the limb. Once the plaster bandage has been applied, the limb should be held still until the plaster sets.

If proprietary plaster of Paris bandages are not available, it is possible to make them using gauze bandages and plaster. Medicinal-grade plaster (calcium sulphate PBC) is ideal, but failing this, building plaster can be used. The plaster should be sprinkled on to an unrolled bandage that is **just damp** (so that the plaster adheres). The bandage can then be rolled up and used in a similar way to a commercially available plaster bandage.

Once set, a useful technique is to write, with broad marker pen, the details of the fracture on the plaster cast as a so-called 'fracture passport'. These details can include the date of the fracture, the date when the plaster was applied, the intended date of removal, and even a sketch of the fracture configuration itself. This information can be invaluable for subsequent care, as notes and X-rays can easily be mislaid or lost.

Wedging of the plaster can be useful for improving reduction of the fracture.

Traction

An alternative to splintage is traction. By exerting a pull along the axis of the injured bone, traction helps to effect reduction and maintain alignment. Traction can either represent a definitive mode of treatment and be maintained until bony union, or be temporary, being maintained only until the fracture is stable enough to be treated in a plaster cast. Several types of traction exist.

- **Skin traction:** Traction is exerted on the limb by means of a bandage (usually adhesive) applied around the limb.
- **Balanced traction:** Traction of the more distal part of the limb is maintained by reaction against a more proximal structure. The classic example is the Thomas' splint for femoral fractures, where the splint is braced against the ipsilateral ischial tuberosity.
- **Skeletal traction:** Traction is exerted by means of a pin inserted into bone distal to the fracture. An example is a traction pin inserted through the proximal tibia as treatment for a femoral fracture. In the paediatric context, care should be exercised to avoid growth plates when inserting the traction pins.

Traction methods of treatment are most applicable to fractures of the lower limb, but there are occasional circumstances in which these methods are used in the upper limb. One example is temporary skin traction for a supracondylar fracture of the humerus.

External fixation

This involves stabilising the fracture by means of an external scaffold which is fixed to the bones proximal and distal to the fracture by means of threaded pins. It is relevant to unstable compound fractures, particularly those with extensive soft-tissue wounding. Several different types of fixator exist. The pins can be sited away from bone growth plates and the fracture reduced prior to the linking bar being tightened. Following application of the fixator, the pin tracks must be cleaned daily with saline in order to prevent the build-up of crust, infection of the track and secondary osteomyelitis. The fixator can remain in position until bony union occurs, or be replaced by a plaster cast once the fracture becomes stable enough to tolerate this and/or the soft-tissue wound heals.

A variant of external fixation is percutaneous K-wiring, usually used in conjunction with plaster casting. Particularly relevant to peri-articular fractures, this involves the insertion of smooth K-wires across the fracture line in order to prevent secondary displacement. The external ends of the wires should be bent to prevent migration. The wires can be removed once fracture stability permits, typically at 2–3 weeks. In the absence of K-wires, improvisation using long K-wires-type needles is possible.

Internal fixation

This involves the use of screws, plates and other types of metalwork to rigidly hold the reduction of a fracture. Although these techniques permit accurate stable reduction, there is an associated risk of infection of the fixation device. Thus, when considering this form of treatment, the following should be borne in mind:

- The fracture should warrant internal fixation, as opposed to splintage, traction or external fixation.
- There should be an adequate supply of the metalwork in a full range of sizes and the required instruments for their insertion. For a sustainable fracture treatment philosophy, **a constant supply of fixation devices needs to be available**.
- The surgeon should be trained in the application of the device and in the surgical approach necessary for it.
- The fixation devices and tools should be sterile and the level of asepsis in the operating theatre must be high.
- In some cases, intra-operative X-ray guidance (fluoroscopy) is necessary for accurate fixation.
- Intramedullary methods of fixation, popular in well-resourced countries for the fixation of adult long bone fractures, are rarely appropriate in paediatric cases, as they violate the epiphyseal plates, potentially resulting in growth disturbance.

The decision to use this method of fixation will be based on a risk-benefit analysis with consideration given to the fracture configuration, the age of the child, the operative resources available and the training of the surgeon involved.

Ongoing fracture care

Once reduction and stabilisation of the fracture have occurred, ongoing care is required to monitor the progress of the fracture to union. The treating physician should document the treatment provided and estimate the duration of immobilisation needed. Where the provision of notes and X-rays is limited, one suggestion is to draw the fracture on the surface of the plaster cast along with the intended date of removal.

At initial follow-up, the quality of the plaster cast should be inspected and X-rays taken (where possible) to ensure that secondary displacement has not occurred. The overall duration of immobilisation required is dependent upon the age of the patient and the fracture configuration. Determination of bony union involves the removal of the plaster cast or external fixation device (after an appropriate time period during which union would have been predicted to occur) and the gentle stressing of the fracture site. The presence of persistent tenderness, swelling or abnormal movement all indicate that union has yet to occur. The extent of fracture callus on X-ray is also indicative of the state of union.

Rehabilitation

Children rarely need dedicated physical therapy following fracture healing. They should be encouraged to move their joints through a full range of motion, and exercises should be prescribed to restore muscle bulk.

Specific fractures

Femoral shaft

Closed femoral shaft fractures in children are usually best treated with traction, with the type dependent on the age of the child. Typically the duration required is 1 week per year of age, but this can be shortened by transfer into a plaster hip spica once fracture stability permits.

- Age 0–2 years and weight under 12 kg: Gallows traction, thighs in 45-degree flexion and hips 30-degree abduction. Limb length inequality is seldom a problem as fracture does not shorten excessively. Shortening of up to 1.5 cm and angulation of up to 30 degrees is acceptable. Early spica casting is often possible. **This fracture is associated with non-accidental injury in 50–80% of cases at this age.**
- Age 2–10 years: Skin traction, either in the 90/90 position (hip and knee flexed to 90 degrees) or Perkins type (straight traction). Alternatively, especially in the older members of this group, skeletal traction through a distal femoral traction pin; again either in the 90/90 position or straight. Up to 2 cm of bayonet shortening can be tolerated with no adverse effects. Early spica casting can be used if the position is acceptable. With skin traction the weight used should not exceed 5 kg, but with skeletal traction up to 10% of body weight can be applied.
- Age 10–15 years: Skeletal traction, either in 90/90 position or straight. There is a much greater risk of shortening in this group, and less potential for subsequent growth acceleration and length equalisation.
- Above the age of 15 years, children can be treated as adults.

Tibial shaft

Closed tibial shaft fractures in children are usually uncomplicated, and can be treated satisfactorily with closed reduction and long leg cast application.

- The cast should be applied with the knee in 5–10 degrees of flexion.
- In comparison to the femur there is less potential for overgrowth and thus it is important to maintain the fracture out to length, that is, to ensure that the length of the fractured limb is the same length as the uninjured side. Acceptable degrees of shortening are 5–10 mm in the 0–5 years age group, but aim for none in any older age group.
- Acceptable axial alignment is less than 10 degrees of recurvatum (where the apex of the fracture site points posteriorly) and less than 5 degrees of varus or valgus angulation.
- As union progresses it may be possible to convert the long leg cast to a patellar tendon bearing cast after 3 weeks.
- Undisplaced fractures in children aged 1–5 years can often be treated in below-knee casts or even below-knee plaster cylinders.

Distal humeral

Supracondylar fractures of the humerus have the highest rate of complications and some of the poorest results of treatment of all paediatric fractures. They are also difficult to diagnose without an X-ray. The peak incidence is at the age of 6 or 7 years.

- The vast majority (98%) are extension type, featuring a posteriorly displaced distal part. Only 2% are flexion type, resulting from a fall on to the point of the elbow.
- A careful assessment of distal vascularity should be made. In fractures with posterolateral displacement, the medial humeral spike can tether the brachial artery.
- If distal pulses are absent, closed reduction should be attempted. If this fails to restore pulses, immediate open reduction and surgical exploration of the brachial artery should be performed.
- In other displaced fractures with palpable distal pulses, closed reduction should be attempted, possibly combined with percutaneous pin fixation for unstable fractures.
- Acceptable reductions will have no more than 4 degrees of varus as determined by Baumann's angle on the antero-posterior radiograph. Additionally, the axis of the capitellum should be at 45 degrees to the humeral shaft.
- If an acceptable position is not obtained, this may be an indication for open reduction and percutaneous K-wire fixation.
- Alternatively, the limb can be placed on traction in extension. As the swelling subsides, it will become easier to effect a closed reduction (with or without K-wiring).
- Once reduced, an above-elbow plaster backslab should be applied with the elbow flexed. Flexion above 90 degrees will assist in maintaining the reduction of extension-type fractures, but care should be taken to ensure that distal pulses are maintained.
- Ideally, X-rays should be taken on a weekly basis to ensure that reduction is maintained. The plaster cast can be completed once swelling has resolved, and percutaneous wires can be removed after 3 weeks.
- The typical duration of immobilisation necessary for union is 4–5 weeks in the 0–5 years age group and 6–7 weeks in the 5–10 years age group.

Forearm fractures

- Both types of bone paediatric forearm fractures typically result from the indirect violence of a fall on an outstretched hand. They may be greenstick or complete. If the periosteal sleeve is disrupted the fractures may be unstable.
- X-rays should include the wrist and elbow, as the integrity of the proximal and distal radio-ulnar joints needs to be determined.
- Be aware of the possibility of a Monteggia fracture, which consists of dislocation of the radial head along with fracture of the ulna.
- In contrast to adult forearm fractures, the majority of these injuries can be treated by closed reduction and plaster immobilisation.
- Up to the age of 9 years, acceptable reduction can be defined as anything less than 15 degrees of displacement and 45 degrees of malrotation.
- Above 9 years, at least bayonet apposition is required with less than 30 degrees of malrotation, less than 10 degrees angulation if the fracture is proximal or less than 15 degrees if it is distal.
- Immediately following fracture union, there may be a cosmetic deformity if the above reduction criteria are utilised, but this deformity should remodel if there is over 2 years of skeletal growth remaining.
- Following reduction, an assessment of forearm supination and pronation should be undertaken to ensure that there is no block.
- The arm should be immobilised in an above-elbow cast with the elbow flexed to 90 degrees. Opinion varies as to the position of the wrist in the cast. Some surgeons place the wrist in neutral supination/pronation for all fractures, others placing it in supination for proximal

third fractures, neutral for middle third and pronation for distal third.

- Follow-up X-rays should be taken at 1- and 2-week intervals following manipulation to ensure that secondary displacement has not occurred. If displacement does occur, re-manipulation can be attempted.
- Some very unstable fractures may prove difficult to treat by closed methods. These may benefit from intramedullary pinning (Rush pins) or cross K-wiring if facilities exist for this **(intra-operative fluoroscopy is required)**.

Distal radial ('wrist') fractures

- Children's distal radial fractures are usually the result of a fall on the outstretched hand, and are rarely intra-articular.
- Common types include the following:
  - Galeazzi fracture (isolated fracture of the distal radius) implies associated disruption of the distal radio-ulnar joint.
  - Physeal fracture (pattern of injury described by the Salter-Harris classification)
  - Torus (buckling of the cortex on the compression side of the fracture without angulation).
  - Greenstick fracture (incomplete fracture).
- In children these fractures can almost always be treated with closed reduction and plaster immobilisation.
- The reduction manoeuvre is to hyperextend the wrist, followed by traction and 'hinging' of the distal fragment over the fracture site.
- Acceptable reduction can be defined as anything less than complete displacement and slight angulation. As in forearm fractures, cosmetic deformity should remodel if more than 2 years of skeletal growth remain.
- Check X-rays should be taken at 1 and 2 weeks post-reduction to exclude secondary displacement.
- The duration of immobilisation required depends upon the fracture configuration and the age of the child, but is typically 3–5 weeks.

Conclusions

- Most paediatric fractures can be treated by closed methods.
- Very often the periosteal sleeve will be intact, leading to enhanced fracture stability.
- Completely accurate reduction is not always necessary, as children's bones have the potential to remodel with continued skeletal growth.

7.3 Life-threatening trauma

7.3.A Structured approach to trauma in pregnancy and childhood

BOX 7.3.A.1 Minimum standards

- Triage.
- Structured approach: primary assessment and resuscitation, and then secondary assessment and emergency treatment.
- Availability of emergency surgery or safe transport system.
- Oxygen.
- Blood transfusion service.
- Chest drain.
- Analgesia.
- High-dependency care.
- Tetanus immunoglobulin and toxoid.
- Mannitol or hypertonic saline.
- Tranexamic acid.

Introduction

Most regions of the world are experiencing an epidemic of trauma, but the most serious increase has been in the resource-limited countries.

Proliferation of roads and increased use of vehicles have led to an increase in injuries and deaths, and many peripheral medical facilities find themselves faced with multiple casualties from bus crashes or other disasters. Severe burns and drownings have always been more common in middle- and low-income countries.

There are a number of important differences between high- and low-income countries:

- use of open fires and kerosene stoves for cooking and heating
- unsafe water storage practices and unsupervised play in water courses, lakes and ponds by young children
- poor or absent flood defences, making poor people much more vulnerable to natural disasters
- poorly maintained road networks and vehicles, contributing to a higher injury rate per distance travelled in low-income countries
- the absence of a paramedic-manned emergency ambulance service to give life-saving medical care at the scene
- the great distances over which the injured may have to be transported, and therefore the time taken for them to reach medical care, thus losing the opportunity to prevent secondary damage caused by hypoxia and hypovolaemia
- the absence of appropriate equipment, supplies, and the

necessary knowledge and skills to manage the injured once they have arrived at a healthcare facility
- the absence of skilled people to operate and service equipment.

Prevention of trauma is by far the best and most cost-effective way forward, but accident prevention has not yet had much impact in low-income countries.

Trauma is the commonest cause of death in children over the age of 5 years in high-income countries, and it is increasing in absolute numbers as well as in ranking in low- and middle-income countries. In the World Health Organization (WHO) 2008 report 'World Report on Child Injury Prevention', the death rate in under 20 year olds from injury was 12.2 per 100 000 in high income countries while in low and middle income countries, the figure was 41.7 per 100 000.

Trauma is also a major cause of disability, especially following head injury, burns and drownings. In high-income countries, road accidents and falls predominate; in low-income countries road traffic accidents are increasing, but there has been no fall in the number of burns, falls and drownings.

Children are less likely than adults to suffer from serious penetrating injuries, although in cities where stabbings and shootings are common, or in armed conflict, such violence spills over into childhood. Intentional injury, in the form of child abuse, also contributes to a significant degree to childhood trauma (*see* Section 7.6).

The patterns of injury and the physiological consequences can be quite different in children compared with adults, reflecting their different size and shape, the elasticity of their body tissues, and the immaturity of their physiological systems.

The key principles of managing major trauma are to

> **Treat the greatest threat to life first**
>
> Do no further harm
>
> AVOID: hypoxia, hypercapnia, hypovolaemia, hypoglycaemia and hypothermia

By following a structured approach, problems will be identified and managed in order of priority. The key steps are outlined in the primary assessment and resuscitation, enabling identification and treatment of life-threatening injuries. The secondary assessment identifies all other injuries, and provides emergency treatment for them.

> Structured approach
> - Primary assessment and resuscitation
> - Secondary assessment and emergency treatment
> - Definitive care
>
> Primary assessment
> - **A**irway and control of haemorrhage (**and cervical spine control**)
> - **B**reathing
> - **C**irculation **and** continued haemorrhage control

If there is more than one injured patient, then treat the patients in order of priority (*see* Section 1.10).

Management of major trauma

A team leader should be in overall charge of resuscitating a child or pregnant woman or girl who is suffering from major trauma.

Primary assessment and resuscitation

During the primary assessment, assess and resuscitate in sequence – Airway, Breathing and Circulation (ABC) – as these, if compromised, can be an immediate threat to life.

Although the patient may have obvious severe injuries, the clinician's first task is to prevent further deterioration of the patient's condition by ensuring that vital organs, especially the heart and the brain, are supplied with oxygenated blood by ensuring an open airway, adequate breathing and circulation. This is what is meant by **primary assessment and resuscitation**.

Although ABC management is described sequentially, if there are sufficient trained clinicians present, they can be managed at the same time. If there are limited personnel, the approach must be A then B then C. If there is only one trained person available, make use of untrained staff such as ward orderlies or relatives to perform tasks under your supervision. For example, if there is visible severe exsanguinating haemorrhage, once you have identified and controlled it, the ward orderly can continue to apply the pressure while you open the airway and give oxygen, etc. You will need to continually monitor the untrained person's actions to make sure that they are still effective.

The first priority is establishment or maintenance of airway opening, and control of any obvious life-threatening haemorrhage.

> Primary Assessment and Resuscitation:
> **Airway** and control of exsanguinating haemorrhage (plus cervical spine control, if appropriate)
>
> **Breathing**
>
> **Circulation**

Stop visible external exsanguinating bleeding, if any, by applying direct pressure. This bleeding will be from a superficial artery or large vein. Minor bleeding can be left until the vital ABC have been assessed and resuscitated. Internal bleeding will be dealt with first in 'C' by replacing fluid, and then, if necessary, by emergency surgery.

Open and maintain the airway

We assess the airway patency by assessing its function, which is to allow air to pass through it into the lungs. If the airway is blocked, the lungs will not receive air.

The approach is similar to that used for managing any airway, in that you must:

> LOOK for chest movement
> - LISTEN for breath sounds
> - FEEL for exhaled air
> - **Talk to the patient**

If the patient is conscious, a rapid way to assess the airway is to ask them to speak, using the question 'Are you all right?'

A patient who can speak (or, in the case of a baby, who can cry) must have a clear airway.

If the patient is unconscious, airway obstruction is most commonly due to obstruction by the tongue.

The signs of airway obstruction may include:

- snoring or gurgling
- stridor or abnormal breath sounds
- agitation (hypoxia)
- using the accessory muscles of ventilation/paradoxical chest movements
- cyanosis.

Cervical spine protection

In countries where there is no trained emergency ambulance service available to rescue trauma victims at the scene, the risk of an unstable cervical fracture causing permanent spinal cord damage, and subsequent paresis occurring before the patient is brought to medical attention, is high. Therefore any cervical fracture presenting to a medical facility after being brought in by passers-by is likely to be stable.

Fortunately, unstable cervical spinal fractures are relatively uncommon. They are more likely to occur as a result of very severe road traffic accidents or falls from a significant height.

Protect the cervical spine with collar, sand bags and tape if the patient is likely to have an unstable cervical spine.

Definitive treatment requires specialist surgery, and health services in many low-income countries may struggle to access the appropriate service for their population.

It is important to recognise that although protection of the cervical spine may occasionally be beneficial, the opening and maintaining of a clear airway benefits every patient and is an absolute priority.

Cervical spine immobilisation

The cervical spine can be mobilised in three ways:

1 In-line stabilisation: the spine is held in the neutral position (the same as the airway position for an infant; *see* Section 1.12) by the clinician's hands on either side of the patent's head, ensuring that the ears are not covered, as the patient must be able to hear to be reassured and informed. This position must be held until the collar and/or blocks are in place.

2 A cervical collar can be placed around the neck. Before placing the collar, gently feel around the back of the patient's neck to ascertain if there is any midline tenderness and/or a 'step' indicating a fracture or if there is any bleeding. Collars are manufactured in several sizes to fit different sized patients. They are measured according to the manufacturer's instruction and then gently slid under the neck at the back. The shaped part is placed under the chin at the front, and the collar is fastened with the 'Velcro' tape fastening. This should leave the patient with a firmly held neck in a neutral position. The collar is used by itself in the combative patient, and in conjunction with blocks or sandbags in the unconscious or cooperative patient (i.e. one who will remain still).

3 Sandbags or blocks and tape are usually added after the collar has been fitted. They cannot be used in combative patients as their movements to free themselves will cause more injury. They are essential in the unconscious patient who has a possibility of neck injury. These objects are placed on either side of the patient's head to prevent lateral movement, and held in place with two tapes, one across the patient's forehead and the other across the chin part of the cervical collar.

Management of the airway

- **Head tilt/chin lift or jaw thrust.** Jaw thrust is recommended in trauma, as it does not require any neck movement. However, if a jaw thrust is unsuccessful, try chin lift with some head tilt. **A closed airway will always be potentially fatal, so the airway takes priority.**
- **Suction/removal of blood, vomit or a foreign body**, if any, but only under direct vision. Do not blindly suck in the mouth or pharynx.
- **If there is no improvement, place an oropharyngeal airway.** Avoid using a nasopharyngeal airway if base of skull injury is suspected.
- **If the airway is still obstructed, a definitive airway by intubation or surgical airway may be needed.**
- Identify the 'at-risk' airway:
  - Altered level of consciousness will fail to protect the airway.
  - Vomiting, with risk of aspiration, is a major risk in pregnancy.
  - Facial trauma, including burns, will continue to worsen as the tissues swell.

Once the airway is open, give high-flow oxygen using a mask and reservoir.

If the airway cannot be maintained and/or protected, consider the need for **advanced airway management**.

Indications for advanced techniques for securing the airway (intubation or surgical airway) include:

- persistent airway obstruction
- a conscious level of ≤ 8 on the Glasgow Coma Scale, or 'P' or 'U' on the AVPU scale (see below for both)
- penetrating neck trauma with haematoma (expanding)
- apnoea
- hypoxia
- severe head injury
- chest trauma
- maxillofacial injury.

Intubation techniques should ideally be performed by an experienced anaesthetist. A surgical airway is best performed by an ENT surgeon, but general surgeons will have been trained even if they are not experienced in the technique. The technique of emergency cricothyrotomy can be performed by any emergency clinician (see below).

For intubation, the following sequence should be followed:

1 Pre-oxygenation with 100% oxygen, with manual lung inflation if required.
2 Administration of a carefully judged, reduced dose of an anaesthetic induction agent.
3 Application of cricoid pressure.
4 Suxamethonium 1–2 mg/kg.
5 Intubation with a correctly sized tracheal tube.

Confirmation of correct placement of the endotracheal tube

Signs such as chest movement and auscultation remain helpful, but are occasionally misleading, especially in inexperienced hands. The most reliable evidence is to see the tube pass through the vocal cords. The correct size is a tube that can be placed easily through the cords with only a small leak. Intubation of the right main bronchus is best avoided by carefully placing the tube only 2–3 cm below the cords, and noting the length at the teeth before checking by auscultation, which is best done in the left and right lower axillae. **Capnography (if available) is a useful adjunct to help to confirm correct tube placement.**

Indications for surgical cricothyrotomy

- Inability to open or clear the airway, and the patient losing consciousness due to cerebral hypoxia (usually also cyanosed and bradycardic).
- Inability to ventilate the lungs despite high-level CPAP via a bag-valve-mask system and 100% oxygen through a reservoir attached to the bag.
- Inability to intubate through the larynx, either because this is not possible or due to lack of experience.

Method

1. Place the patient in a supine position.
2. If there is no risk of neck injury, consider extending the neck to improve access. Otherwise, maintain a neutral alignment.
3. Identify the cricothyroid membrane (*see* Figure 7.3.A.1).
4. Prepare the skin, and, if the patient is conscious, infiltrate with local anaesthetic.
5. Place a hand on the neck to stabilise the cricothyroid membrane, and to protect the lateral vascular structures from injury.
6. Make a small vertical incision in the skin, and press the lateral edges of the incision outwards, to minimise bleeding.
7. Make a transverse incision through the cricothyroid membrane, being careful not to damage the cricoid cartilage.
8. Insert a tracheal spreader, or use the handle of the scalpel by inserting it through the incision and twisting it through 90 degrees to open the airway.
9. Insert an appropriately sized endotracheal or tracheostomy tube.
10. Ventilate the patient and check that this is effective.
11. Secure the tube to prevent dislodgement.

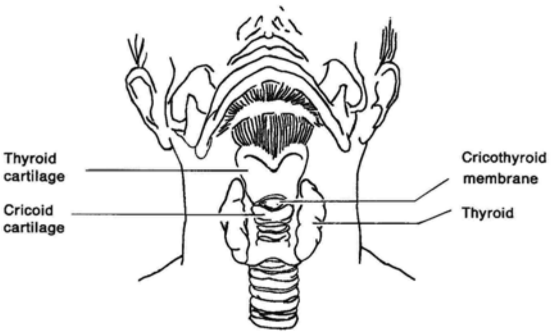

FIGURE 7.3.A.1 Anatomy of neck, showing landmarks for surgical cricothyroidotomy.

Complications of surgical cricothyroidotomy

These include the following:

- asphyxia
- aspiration (e.g. blood)
- laceration of the trachea
- laceration of the oesophagus
- haemorrhage or haematoma formation
- mediastinal emphysema
- subsequent glottic stenosis
- creation of a false passage into the tissues
- subsequent subglottic stenosis or oedema.

Primary assessment and resuscitation: Breathing

After management of the airway, the patient's breathing should be assessed. The same approach is adopted as for the patient suffering a serious illness.

Assessment of breathing

- Effort: recession, rate, added noises, accessory muscles, alar flaring.
- Efficacy: breath sounds, chest expansion, abdominal excursion.
- Adequacy: heart rate, skin colour (look for cyanosis), mental status.
- A pulse oximeter is very useful to monitor oxygenation adequacy (SaO_2).

Unequal breath sounds or poor oxygenation:

- Pneumothorax or haemothorax.
- Misplaced or blocked endotracheal tube.

Looking at the respiratory rate and chest expansion is essential. In addition to the signs listed above, check whether any of the following are present:

- penetrating injury
- presence of flail chest
- sucking chest wounds.

Listen for breath sound character and equality:

- pneumothorax (decreased breath sounds on site of injury)
- detection of abnormal sounds in the chest.

Feel for:

- tracheal shift (sign of tension pneumothorax on side away from the deviation)
- broken ribs
- subcutaneous emphysema.

Percuss:

- percussion is useful for diagnosis of **haemothorax** (dull on affected side) and **pneumothorax** (hyper-resonant on affected side).

Continue giving high-flow oxygen (15 litres/minute) in all cases.

Careful examination of the trachea, neck veins and chest may indicate the presence of pleural collections of air or blood. Tension pneumothorax should be treated immediately with needle thoracocentesis in the second intercostal space in the mid-clavicular line.

Needle thoracocentesis

This procedure is used for the rapidly deteriorating patient who has a life-threatening tension pneumothorax. If it is used with a patient who does not have a tension pneumothorax, there is a 10–20% risk of producing a pneumothorax or causing damage to the lung, or both. In such cases immediate subsequent insertion of a chest drain is mandatory.

1 Identify the second intercostal space in the mid-clavicular line on the side of the pneumothorax (the **opposite** side to the direction of tracheal deviation, and the **same** side as the hyper-resonance).
2 Swab the chest wall with surgical prep or an alcohol swab.
3 Attach the syringe to the over-needle venous cannula.
4 Insert the cannula into the chest wall, just above the rib below, aspirating all the time.
5 If air is aspirated, remove the needle, leaving the plastic cannula in place. Alternatively, insert the over-needle venous cannula without a syringe and note a ‘hiss’ of air on relief of the tension pneumothorax when the metal stylet is removed from the plastic cannula.
6 Tape the open cannula in place and proceed to chest drain insertion as soon as possible.

Complications of needle thoracocentesis

- Local cellulitis.
- Local haematoma.
- Pleural infection.
- Empyema.
- Pneumothorax.

Ventilation

Provide assisted ventilation if needed to patients with breathing problems, using a bag and mask with a reservoir attached, or by intubation and intermittent positive pressure ventilation. **Do not persist with intubation attempts without oxygenating the patient.**

Look for and treat the following:

- airway obstruction (see above)
- tension pneumothorax
- open pneumothorax
- haemothorax
- flail chest
- cardiac tamponade.

See below for details.

TABLE 7.3.A.1 Serious chest trauma: signs and treatment

Breathing problem	Clinical signs	Treatment
Tension pneumothorax	● Decreased air entry on side of pneumothorax ● Decreased chest movement on side of pneumothorax ● Hyper-resonance to percussion on side of pneumothorax ● Tracheal deviation away from side of pneumothorax ● Hypoxic shocked patient ● Full neck veins	High-flow oxygen Needle thoracocentesis Chest drain insertion
Open pneumothorax	● Penetrating chest wound with signs of pneumothorax ● Sucking or blowing chest wound	High-flow oxygen Chest drain Wound occlusion on three sides
Massive haemothorax: blood in pleural space	● Decreased chest movement ● Decreased air entry ● Dullness to percussion ● Shock and hypoxia ● Collapsed neck veins	High-flow oxygen Venous access and IV volume replacement Chest drain (a haemothorax of 500–1500 mL that stops bleeding after insertion of an intercostal catheter can generally be treated by closed drainage alone; a haemothorax of greater than 1500–2000 mL, or with continued bleeding of more than 200–300 mL/hour, may be an indication for further investigation, such as thoracotomy)
Flail chest: paradoxical movement of a chest wall segment associated with underlying lung contusion	● Rare in children because they have an elastic chest wall ● Decreased efficiency of breathing	Oxygen and pain relief May need intubation and ventilation Transfer if feasible
Cardiac tamponade: blood in pericardial sac causing a decrease in cardiac output	● Shock associated with penetrating or blunt chest trauma ● Faint apex beat and/or muffled heart sounds ● Distended neck veins	Oxygen IV access and IV fluids Emergency needle pericardiocentesis (*see* Section 8.4.C: may need to be repeated) Consider transfer if feasible

Primary assessment and resuscitation: Circulation

Assessment of circulation

Circulatory assessment includes identification of actual and potential sources of blood loss. Closed fractures and bleeding into the chest, abdomen or pelvis may make it difficult to detect how much blood has been lost. The ability to estimate the percentage blood loss is helpful when planning resuscitation. Remember that a child's circulating blood volume is only 80 mL/kg, so is easily compromised. Blood volume in pregnancy is 100 mL/kg, or 5–7 litres.

TABLE 7.3.A.2 Blood loss in pregnancy

	Percentage blood loss		
Sign	**< 25**	**25–40**	**> 40**
Heart rate	slight increase	moderate increase	marked increase or bradycardia
Systolic BP	normal	normal	beginning to fall
Pulse volume	normal or decreased	seriously decreased	very seriously decreased
Skin*	cool, pale, sweaty	cool, mottled, sweaty	cool and sweaty
Respiratory rate	slight increase	moderate increase	sighing respirations
Mental status	slight agitation	lethargic or uncooperative	only reacts to pain

* Capillary refill time > 3 seconds.

Note that blood pressure may be normal until up to 50% of the patient's circulatory volume has been lost. The blood pressure is initially well maintained despite continuing bleeding in children and pregnant women and girls. As an indicator of haemorrhage, it can be falsely reassuring. A progressively worsening tachycardia is a more revealing feature.

A monitoring device which records pulse rate, ECG trace and blood pressure is a very useful adjunct if available.

Resuscitation of circulation

Management is focused on avoiding hypovolaemia and controlling blood loss.

Loss of blood is the most common cause of shock in major trauma.

Concealed bleeding severe enough to cause shock can occur into the pleural cavity, abdomen, pelvis and femur. Around 40% of the circulating blood volume can be lost via an open femoral fracture, wherein initial treatment should include pressure, splinting and analgesia.

Stop bleeding

The first priority is to stop obvious bleeding by applying direct pressure. Do not forget that the patient may have a wound on their back that is bleeding into the bed. To examine the back, the patient should be log-rolled, if indicated.

- **Injuries to the limbs:** tourniquets do not work well and may cause reperfusion syndromes and add to the primary injury. The recommended procedure of 'pressure dressing' is an ill-defined entity. Severe bleeding from high-energy penetrating injuries and amputation wounds can be controlled by sub-fascial gauze pack placement, plus manual compression on the proximal artery, plus a carefully applied compressive dressing of the entire injured limb.
- **Injuries to the chest:** the most common source of bleeding is chest wall arteries. Immediate placement of a chest tube drain plus intermittent suction plus efficient analgesia (IV ketamine is the drug of choice, if available) expand the lung and seal off the bleeding.

Recent evidence has shown that tranexamic acid can reduce mortality from major haemorrhage in major trauma in adults. It is also now recommended for use in children. The drug should be started as soon as possible, and within the first 3 hours after the trauma, to be effective.

In pregnancy

The loading dose is 1 gram over 10 minutes followed by an IV infusion of a further 1 gram over 8 hours.

The slow IV bolus dose is given by injecting 1 gram of tranexamic acid into a 100-mL bag of 0.9% saline and letting it run through over about 10–20 minutes (the exact timing is not crucial).

The 8-hour infusion is given by injecting 1 gram of tranexamic acid into a 500-mL bag of 0.9% saline and giving it over 8 hours (approximately 60 mL/hour). If there is a gap between the initial bolus and the subsequent infusion this probably does not matter too much, but ideally one should follow the other.

In children

The loading dose is 15 mg/kg (maximum 1 gram) diluted in a convenient volume of sodium chloride 0.9% or glucose 5% and given over 10 minutes.

The maintenance infusion rate is 2 mg/kg/hour. The suggested dilution is 500 mg in 500 mL of sodium chloride 0.9% or glucose 5% given at a rate of 2 mL/kg/hour for at least 8 hours, or until bleeding stops.

Elevate the legs if the patient is in shock.

IV fluid resuscitation

The goal is to restore oxygen delivery to the tissues. As the usual problem is loss of blood, fluid resuscitation must be a priority.

- Adequate vascular access must be obtained. This requires the insertion of at least one, and ideally two, large-bore cannulae (14–16 G). Peripheral cut-down or intra-osseous infusion may be necessary.
- Infusion fluids: These should be warmed to body temperature if possible (e.g. pre-warm in a bucket of warmed water or under a relative's clothing). Remember that hypothermia can lead to abnormal blood clotting. Use crystalloids such as Ringer-lactate or Hartmann's solution. Normal (0.9%) saline can be used if these fluids are unavailable, but **be aware that, especially in larger volumes, normal saline causes a hyperchloraemic acidosis which is detrimental to sick or injured patients**.)
- Avoid solutions containing ONLY glucose (e.g. 5% Dextrose in water or 5% Dextrose with 1/5N saline, these are dangerous in this situation) but glucose can be added to Ringer–lactate, Hartmann's or N saline if there is evidence of or concern about hypoglycaemia.
- Take blood for Hb, group and cross match and glucose, electrolytes and amylase for urgent analysis.

Not all cases of hypovolaemia require aggressive fluid therapy. In adults, withholding fluids in penetrating trunk trauma before achieving surgical haemostasis has been associated with an improved outcome. The rationale is to avoid pushing up the blood pressure, which hinders clot formation and promotes further bleeding. Aggressive crystalloid fluid replacement can lead to increased fluid requirements, hypothermia, dilution of clotting factors, excessive blood transfusion and its associated immunosuppression. Aim to give sufficient fluid to maintain vital organ perfusion. This can be monitored by monitoring the patient's state of alertness which is a measure of brain perfusion in the absence of a head injury.

On the other hand, in severe head injury, cerebral perfusion is critically dependent on maintaining blood pressure. If the patient has both a severe head injury and major trunk bleeding, the apparently conflicting requirements are best managed by maintaining priorities in ABC order and achieving prompt surgical haemostasis. Beyond this strategic conflict, it should be remembered that the normal blood pressure is lower in children, hypovolaemia mimics head injury, and blood pressure itself is a poor indicator of organ perfusion.

As outlined above, the concept of '**targeted fluid resuscitation**' is important if the cause of hypovolaemic shock is haemorrhage from penetrating injury. Here the initial boluses of IV crystalloids required to treat shock should only be given to keep the vital organs (especially the brain, heart and kidneys) perfused before emergency surgery and blood transfusion is available. Fresh blood is particularly useful to combat the coagulopathy that occurs in major blood loss if specific coagulation components such as platelets are unavailable.

However, it must be borne in mind that penetrating trauma is not common in women and children in civilian life.

We suggest that when giving boluses of crystalloid or blood to patients in shock **due to bleeding** in major trauma, only the amount needed to keep the blood pressure at a level sufficient to perfuse the vital organs should be given. There is no clear evidence to indicate the precise blood pressure that should be achieved in a pregnant woman or child in shock due to haemorrhage. Adequate perfusion of vital organs may best be indicated by **a radial pulse which can be palpated and an alert conscious level (in the patient without a significant head injury). In pregnancy, the adequacy of the fetal heart rate may also be helpful**.

In children under 2–3 years of age, the radial pulse may be difficult to feel, and the presence of a palpable brachial pulse may be the best available indicator at present.

Therefore to maintain a palpable radial pulse in pregnancy, start with IV boluses of 500 mL of crystalloid or ideally blood, and reassess after each bolus.

In children, to maintain a radial or brachial pulse give 10 mL/kg IV boluses of crystalloid or, ideally, blood, and reassess after each bolus.

In the absence of further evidence, it is recommended that in children it is best to start with 10 mL/kg boluses (infusions given as rapidly as possible) of Ringer-lactate or Hartmann's solution or plasma expander with frequent reassessment, rather than the full 20 mL/kg recommended in other life-threatening situations, such as meningococcal sepsis or severe dehydration.

Fluid resuscitation in pregnancy starts with a 500-mL bolus of Ringer-lactate or Hartmann's solution or plasma expander.

After repeating boluses twice (i.e. 10 mL/kg twice in a child, or 500 mL twice in pregnancy), the transfusion of blood (packed red cells) should be considered. The most important aspect of fluid resuscitation is **the patient's response to the fluid challenge**.

Improvement is indicated by the following:

- a decrease in heart rate
- an increase in systolic blood pressure
- an increase in skin temperature
- faster capillary refill
- improving mental state.

Failure to improve should prompt an urgent search for chest, abdominal or pelvic haemorrhage, with the immediate involvement of an experienced surgeon. Similar volumes may be repeated if there is continuing evidence of haemorrhagic shock, after re-evaluating the state of the circulation.

It is useful to delegate the initial fluid bolus to a member of the trauma team (if a team is available), who attaches the warmed fluid bag to the IV cannula via a three-way tap to which is attached a 20- or 50-mL syringe to give the boluses.

Blood transfusion

There may be considerable difficulty in getting blood. Remember possible incompatibility, and hepatitis B and HIV risks, even among the patient's own family.

Blood transfusion must be considered when the patient has persistent haemodynamic instability despite fluid (colloid/crystalloid) infusion. If the type-specific or cross-matched blood is not available, type O negative packed red blood cells should be used. Transfusion should be seriously considered if the haemoglobin level is less than 7 grams/dL and if the patient is still bleeding. Blood transfusion is most important, and requires blood to be taken for urgent cross-matching.

As described above, early surgical involvement is essential.

Vascular access

This is essential in all seriously injured patients. A minimum of two relatively large-bore IV cannulae is essential.

TABLE 7.3.A.3 Infusion IV line flow rates

Colour code	Gauge	Crystalloid flow rate (mL/minute)
Brown	14	240
Grey	16	172
Yellow	17	130
Green	18	76
Pink	20	54
Blue	22	25
Lime green	24	14

Peripheral veins are preferable; the inexperienced should not attempt central venous cannulation. The external jugular vein can be accessed even in shock, but the cannula can become easily displaced and must be very carefully taped in place. A cut-down on to the long saphenous vein at the ankle can also be used. If venous access is difficult and is taking too long, the new intra-osseous EZ-IO drill is simple to operate and can be life-saving (*see* Section 8.4.C), and **should be available in all emergency departments**.

Central venous cannulation can permit large volumes to be rapidly infused and also permit central venous pressure measurements. It must be undertaken by a skilled person (e.g. an anaesthetist), and a Seldinger technique should be used. The femoral vein is used for children, but not for pregnant women where the internal jugular or subclavian vein may be used. Peripheral venous access can often be established once peripheral perfusion has been improved. Both femoral venous and tibial intra-osseous access are best avoided if there is clinical evidence of a pelvic or abdominal injury. In such cases it is better to secure vascular access above the diaphragm. The upper outer aspect of the humerus can be used for intra-osseous access in that case (*see* Section 8.4.C).

Blood from a vein or bone marrow should be drawn for typing and cross-matching, haemoglobin, glucose and electrolytes. These tests are clinically accurate on a marrow sample from an intra-osseous approach provided there has not been prior infusion of blood or crystalloid fluid. The infused fluids should be warm. Physiological coagulation works best at normothermia, and haemostasis is difficult at core temperatures below 35°C. Hypothermia in trauma patients is common during protracted improvised outdoor evacuations, even in the tropics. It is easy to cool a patient but difficult to rewarm them, so prevention of hypothermia is essential. IV fluids should have a temperature of 40–42°C (using IV fluids at 'room temperature' means cooling!).

Venous cut-down

Anatomical considerations

In adults the primary site for cut-down is over the long saphenous vein above the ankle at a point approximately 2 cm anterior and 2 cm superior to the medial malleolus, **but not if there is significant injury proximal to this site**.

Identify the surface landmarks. These are shown in Table 7.3.A.4.

TABLE 7.3.A.4 Surface landmarks for cut-down incision

	Saphenous
Infant	Half a finger's breadth superior and anterior to the medial malleolus
Small children	One finger's breadth superior and anterior to the medial malleolus
Older children and pregnant mothers	Two finger breadths superior and anterior to the medial malleolus

- Apply a venous tourniquet proximal to the intended cannulation site.
- Prepare the skin with antiseptic and sterile drapes.
- Infiltrate the area with local anaesthetic (1% lignocaine using a fine 24–25G needle).
- Make a full-thickness transverse incision through the skin.
- By blunt dissection, identify and display the vein.
- Free the vein from its bed and elevate a 2 cm length.
- Pass a dissolvable suture around the proximal end of the vein but do not tie it yet.
- Introduce the plastic cannula (with trochar) through the venotomy, remove the trocar and secure it in place by tying the proximal ligature.
- Attach the giving set and commence flow at the required rate.
- If possible, close the incision; otherwise apply a sterile dressing and secure the giving set tubing in place.

See also Section 8.4.C.

Complications

- Haemorrhage or haematoma.
- Perforation of the posterior wall of the vein.
- Nerve transection.
- Phlebitis.
- Venous thrombosis.

External jugular venous cannulation

Procedure

Place the patient in a head-down position to dilate the vein and reduce the risk of air embolus.

1. Place the patient in a 15–30-degree head-down position (or with padding under the shoulders so that the head hangs lower than the shoulders).
2. Turn the head away from the site of puncture.
3. Clean the skin over the appropriate side of the neck.
4. Identify the external jugular vein, which can be seen passing over the sternocleidomastoid muscle at the junction of its middle and lower thirds.
5. Have an assistant place their finger at the lower end of the visible part of the vein just above the clavicle. This stabilises it and compresses it so that it remains distended.
6. Puncture the skin and enter the vein.
7. When free flow of blood is obtained, ensure that no air bubbles are present in the tubing and then attach a giving set.
8. Tape the cannula securely in position.

Other less common causes of shock in major trauma

Cardiogenic shock

Inadequate heart function may result from:

- myocardial contusion (bruising)
- cardiac tamponade
- tension pneumothorax (preventing blood from returning to the heart)
- myocardial infarction.

Assessment of the jugular venous pressure is essential in these circumstances. It will be elevated compared with hypovolaemic shock, where it may not be visible.

An ECG should be recorded (if available).

Neurogenic shock

This is due to the loss of sympathetic tone, usually resulting from spinal cord injury, with the classical presentation of hypotension without reflex tachycardia or skin vasoconstriction.

Tension pneumothorax

See under breathing section above. This can present with shock as well as breathing impairment.

Primary assessment: neurological failure

Head injury is the major cause of death in trauma.

Rapid assessment of the central nervous system for evidence of failure includes determining the AVPU score: AVPU score: A = Alert, V = responds to a Voice, P= response to Pain, U = Unresponsive.

- With a score of ‘P’ or ‘U’, intubation should take place in order to maintain and protect the airway. If there is no one skilled in intubation available, the patient should be placed in the recovery position.
- Remember to check for a pain response above the level of the clavicle, as a patient with a spinal injury may not be able to respond by moving their limbs.
- Look for signs indicative of injury (e.g. bruises, lacerations or haematoma) in the head and neck area.
- Examine the pupils for size, equality and reaction to light. Look for other lateralising signs, such as limb weakness or focal seizures.

At this stage, the brain is best cared for by close attention to managing A B and C, and by correction of any hypoglycaemia.

If there is evidence of raised intracranial pressure (RICP):

- Intubate and ventilate to maintain oxygenation, and aim for a pCO_2 of about 4 kPa.
- Maintain systolic blood pressure.
- Nurse the patient in a 30-degree head-up position.
- Contact a neurosurgeon (if available).

Mannitol 0.5 mg/kg should be administered after first excluding intracranial haematoma. If this is not excluded, there will be temporary improvement due to relief of cerebral oedema, but there may be sudden worsening a short time later due to rapid expansion of the haematoma. An alternative is hypertonic saline (*see* Section 7.3.C).

Low blood glucose levels are common in child trauma victims, and can cause brain damage. Always check the blood glucose level where possible. If it is not possible to check it, treat any baby or small child immediately with 5 mL/kg of 10% glucose IV.

Analgesia in major trauma (*see* Section 1.15)

Pain increases fear and distress, makes the patient less able to cooperate, and raises intracranial pressure. If the patient is fully conscious and in severe pain, control of pain is required.

Pain relief takes several different forms:

- Reassurance.
- Splinting of fractures.
- Covering wounds, especially burns.
- Drugs:
  - There is no place for oral or IM medication in a major trauma situation.
  - There are three alternatives in severe trauma: ketamine, morphine and Entonox.

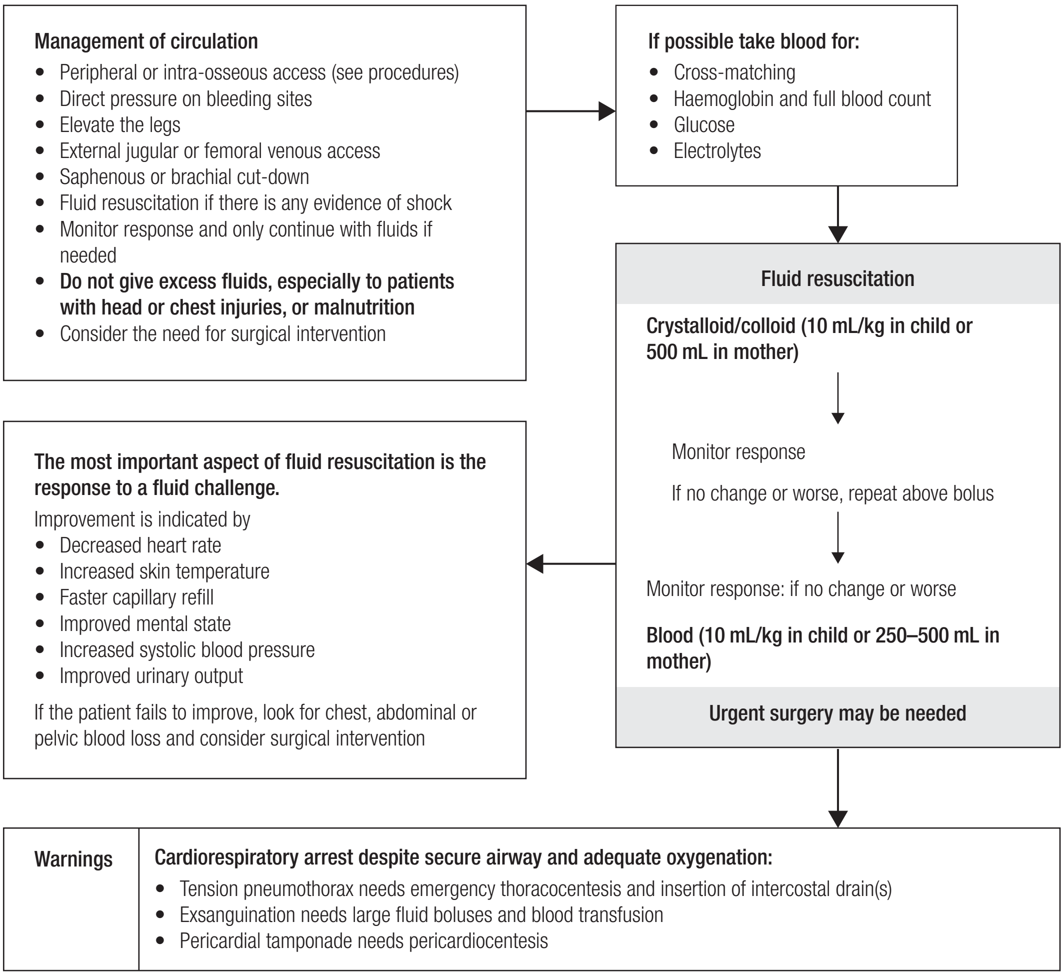

FIGURE 7.3.A.2 Managing the circulation in major trauma.

Ketamine

The positive inotropic effects of ketamine, and the fact that it does not affect the gag reflex, make this a very helpful analgesic, especially if there is or has been shock. Repeated IV doses of 200 micrograms/kg followed by careful reassessment are usually effective, especially during transfer to a more specialised hospital (if available and relevant).

Morphine

In major trauma, 100–200 micrograms/kg morphine IV in a child, or 5–10 mg in a mother, is the drug of choice, followed by careful reassessment. If the conscious level falls, the effect can be reversed with naloxone, showing whether the effect is caused by the morphine or by a worsening brain injury. If there is respiratory depression, first ventilate with a bag-valve-mask before giving naloxone.

Entonox

Entonox (a 50:50 mixture of nitrous oxide and oxygen) is useful, especially for limb injuries while splints are being applied. Do not use it in the presence of head, chest or abdominal trauma.

A head injury is NOT a contraindication to giving morphine unless there is depressed consciousness, when great care is needed.

Summary of primary assessment and resuscitation

The injured patient should have:

- a team approach with an urgent call for surgical and anaesthetic availability
- a clear airway and 100% oxygen for breathing
- adequate respiration, achieved by manual or mechanical ventilation and chest decompression when indicated
- venous access and an initial fluid challenge, if indicated on circulatory assessment
- blood sent for typing and cross-matching
- identification of the need for life-saving surgery and preparation under way
- identification of any serious head injury, and attention paid to maximising A, B and C
- cervical spine immobilisation, where appropriate

Life-threatening injuries identified and treated

Injury	*Treatment*
Airway obstruction	Head tilt, chin lift and jaw thrust, oropharyngeal airway, intubation or surgical airway
Tension pneumothorax	Needle thoracocentesis and chest drain
Open pneumothorax	Three-sided dressing, then chest drain
Massive haemothorax	IV access, chest drain and blood transfusion
Flail chest	Intubation if needed
Cardiac tamponade	Pericardiocentesis

Before the secondary assessment begins, it should be remembered that:

ABC and neurological failure components of the primary assessment and resuscitation require constant re-evaluation, as deterioration can be rapid and unexpected.

Emergency operative treatment to control life-threatening haemorrhage should be performed promptly, without waiting for non-urgent examination and imaging.

Identification of all anatomical injuries remains an important goal, but may be overridden by pressing physiological requirements to ensure that oxygenated blood reaches vital organs in sufficient degree. This may require emergency surgery before all non-life-threatening injuries have been identified.

Secondary assessment and emergency treatment

Secondary assessment and emergency treatment are undertaken only when the patient's ABC's are stable. **If any deterioration occurs during this phase, secondary assessment must be interrupted by another primary assessment and resuscitation.**

Documentation is required for all procedures undertaken. This involves careful examination from head to toe in a systematic way, including a **controlled examination of the back, avoiding spinal movement** by log-rolling (*see* Section 8.5). Clear documentation of all injuries is required, to serve as the basis of the subsequent management strategy.

Shortly after the primary assessment and resuscitation, various adjuncts help with protecting the patient and monitoring progress.

Secondary assessment: adjuncts

- Monitoring ECG, SaO_2 and blood pressure
- Urinary and gastric catheters
- Portable X-rays of chest and pelvis
- Ultrasound of abdomen (if available)
- Adequate pain control (see below)
- Baseline blood tests (especially haemoglobin, cross-matching, biochemistry and clotting)

History

- Events before and after incident
- First aid given at scene
- Past medical history
- Medications and allergies
- Immunisation status
- Last food and drink

Adjuncts to the secondary assessment and emergency treatment include:

- ECG, oxygen saturation and blood pressure monitoring (as used in primary assessment and resuscitation).
- Gastric and urinary catheters.
- **Portable** X-rays of the chest, neck and pelvis.

Head examination

This includes the following:

- scalp and ocular abnormalities
- external ear and tympanic membrane
- periorbital soft-tissue injuries.

Head injury patients should be suspected of having cervical spine injury until demonstrated otherwise.

Neck examination

This includes the following:

- looking for a penetrating wound
- subcutaneous emphysema
- tracheal deviation
- neck vein appearance (JVP).

Neurological examination

This includes the following:

- brain function assessment using the AVPU Scale or the Glasgow Coma Scale (GCS)
- spinal cord motor activity
- sensation and reflex.

Chest examination

This includes the following:

- the clavicles and all ribs
- breath sounds and heart sounds
- ECG monitoring (if available).

Abdominal examination

This includes the following:

- look for a penetrating wound of the abdomen requiring surgical exploration
- look for blunt trauma; a nasogastric tube is inserted (but not in the presence of facial trauma)
- rectal examination (but not in children unless absolutely essential)
- insertion of urinary catheter except in children (check for meatal blood before insertion).

Examination of pelvis and limbs

This includes the following:

- pain, tenderness on palpation
- deformity
- wounds.

X-rays (if possible and where indicated)

These include the following:

- chest X-ray and cervical spine films (it is important to see all seven vertebrae)
- pelvic and long bone X-rays
- skull X-rays may be useful to search for fractures when head injury is present without focal neurological deficit if CT is unavailable
- CT scans of the head and abdomen (if available).

Head injury

This remains the commonest cause of death and disability in severe trauma in children, and is dealt with in more detail elsewhere (*see* Section 7.3.C). The scalp and face are examined for bruising, abrasions, lacerations and evidence of fracture.

Basal skull fracture is manifested by signs such as:

- 'raccoon eyes' (bilateral peri-orbital haematoma), bleeding from the ears or a visible haemotympanum
- Battle's sign (bruising over the mastoid process, which is a relatively late sign)
- CSF leakage from the nose, mouth or ears.

The AVPU Scale score or the Glasgow Coma Scale score is again evaluated (*see* Section 7.3.C), allowing a dynamic comparison with the primary assessment estimation, unless the child is now intubated and sedated.

As infants and small children are prone to hypoglycaemia, it is important to consider this as a potential cause of altered consciousness (*see* Section 5.8.B).

Delay in the early assessment of head-injured patients can have devastating consequences in terms of survival and patient outcome. Hypoxia and hypotension double the mortality of head-injured patients.

The following conditions are potentially life-threatening but difficult to treat in district hospitals. It is important to treat what you can with the expertise and resources that you have available, and to triage casualties carefully.

Immediate recognition and early management of the following conditions are essential:

Acute extradural haemorrhage

Classical signs consist of:

- loss of consciousness following a lucid interval, with rapid deterioration
- a rapid rise in intracranial pressure, due to bleeding from the middle meningeal artery
- development of hemiparesis on the opposite side, with a fixed pupil on the same side as the impact area.

The management is surgical, and every effort should be made to do burr-hole decompressions.

Acute subdural haematoma

There is bleeding with clotted blood in the subdural space, accompanied by severe contusion of the underlying brain. This condition results from tearing of bridging veins between the cortex and the dura. Again, surgery is needed, but it requires a neurosurgeon, not burr-holes alone.

The following conditions should be treated with more conservative medical management, as neurosurgery does not usually improve the outcome:

- base-of-skull fractures
- cerebral concussion, with temporarily altered consciousness
- depressed skull fracture: an impaction of fragmented skull that may result in penetration of the underlying dura and brain
- intracerebral haematoma, which may result from acute injury or progressive damage secondary to contusion
- in children, diffuse brain swelling is a more frequent problem than bleeding; again this is managed medically, but apart from ventilation and general supportive therapy, recovery is dependent on the severity of the injury and the effect of the initial physiological support of ABC.

Alteration of consciousness is the hallmark of brain injury.

The most common errors in head injury evaluation and resuscitation are:

- failure to perform ABC and prioritise management
- failure to look beyond the obvious head injury
- failure to assess the baseline neurological examination
- failure to re-evaluate the patient who deteriorates.

Management of head trauma

The Airway, Breathing and Circulation are stabilised (and the cervical spine immobilised, if possible).

Vital signs are important indicators of the patient's neurological status, and must be monitored and recorded frequently.

The Glasgow Coma Scale (GCS) score is interpreted as follows:

- severe head injury: GCS score is ≤ 8
- moderate head injury: GCS score is 9–12
- minor head injury: GCS score is 13–15.

Remember:

- Deterioration may occur due to bleeding or brain swelling.
- Unequal or dilated pupils may reflect an increase in intracranial pressure.
- Head or brain injury is never the cause of hypotension in the adult trauma patient.
- Sedation should be avoided, as it decreases the level of consciousness, and promotes hypercarbia due to slow breathing with retention of CO_2.
- The Cushing response is a late sign, reflecting a lethal rise in intracranial pressure, associated with a poor prognosis. The hallmarks of the Cushing response are:
  - bradycardia
  - hypertension
  - decreased and erratic respiration.

Basic medical management for severe head injuries includes:

- Intubation and ventilation, producing normocapnia (pCO_2 in the range 4.5–5 kPa, if it is possible to monitor this). This will reduce both intracranial blood volume and intracranial pressure temporarily.
- Sedation with possible paralysis provided that the airway is fully protected by intubation and a means of assisted ventilation present.
- Moderate IV fluid input with diuresis: do not overload.
- Nursing with the head up at an angle of 20 degrees.
- Prevention of hyperthermia/fever.
- Avoidance of hypoglycaemia and electrolyte abnormalities.

Chest trauma

The majority of chest injuries result from blunt trauma, and are usually associated with injuries in other organ systems.

Approximately 25% of deaths due to trauma are attributed to chest injury. Immediate deaths are essentially due to major disruption of the heart or of the great vessels. Early deaths due to chest trauma include airway obstruction, tension pneumothorax, cardiac tamponade or aspiration.

The majority of patients with thoracic trauma can be managed by simple manoeuvres and do not require surgical treatment.

Respiratory distress may be caused by:

- rib fractures/flail chest
- pneumothorax
- tension pneumothorax
- haemothorax
- pulmonary contusion (bruising)
- open pneumothorax
- aspiration.

Haemorrhagic shock may be due to:

- haemothorax
- haemomediastinum.

The increased compliance of the chest wall in the child is protective, but can make interpretation of the severity of injury difficult. Rib fractures are uncommon in the infant or child, but indicate that significant blunt force has been applied. Moreover, serious chest injury can occur without obvious external signs of trauma. The energy that is not dissipated in breaking the elastic ribs may be transferred to the lungs, to be manifested as pulmonary contusion. Respiratory failure can occur quickly in infants and young children with chest trauma, yet the majority of chest injuries require no more than the insertion of an intercostal drain.

- Thorough re-examination of the chest front and back, using the classical **inspection–palpation–percussion–auscultation approach**, is combined with a chest X-ray.
- Particular attention is directed to the symmetry of chest movement and breath sounds, the presence of surgical emphysema and pain, or instability on compressing the chest.
- Tracheal deviation and altered heart sounds are noted.
- On log-rolling the child, **it is important to reconsider flail chest**, as a posterior floating segment is often poorly tolerated in children.

Rib fractures

Fractured ribs may occur at the point of impact, and damage to the underlying lung may produce lung bruising or puncture. The ribs usually become fairly stable within 10 days to 2 weeks. Firm healing with callus formation is seen after about 6 weeks.

Flail chest

The unstable segment moves separately and in an opposite direction from the rest of the thoracic cage during the respiration cycle. Severe respiratory distress may ensue. Treatment is by analgesia, as breathing is painful, and shallow breathing may predispose to pneumonia in this situation. In severe cases, ventilation is needed in children but not usually in adults.

Pneumothorax

- A **tension pneumothorax** develops when air enters the pleural space but cannot leave, increasing the compression of the underlying lung with each breath. The consequence is progressively increasing intra-thoracic pressure in the affected side, resulting in mediastinal shift. The trachea may be displaced (late sign) and is pushed away from the midline by the air under tension. The patient will become short of breath and hypoxic. Urgent needle decompression (thoracocentesis) is required prior to the insertion of an intercostal drain.
- A **simple pneumothorax** can be diagnosed by X-ray or ultrasound scanning and, although not life-threatening, may be associated with significant underlying lung injury. All traumatic pneumothoraces **require close observation**. Small ones often absorb spontaneously, but larger ones frequently require chest drainage.
- **Open pneumothoraces**, or sucking chest wounds, allow bidirectional flow of air through a chest wall defect. The lung on the affected side is exposed to atmospheric pressure with lung collapse and a shift of the

mediastinum to the uninvolved side. This must be treated rapidly. In compromised patients, intercostal drains, intubation and positive pressure ventilation are often required. Alternatively, they can be treated by applying an occlusive dressing, taped on three sides to serve as a flap valve, followed by insertion of a chest drain remote from the site of injury. A better dressing is the customised Asherman chest seal, which consists of an adhesive ring, similar to that on a colostomy stoma bag, which projects into a pipe-shaped flap valve, resembling that in a Heimlich valve. **Beware of the possibility of a tension pneumothorax developing when one of these is used.**

Pulmonary contusion

This is usually caused by blunt trauma, and may occur in association with rib fractures with or without a flail segment. It is common after chest trauma, and is a potentially life-threatening condition. The onset of symptoms may be slow, progressing over 24 hours post-injury. Pulmonary contusion is likely to occur in cases of high-speed accidents, falls from great heights, and injuries by high-velocity bullets.

Symptoms and signs include:

- dyspnoea
- cyanosis
- sparse or absent breath sounds
- hypoxaemia
- tachycardia.

Treatment involves supplemental oxygen, careful fluid management and particular attention to pain relief. Endotracheal intubation may be necessary in severe cases.

Traumatic haemothorax

This is more common in penetrating than in non-penetrating injuries to the chest. If the haemorrhage is severe, hypovolaemic shock will occur, and also respiratory distress due to compression of the lung on the involved side.

Optimal therapy consists of the placement of a large chest tube and the concomitant replacement of lost blood. In some instances where the bleeding continues and is significant, open chest surgery is necessary to stop the bleeding (see below).

- A haemothorax of 500–1500 mL in pregnancy, or 10–30 mL/kg in a child, that stops bleeding after insertion of an intercostal catheter, can generally be treated by closed drainage alone
- A haemothorax of greater than 1500–2000 mL in pregnancy, or > 30 mL/kg in a child, with continued bleeding of more than 200–300 mL per hour in pregnancy or > 5 mL/kg per hour in a child, is an indication for further investigation e.g. thoracotomy.

The injuries listed below are also possible in severe trauma, but carry a high mortality even in regional centres.

1. **Myocardial contusion:** This is associated, in blunt chest trauma, with fractures of the sternum or ribs. The diagnosis is supported by abnormalities on ECG and elevation of serial cardiac enzymes (if available). Cardiac contusion can simulate a myocardial infarction. The patient must be closely observed, with cardiac monitoring (if available). This type of injury is more common than is often realised, and may be a cause of sudden death some time after the accident.
2. **Pericardial tamponade:** Penetrating cardiac injuries are a leading cause of death in young men in some notorious urban areas, but rare in other settings. It is rare to have pericardial tamponade with blunt trauma. Pericardiocentesis must be undertaken early if this injury is considered likely (*see* Section 8.4.B for method). Look for pericardial tamponade in patients with:
   - shock
   - distended neck veins
   - no pneumothorax
   - muffled heart sounds.
3. **Thoracic great vessel injuries:** Injury to the pulmonary veins and arteries is often fatal, and is one of the major causes of on-site death.
4. **Rupture of the trachea or major bronchi:** This is a serious injury with an overall estimated mortality of at least 50%. The majority (80%) of the ruptures of bronchi are within 2.5 cm of the carina.

   The usual signs of tracheobronchial disruption are:
   - haemoptysis
   - dyspnoea
   - subcutaneous and mediastinal emphysema
   - occasionally cyanosis.

Trauma to the oesophagus

This is rare in patients with blunt trauma, and more frequent in association with penetrating injury. It is lethal if unrecognised, because of mediastinitis. Patients often complain of sudden sharp pain in the epigastrium and chest, with radiation to the back. Dyspnoea, cyanosis and shock occur, but these may be late features. Urgent IV broad-spectrum antibiotics covering both aerobic and anaerobic organisms, as well as nil-by-mouth nursing, are required.

Diaphragmatic injuries

These may occur in association with either blunt or penetrating chest trauma, paralleling the rise in frequency of road traffic accidents. The diagnosis is often missed.

Diaphragmatic injuries should be suspected in any penetrating thoracic wound which is:

- below the fourth intercostal space anteriorly
- below the sixth interspace laterally
- below the eighth interspace posteriorly.

These injuries are more commonly seen on the left side.

Thoracic aorta rupture

This occurs in patients who are exposed to severe decelerating forces, such as high-speed car accidents or a fall from a great height. It has a very high mortality due to rapid exsanguination; the total adult blood volume of 5 litres may be lost in the first minute following injury.

Abdominal trauma

Abdominal injuries are common and, if unrecognised, may prove fatal. Any patient involved in any serious accident should be considered to have an abdominal injury until it has been ruled out.

Severe visceral injuries occur more frequently in children than in adults especially to the liver because of its relative size and lack of protection by the ribs in the young child.

Unexplained blood loss evident during the primary assessment may be due to intra-abdominal haemorrhage.

The abdomen is a classical silent area after trauma. It has to be actively cleared of injury rather than simply noted to be soft and non-tender, especially in the face of altered consciousness.

Cardiovascular decompensation may occur late and precipitously.

The organ most commonly injured in penetrating trauma is the liver, and in blunt trauma the spleen is often torn and ruptured. This is especially the case in children, in whom these organs are poorly protected by ribs and muscles, and especially where chronic illness may cause enlargement and fragility of the liver and spleen.

Thorough history taking and a careful examination of the abdomen may give clues to the origin of bleeding or perforation.

Gastric distension may cause respiratory embarrassment, and a gastric tube should be placed.

In order to gain the cooperation of a frightened child, place the examiner's hand over the mother's hand to undertake palpation.

There are two basic categories of abdominal trauma:

1 **Penetrating trauma**, where the need for surgical consultation is urgent. For example:
   - gunshot
   - stabbing.
2 **Non-penetrating trauma.** For example:
   - compression injuries
   - crushing injuries
   - seat-belt injuries
   - acceleration/deceleration injuries.

About 20% of trauma patients with acute haemoperitoneum have no signs of peritoneal irritation at the first examination, and **repeated primary assessment** must be undertaken.

Blunt trauma can be very difficult to evaluate, especially in the unconscious patient. These patients may need a peritoneal lavage although where ultrasound and/or abdominal CT is available, peritoneal lavage has been superceded. However, an exploratory laparotomy may be the best definitive procedure if abdominal injury needs to be excluded.

Complete physical examination of the abdomen includes rectal examination (although this should be avoided in children as a routine, and only performed if clinically indicated), assessing:

- sphincter tone
- integrity of the rectal wall
- blood in the rectum
- prostate position in adults.

Remember to check for blood at the external urethral meatus.

Women and girls of childbearing age should be considered pregnant until pregnancy has been excluded. The fetus may be salvageable, and the best treatment of the fetus is resuscitation of the mother. A pregnant mother at term, however, can usually be resuscitated properly only after delivery of the baby. This difficult situation must be assessed at the time (*see* Section 1.13).

The diagnostic peritoneal lavage (DPL) may be helpful for determining the presence of blood or enteric fluid due to intra-abdominal injury. The results can be highly suggestive, but it is overstated as an important diagnostic tool. If there is any doubt, a laparotomy is still the gold standard.

The indications for DPL include:

- unexplained abdominal pain
- trauma of the lower part of the chest
- hypotension, and a fall in haematocrit with no obvious explanation
- any patient with abdominal trauma who has an altered mental state
- any patient with abdominal trauma and spinal cord injuries
- pelvic fractures.

The relative contraindications to DPL are:

- pregnancy
- previous abdominal surgery
- operator inexperience
- if the result would not change your management (e.g. if laparotomy is planned).

Other specific issues with regard to abdominal trauma

- **Pelvic fractures** are often complicated by massive haemorrhage and urological injury.
- It is important to examine the rectum for the presence of blood and for evidence of rectal or perineal laceration (see above for the approach in children).
- X-ray of the pelvis may be valuable, if clinical diagnosis is difficult.

The management of pelvic fractures includes:

- resuscitation (ABC)
- transfusion
- immobilisation and assessment for surgery
- analgesia.

In a severely injured child, a urinary catheter should be inserted. This may be omitted in small babies and in less severely injured children. Small boys are particularly prone to urethral stricture after catheterisation. If the mechanism of injury is of concern, it is important to exclude renal tract injury by examining the first urine for red blood cells.

Management of severe abdominal injury

Abdominal ultrasound (and CT scanning, if available) have become invaluable adjuncts to the secondary assessment, not only for diagnosing intra-abdominal injury, but also for monitoring progress when a defined injury is being managed conservatively.

Bleeding from solid organs may not show up immediately in the resuscitation room, and evidence of hollow-organ rupture may take 24 hours or more to show as free fluid on ultrasound. This commits the trauma team to a high index of suspicion well beyond the classical 'golden hour'. This phrase indicates the importance of prompt identification and resuscitation of Airway, Breathing or Circulation problems that, without intervention, would lead to further damage from hypoxia and hypovolaemia being suffered by the injured patient.

Patients with refractory shock, penetrating injuries or signs of perforation require laparotomy.

Other injuries may be managed conservatively. After initial fluid transfusion, an experienced surgeon may decide that bleeding from an injured spleen, liver or kidney does not require immediate operative intervention. **CT scanning (if available) is an invaluable aid to decision making.**

Splenic injury is relatively common, and can occur after relatively minor trauma, especially if the spleen is enlarged following an inflammatory process or infection, notably malaria. Signs include left upper quadrant pain and tenderness, with referred pain to the shoulder tip. Non-operative management is used frequently in many centres, but long-term problems of splenectomy are insignificant by comparison with the potential consequences of inadequate supervision of conservative management which requires careful monitoring and fluid management with on-site, round-the-clock theatre, anaesthetic and surgical availability: all of which are difficult to provide in a low resource setting.

Increasingly, **liver injuries** are also being managed conservatively. Unlike the relatively straightforward operation of splenectomy, operative liver repair or resection is hazardous, and packing plays a major role in the operative management of uncontrolled hepatic bleeding.

Injuries to the retroperitoneal organs, such as the kidneys or pancreas, may present with vague or atypical signs, again requiring a high index of suspicion. A significant kidney injury does not always cause demonstrable haematuria.

Ultrasound studies and dynamic contrast CT scans (if available) **may** provide valuable information on renal structure and function, but false-negative results commonly occur. Intravenous urography remains useful for demonstrating the details of renal and ureteric injury, especially in centres without a CT scanner. Pancreatic injury may occur with a normal amylase level, and the amylase level may be raised in the absence of pancreatic damage.

Spinal trauma (*see* Section 4.2.D)

Management of spinal cord injuries is particularly difficult in resource-limited settings, where spinal surgery may not be available within the country. Usually patients in these settings have not been handled carefully during transport from the site of injury to the hospital. Decisions have to be made as to whether or not cervical spinal immobilisation is appropriate, especially if it could interfere with airway resuscitation.

Spinal injury should be ruled out in any patient who has been subject to a mechanism of injury capable of damaging the spine. This seemingly obvious statement highlights the fact that it is often surprisingly difficult to ascertain whether there has been an injury to the spine or not, particularly in the face of a concomitant head injury, or in a child who is too young to communicate.

Even in an alert older child, distracting pain from a limb injury may lead the patient to ignore and deny neck pain, even when a spinal fracture exists. Radiological clearance in children is further complicated by the difficulty of interpreting X-rays of immature bones (*see* Section 7.3.B), and by the relative laxity of ligaments, which gives rise to pseudo-subluxation.

Be aware of the significant incidence of spinal cord injury without radiological abnormality (SCIWORA) in children.

Spinal injury is less common in children than in adults, partly because of the elasticity of the bones and ligaments. This same elasticity contributes to the different patterns of spinal injury that are seen. In the cervical spine, for example, injuries tend to occur at a higher level than in adults, and often span several segments rather than dissipating energy in fracturing a single vertebra.

Examination of potentially spine-injured patients must be carried out with the patient in the neutral position (i.e. without flexion, extension or rotation), and without any movement of the spine.

The patient should be:

- log-rolled
- properly immobilised (using in-line immobilisation, a stiff neck cervical collar or sandbags)
- transported in the neutral position.

With vertebral injury (which may overlie spinal cord injury), look for:

- local tenderness
- deformities, as well as (for a posterior spinal cord injury) oedema.

Clinical findings pointing to injury of the cervical spine include:

- difficulties in respiration (diaphragmatic breathing; check for paradoxical breathing)
- flaccidity, with no reflexes (check the rectal sphincter)
- hypotension with bradycardia (without hypovolaemia).

The entire spine should be palpated during a log-roll, when the patient is turned on to their side in a controlled way, keeping the spine in line. The presence of palpable steps, bogginess or tenderness should be noted. The limbs should be examined for sensory and motor signs of focal or segmental deficit.

Neurological assessment

Assessment of the level of injury must be undertaken. If the patient is conscious, ask him/her questions relevant to their sensation, and ask them to try to make minor movements, to enable you to assess motor function of the upper and lower extremities.

Key reflex assessment to determine the level of the lesion is summarised below.

Motor response

Diaphragm intact level	C3, C4, C5
Shoulder shrug	C4
Elbow flexion (biceps)	C5
Wrist extension	C6
Elbow extension	C7
Wrist flexion	C7
Abduction of fingers	C8
Active chest expansion	TI-T12
Hip flexion	L2
Knee extension	L3-L4
Ankle dorsiflexion	L5-S 1
Ankle plantarflexion	S1-S2

Sensory response

Anterior thigh	L2
Anterior knee	L3
Anterolateral ankle	L4
Dorsum great and 2nd toe	L5
Lateral side of foot	SI
Posterior calf	S2
Peri-anal and perineal sensation	S2-S5

If no sensory or motor function is exhibited, with a complete spinal cord lesion, the chance of recovery is small.

A diaphragmatic breathing pattern, bradycardia, hypotension, peripheral vasodilatation and priapism suggest spinal cord injury.

Throughout the primary and secondary assessments, precautions for spinal protection should ideally be maintained, using a hard collar and side-supports (blocks and straps or sandbags and tape), except for airway procedures and local examination, when manual in-line immobilisation is reinstituted.

If the patient is alert, able to communicate clearly and has no distracting pain from another injury, the spine can be cleared clinically without resorting to X-rays. Otherwise, ideally spinal precautions are maintained until radiological clearance is achieved and the patient is re-examined.

If possible, three X-rays of the cervical spine should be taken: cross-table lateral view with arm traction to reveal the C7-T1 interface; antero-posterior view and transoral odontoid peg view. These must be assessed by an experienced professional (if available), paying particular attention to the soft tissues as well as the bony structures (*see* Section 7.3.B).

If the mechanism of injury warrants it, thoracic and lumbar views are also required.

If the lower cervical spine is not adequately visualised on the lateral view, oblique views are requested. If the X-rays are inadequate or show suspicious areas, CT scanning (if available) is recommended to confirm or exclude a fracture. The MRI scan provides a better examination of neural, ligamentous and other soft tissues, although its sensitivity reveals minor as well as major tissue injury, making interpretation more difficult. It remains expensive and is not universally available. The MRI scanner is a frightening environment for an unsedated child, and the powerful magnetic field creates challenging logistical problems for the monitoring equipment applied to the patient.

Other neurological injuries include damaged nerves to fingers and the brachial plexus.

Pelvic trauma

Pelvic injury remains a potentially life-threatening injury, especially if it is associated with a large retroperitoneal haematoma, or if the fracture site communicates with the rectum. External fixation of the pelvis may be valuable in controlling major venous haemorrhage.

Arterial bleeding may be controlled by embolisation (if available).The suitability of these techniques depends on the particular configuration of the fracture. It may be difficult to distinguish retroperitoneal haemorrhage from intraperitoneal haemorrhage, the latter requiring laparotomy.

In the absence of suitable equipment, tight compressive binding of the pelvis may help bleeding vessels to clot, although this is not practical in the presence of advanced pregnancy.

The purpose of pelvic binding is to reduce the volume of the pelvis thus tamponading any haemorrhage, as well as providing biomechanical stabilisation. This can be achieved by wrapping a folded sheet around the pelvis. The sheet should centre on the greater trochanters and extend to the iliac crests. Taping the thighs or the feet together also helps maintain the anatomical position of the pelvis.

Not all pelvic trauma is serious. Some pubic rami fractures are minor injuries, with little intervention required. Nevertheless, the pelvis is a ring structure that tends to break in two places. On inspecting the pelvic X-ray, careful attention should be paid to the sacro-iliac joints and sacral foramina, to seek subtle evidence of a second break in the ring.

Limb trauma

In general, limb fractures in children are more likely to be managed conservatively than those in adults, reflecting the child's capacity to heal, and the risk of interfering with growth plates. An understanding of the Salter–Harris classification of epiphyseal fractures is essential, and access to a radiological atlas of developmental stages is helpful (*see* Section 7.2).

Examination must include:

- skin colour and temperature
- distal pulse assessment
- grazes and bleeding sites
- limb's alignment and deformities
- active and passive movements
- unusual movements and crepitation
- the severity of pain caused by injury.

Management of extremity injuries

Aim to:

- keep blood flowing to peripheral tissues
- prevent infection and skin necrosis
- prevent damage to peripheral nerves.

Special issues relating to limb trauma

Stop active bleeding by applying direct pressure, rather than by using a tourniquet, as the latter can be left on by mistake, and this can result in ischaemic damage.

Open fractures

Any wound situated in the vicinity of a fracture must be regarded as a communicating one.

Principles of the treatment are to:

- stop external bleeding
- immobilise, and relieve pain.

Amputated parts of extremities (such as fingers) should be covered with sterile gauze towels which are moistened and put into a sterile plastic bag. A non-cooled amputated part may be used within 6 hours after the injury, and a cooled one as late as 18–20 hours after it. This practice is only worthwhile if facilities for reimplantation are available.

Early fasciotomy

Compartment syndrome is fairly common, and often underestimated. This condition is caused by an increase in the internal pressure of fascial compartments, which may result from crush injuries, fractures, intramuscular haematomas or amputations. This causes compression of vessels, with resultant hypoperfusion and hypoxia of tissues, including peripheral nerves.

Compartment syndrome is recognised by the following signs in a fractured or otherwise injured limb:

- pain, accentuated by passive stretching of the involved muscles
- decreased sensation
- swelling

- limb pallor
- limb paralysis
- absence of limb pulse.

The final result of this compartment syndrome is ischaemic (or even necrotic) muscles with restricted function.

Fasciotomy involves cutting the fascial bands around the affected muscle to release the pressure within the compartment, allowing the tissues to re-perfuse. The procedure requires a good knowledge of the relevant anatomy, and is usually performed by an orthopaedic surgeon.

Special issues with regard to major trauma in pregnancy

Road traffic accidents are the most common cause of major trauma in pregnancy. Intimate partner violence starts or increases during pregnancy, and 40% of women who are murdered are killed by a current or former partner.

Anatomical and physiological changes of pregnancy and the management of trauma

The anatomical and physiological changes that occur in pregnancy are extremely important in the assessment and resuscitation of the pregnant trauma patient.

Anatomical changes

- As the uterus increases in size during pregnancy, it becomes more vulnerable to damage by both blunt and penetrating injury. Before 12 weeks of gestation it is protected by the bony pelvis, but thereafter it is an abdominal organ. The uterine fundus reaches the umbilicus at 20 weeks, and the xiphisternum at 36 weeks.
- In the first trimester, the fetus is well protected by the thick-walled uterus and relatively large amounts of amniotic fluid. As the pregnancy progresses, the uterine wall becomes thinner, providing less protection for the fetus.
- In late pregnancy, the uterus and its contents shield the maternal abdominal contents, providing a degree of protection for the maternal viscera, at the expense of fetal well-being.

Physiological changes in pregnancy

These include the following:

- increased tidal volume
- blood volume increases by 40% to 100 mL/kg
- basal heart rate increases to 85–90 bpm
- 30% increased cardiac output
- a fall in blood pressure of 5–15 mmHg
- aortocaval compression as the uterus increases in size from 20 weeks' gestation, with the potential for reduced cardiac output
- upward displacement of the diaphragm as the uterus increases in size, with an impact on lung volume, and predisposing to gastro-oesophageal reflux.

Special issues in the traumatised pregnant woman or girl

Blunt trauma may lead to:

- haemorrhage from abdominal organs, notably the spleen and liver
- uterine irritability and premature labour
- partial or complete uterine rupture
- partial or complete placental separation (up to 48 hours after trauma)
- fetal death
- fetal distress.

Pelvic fractures may be associated with severe blood loss.

What are the priorities?

- Assessment and resuscitation according to the ABC and neurological failure structured approach.
- Resuscitation in the left lateral position after 20 weeks' gestation, to avoid aortocaval compression: remember the **left lateral tilt**.
- Assessment of fundal height and tenderness, and fetal heart rate monitoring as appropriate.
- Vaginal examination or speculum examination to assess vaginal bleeding, cervical dilatation and rupture of membranes.

If placenta praevia is known or suspected, digital vaginal examination should **not** be performed, as major haemorrhage may occur. Careful speculum examination is acceptable.

It is important to be alert to signs of hypovolaemia, which are delayed in pregnancy as the mother has a higher circulating volume. Hypovolaemia may compromise the fetus before the mother's vital signs become abnormal. A fall in maternal blood pressure is a late and ominous sign.

Resuscitation of the mother may save the baby as well. There are times when the mother's life is at risk and the fetus may need to be delivered in order to save the mother.

Action plan

1. Call for the most senior help available.
2. Perform standard primary assessment and resuscitation.
3. In addition:
    - Assess fetal well-being. Use ultrasound examination to detect the fetal heart rate and to identify any retroplacental or intra-abdominal bleeding. Ultrasound is also useful for ascertaining the presentation of the fetus; transverse lie may suggest rupture of the uterus.
    - Consider whether Caesarean section is indicated for maternal or fetal reasons.

Indications for Caesarean section (if facilities are available to perform it safely)

These include the following:

- cardiac arrest
- uterine rupture
- inadequate exposure during laparotomy for other abdominal trauma
- placental abruption
- an unstable pelvic or lumbo-sacral fracture with the patient in labour
- fetal distress with a viable fetus.

Peri-mortem Caesarean section

This should be undertaken when maternal cardiac output has not been restored by initial cardiopulmonary resuscitation (CPR). Delivery should ideally be accomplished within 5 minutes of cardiac arrest.

The rationale behind peri-mortem Caesarean section is as follows:

- improvement in maternal cardiac output due to relief of aortocaval compression
- improvement in maternal oxygenation
- greater efficacy of CPR due to better access
- better chance of fetal survival if in third trimester.

Peri-mortem Caesarean section should be undertaken with a left lateral tilt of 15–30 degrees, or preferably with manual displacement of the uterus. CPR should continue throughout, until cardiac output is restored. The operation should take place at the scene of cardiac arrest, rather than after moving the patient to the operating theatre, which wastes precious time. Blood loss is minimal until cardiac output resumes. The woman can be moved to the operating theatre once cardiac output is restored. The fetus may survive, but this is a secondary consideration. The aim of peri-mortem Caesarean section is to save the mother's life, as resuscitation is more likely to be effective if the gravid uterus is emptied.

Secondary assessment

Left lateral tilt should be maintained throughout the assessment, in order to minimise aortocaval compression. If spinal injury is suspected, manual displacement of the uterus should be undertaken instead.

Specific types of trauma

Blunt trauma

The three commonest causes are road traffic accidents, falls and intimate partner violence.

Uterine rupture due to blunt trauma is relatively rare.

Blunt trauma to the abdomen may cause placental abruption. Kleihauer testing, if available, is useful for detecting feto–maternal haemorrhage as an indicator of placental damage. Detection of intra-abdominal haemorrhage may be difficult in pregnancy, so laparotomy should be considered. Remember that the mother may lose a third of her blood volume before the vital signs become abnormal.

Penetrating abdominal wounds

Knife and gunshot wounds are the most common. Penetrating injuries can cause uterine injury at any stage of pregnancy. The uterus, fetus and amniotic fluid reduce injury to the mother by absorbing energy and displacing bowel upwards and to the side. Penetrating injuries above the uterus may cause extensive gastrointestinal and vascular damage. Exploratory laparotomy is usually required in the management of penetrating abdominal wounds, in pregnancy as in the non-pregnant patient.

Thoracic trauma

Injury to major thoracic structures is particularly dangerous in pregnancy, due to the combination of pre-existing relative aortocaval compression, reduced respiratory excursion and increased oxygen requirement. However, most injuries can be identified by careful assessment, and managed with simple measures, including left lateral tilt and facial oxygen.

Pathway of care: trauma in pregnancy.

Primary assessment and resuscitation	**Airway:** increased risk of aspiration – early gastric tube
	Breathing: if chest drain is needed, place at higher level (3rd or 4th intercostal space)
	Circulation: left lateral tilt Abnormalities in pulse rate, blood pressure and capillary refill are late because of hypervolaemia of pregnancy 'Targeted resuscitation' with IV crystalloids, colloid or blood
	Neurological failure: convulsions may be due to eclampsia as well as head injury

Secondary assessment and emergency treatment:

Assess for:

- Ruptured uterus and placental abruption after blunt trauma to abdomen (including seat-belt injury). Uterine tenderness, vaginal bleeding, shock all occur. They may be indistinguishable clinically. Scan may show fetal death or intra-abdominal fluid (blood)
- Rupture of membranes (by speculum)
- Fetal distress

Evidence of intra-abdominal bleeding or injury to abdominal organs

Consider bowel injury (compressed by uterus and therefore more vulnerable to blunt trauma or penetrating injuries)

Ensure anti-tetanus measures

X-rays as needed

On discharge from hospital, patient to report abdominal pain, decreased fetal movements, vaginal bleeding or fluid leakage

Special issues with regard to major trauma in children

Trauma is a leading cause of death for all children, with a higher incidence in boys. The survival of children who sustain major trauma depends on the severity of the trauma, effective pre-hospital care and early resuscitation.

The initial assessment of the paediatric trauma patient is identical to that of the adult. The first priority is the Airway, Breathing and Circulation, then early neurological assessment, and finally exposing the child for full examination, without loss of heat.

TABLE 7.3.A.5 Paediatric 'normal' values are helpful as follows:

Variable	< 1 year	1–2 years	2–5 years	5–12 years	> 12 years
Respiratory rate (breaths/minute)	30–40	25–35	25–30	20–25	15–20
Heart rate (beats/minute)	110–160	100–150	95–140	80–120	60–100
Systolic blood pressure (mmHg) 50th centile	80–90	85–95	85–100	90–110	100–120

Specific resuscitation and intubation issues in children

- The head, tongue and nasal airway are relatively large.
- The angle of the jaw is greater, the larynx is higher and the epiglottis is proportionally larger and more 'U' shaped.
- The cricoid is the narrowest part of the larynx, which limits the size of the endotracheal tube. By adulthood, the larynx has grown and the narrowest part is at the cords.
- Obligatory nose breathing occurs in small babies.
- The trachea in the full-term newborn is about 4 cm long, and will admit a 2.5 or 3.5 mm diameter endotracheal tube. (The adult trachea is about 12 cm long.)
- Gastric distension is common following resuscitation, and a nasogastric tube is useful for decompressing the stomach.

If tracheal intubation is required, avoid using cuffed tubes in children under 10 years of age, so as to minimise subglottic swelling and ulceration. Oral intubation is easier than nasal intubation for infants and young children.

Shock in the paediatric patient

The femoral artery in the groin and the brachial artery in the antecubital fossa are the best sites at which to palpate pulses in the child. If the child is pulseless, cardiopulmonary resuscitation should be commenced.

Signs of shock in paediatric patients include:

- tachycardia
- weak or absent peripheral pulses
- capillary refill time > 3 seconds
- tachypnoea
- agitation
- drowsiness
- poor urine output.

Hypotension is a late sign, even in the presence of severe shock.

A normal urine output is 1–2 mL/kg/hour for the infant and 0.5–1 mL/kg/hour in the older child.

Hypothermia is a major problem in children because of their relatively large surface area. They lose proportionally more heat through the head. All fluids should be warmed. Exposure of the child is necessary for assessment, but cover them as soon as possible.

Continuing care for patients who have suffered major trauma

Tetanus prophylaxis

This is often forgotten in the management of severe trauma. In the fully immunised patient, an additional booster will depend on a clinical decision as to the possibility of exposure to contamination, the severity of injury and the timing of the last tetanus immunisation. In an unimmunised or incompletely immunised patient, tetanus immunoglobulin should be given and a full course of or a completing course of tetanus toxoid started (using a different limb to the one receiving the immunoglobulin).

Guidance on tetanus-prone wounds

These include the following:

- compound fractures
- deep penetrating wounds
- wounds containing foreign bodies (especially wood splinters)
- wounds complicated by pyogenic infections
- wounds with extensive tissue damage (e.g. crush injuries, contusions or burns)
- any wound that is obviously contaminated with soil, dust or horse manure (especially if topical disinfection is delayed for more than 4 hours).

TABLE 7.3.A.6 Guidance on the use of tetanus immunoglobulin and tetanus toxoid

History of tetanus vaccination		Type of wound	Tetanus vaccine booster (see below)	Tetanus immunoglobulin
≥ 3 doses	< 5 years since last dose	All wounds	No	No
	5–10 years since last dose	Clean minor wounds	No	No
		All other wounds	Yes	No
	> 10 years since last dose	All wounds	Yes	No
< 3 doses or uncertain		Clean minor wounds	Yes	No
		All other wounds	Yes	Yes

Transfer

Not every hospital has the resources and expertise to safely care for injured pregnant women or girls and children. Ideally, children with serious injuries should be transported directly from the scene of the accident to a centre with such capability (if one exists in the country). Even then, geographical constraints may render transfer unsafe.

Patients should be transported only if they are going to a facility that can provide a higher level of care.

Even when the transfer is urgent, it is essential to achieve physiological stability before embarking on a hazardous journey in the isolated environment of the ambulance. There is always physiological deterioration during transfer. Thorough assessment should take place prior to transfer, to exclude coexisting life-threatening conditions which may be amenable to treatment on site. For example, a child with a head injury should not be transferred in a hypotensive condition caused by unrecognised and untreated intra-abdominal bleeding.

It is essential that there is effective communication with:

- the receiving centre
- the transport service
- escorting personnel
- the patient and their relatives.

Communication between the referring and admitting clinicians is necessary, not only to agree that transfer is indicated, but also to establish guidelines for care in transit, and to warn the receiving centre when the patient is expected to arrive.

Effective stabilisation necessitates:

- prompt effective initial resuscitation
- control of haemorrhage and maintenance of the circulation
- immobilisation of fractures
- analgesia.

If the patient deteriorates, re-evaluate them by using the primary assessment, checking and treating life-threatening conditions, and then make a careful assessment focusing on the injuries area.

Inter-hospital transfer requires careful planning, to provide:

- trained medical and nursing escorts
- simple compact robust equipment
- drugs for resuscitation, sedation, pain relief and muscle relaxation
- fluids and blood products if indicated
- a suitable vehicle and ambulance staff.

In trauma care, some transfers are time-limited (e.g. to evacuate an extradural haematoma). In such cases, the extra time taken for a retrieval team to reach the referring hospital may offset the benefit of their specialised skills.

Peri-operative care in major trauma

In the operating theatre, definitive anatomical reduction, repair or resection of individual injuries takes place. While the surgical team focuses on anatomical correction, the anaesthetic team maintains physiological system control. The impetus and sense of urgency evident in the Emergency Department should be maintained, without losing the thoroughness necessary to manage all aspects of care.

If the patient has a significant head injury, the anaesthetic agents should be chosen to avoid increasing intracranial pressure or cerebral blood flow. In general, this means avoiding high doses of volatile agents such as halothane or isoflurane. Ketamine has long been considered to be contraindicated in head injury, although there is recent evidence that challenges this view. It may be the only anaesthetic available.

If the child is undergoing lengthy extracranial surgery in the face of a severe head injury, it is wise to observe the pupils at frequent intervals.

Maintaining the child's core temperature is a key aim during prolonged surgery. Hypothermia impairs platelet function and increases the risk of infection, although it has been claimed to help to preserve brain function in severe head injury.

High-dependency care

In the immediate management of the injured patient, the focus was on physiological assessment and intervention using an ABC structured approach, followed by anatomical assessment and definitive care.

When high-dependency care is instituted, physiological stabilisation again becomes the main concern, although it is important to remain alert to the possibility of any further injuries that were not evident in the secondary assessment. Detailed physiological control is facilitated by monitoring and good nursing.

See Section 1.14 for further information.

Step-down care and rehabilitation

High-dependency care, acute ward care and rehabilitation serve to minimise disability, rather than influence mortality, which is already largely determined by this time. The emphasis shifts towards integration back into normal life, physically and psychologically, although the course may be interrupted by further reconstructive surgery.

7.3.B Emergency trauma radiology

Introduction

Essential initial trauma films to screen for major injuries include the following.

- lateral cervical spine radiograph
- chest X-ray
- pelvic X-ray.

These should only be taken after immediately life-threatening injuries have been identified and treated (resuscitation).

The ABCD approach to X-ray interpretation is as follows:

- **A**dequacy, Alignment and Apparatus.
- **B**ones.
- **C**artilage and soft tissues.
- **D**isc spaces (in the spine), **D**iaphragm (in the chest).

First, all X-ray films should be checked for **adequacy**. Do they include all of the part that needs imaging? Is the film a proper antero-posterior view or is it at an angle? If the film is not of reasonable quality, interpretation is difficult and may be faulty.

Cervical spine

The cervical spine should be immobilised (*see* Section 7.3.A) before any radiology. The standard film is a lateral radiograph, which may be supplemented by an AP (lower cervical spine and odontoid peg views) if appropriate.

Bony injury is not the primary focus in spinal injury. The main concern is to delineate actual or potential injury to the cord, as any unstable fracture, if inadequately immobilised, may lead to progressive cord damage.

A normal lateral cervical X-ray film may be falsely reassuring. The plain film only shows the position of the bones at the time when the film was taken, and gives no idea of the magnitude of flexion and extension forces applied to the spine at the time of injury. **The cord may be injured even in a child without any apparent radiographic abnormality.** This phenomenon is known as SCIWORA (see below).

Unlike adult spine injuries, most paediatric cervical spine injuries occur either through the discs and ligaments, at the cranio-vertebral junction (C1, C2 and C3), or at C7/T1. The relatively large head of the child, moving on a flexible neck with weaker muscles, leads to injury in the higher cervical vertebrae.

Children show three patterns of spinal injury:

1 subluxation or dislocation without fracture
2 fracture with or without subluxation or dislocation
3 spinal cord injury without radiographic abnormality (SCIWORA).

The last of these, SCIWORA, is said to have occurred when radiographic films are completely normal in the presence of significant cord injury. **If the film is normal in a conscious child with clinical symptoms (such as pain, loss of function or paraesthesia in a limb), neck protection measures should be continued.** In an unconscious child at high risk, a cord injury cannot be excluded until the patient is awake and has been assessed clinically, even in the presence of a normal cervical spine film. Adequate spinal precautions should be continued until the child is well enough to be assessed clinically.

The most common site of a 'missed' spinal injury is where a flexible part of the spine meets the fixed part. In the neck these are the cervico-cranial junction and the cervico-thoracic junction.

The whole spine should be viewed from the lower clivus down to the upper body of T1 vertebra.

Alignment

When studying a cervical spine X-ray, look for the four lines shown in Figure 7.3.B.1. These lines should be uninterrupted. It there is a 'step' in any line, the spinal cord is at risk. The cervical immobilisation must be continued and an orthopaedic opinion sought.

The four lines are as follows:

1 anterior vertebral line
2 posterior vertebral line (anterior wall of the spinal canal)
3 facet line
4 spino-laminar line (posterior wall of the spinal canal).

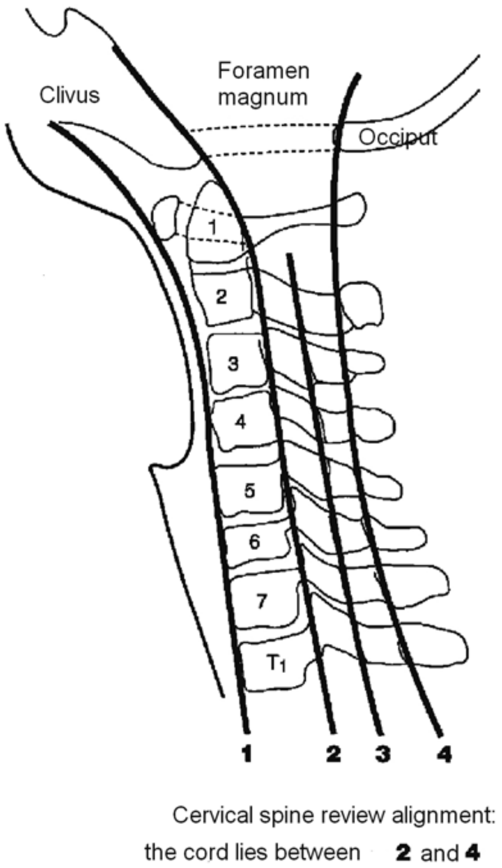

FIGURE 7.3.B.1 Lines to examine on X-ray of the lateral cervical spine.

Figure 7.3.B.2 shows an actual cervical spine X-ray with three of the lines delineated and the odontoid, a facet joint, a spinous process and a lamina identified. The gaps between the adjacent spinous processes and between each facet joint should be similar. Again, any discrepancy is suggestive of a potentially unstable spine.

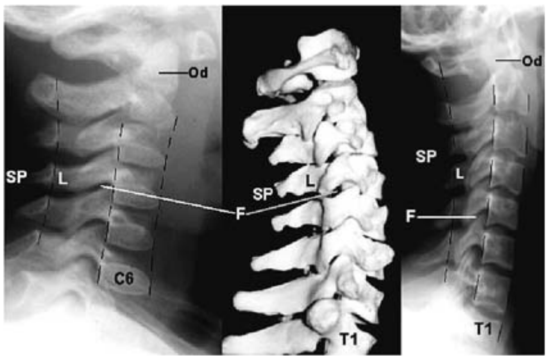

FIGURE 7.3.B.2 X-ray of the lateral cervical spine, showing three of the lines that are indicated in Figure 7.3.B.1. Od, odontoid; F, facet joint; L, lamina; SP, spinous process spaces.

The spinal cord lies in the canal between the posterior vertebral line (2) and the spino-laminar (4) line.

Bones

The outline of each vertebra should be reviewed in turn. Fracture lines going through the cortex, vertebral bodies, laminae or spinous processes should be sought.

The spaces between the facet joints and the gaps between adjacent spinous processes should be similar. The joint between the odontoid peg and the anterior arch of the atlas should be 1–4 mm in a child (*see* Figure 7.3.B.3).

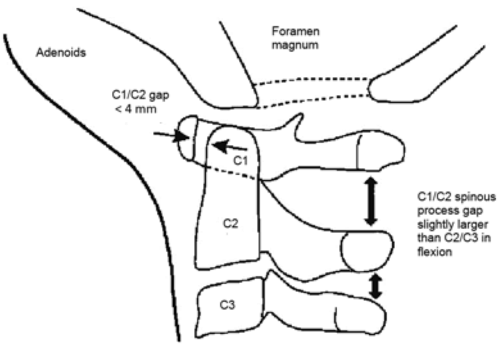

FIGURE 7.3.B.3 C1/C2 anatomy in the older child.

The orientation of the odontoid peg should always be perpendicular to the body of C2.

Cartilage and soft tissues

Abnormal widening of the pre-vertebral soft tissues may indicate a haematoma due to cervical spine injury. However, there may be a significant spinal injury with normal soft tissues. Thus the absence of soft-tissue swelling does not exclude major bony or ligamentous injury. When a child is intubated, it is difficult to assess pre-vertebral soft-tissue swelling. Small children have large adenoids, which are seen as well-demarcated soft tissue swelling at the base of the clivus.

Acceptable soft-tissue thicknesses are as follows:

- above the larynx: less than one-third of the vertebral body width
- below the larynx: not more than one vertebral body width.

Below the level of the larynx, the pre-vertebral soft tissues become progressively **narrower** towards the cervico-thoracic junction (*see* Figure 7.3.B.4). If the pre-vertebral soft tissues are wider at C7 than at the C5 level, this suggests trauma at the C7/T1 level.

FIGURE 7.3.B.4 Lateral cervical spine showing soft tissues.

Any soft-tissue swelling outside these limits should be regarded as abnormal, and neck protection measures maintained until a further clinical opinion can be obtained. In small children the soft tissues may appear abnormally wide if the film is taken with the infant lying in flexion. If in doubt, maintain the neck protection and ask for advice.

Discs

The height of the vertebral disc should be compared from C2/C3 to C7/T1. The discs should all be of similar height, as shown earlier in Figure 7.3.B.1. Any significant discrepancy suggests a crush fracture of the vertebrae (usually caused by a fall from a height).

Flexion and extension cervical spine films should never be performed in the acute trauma situation.

Chest X-ray

Adequacy and alignment

Adequacy can be assessed by evaluating both radiographic penetration and the depth of the patient's inspiration. The film should just show the disc spaces of the lower thoracic vertebrae through the heart shadow. At least five anterior rib ends should be seen above the diaphragm on the right side. If the film is taken in expiration, it may mimic a chest infection. Films are difficult to take in young children, as they are unable to 'hold their breath' on command, so the radiographer has to try to take the picture at the moment of full inspiration.

Alignment can be assessed by ensuring that the medial ends of both clavicles are equally spaced about the spinous processes of the upper thoracic vertebrae. Abnormal rotation may create an apparent mediastinal shift. The trachea should be equally spaced between the clavicles.

Apparatus

Check the position of any apparatus, including the following:

- tracheal tube
- central venous lines
- chest drains.

Misplacement of the endotracheal tube (ETT) into a bronchus should be evident clinically, but may be seen on a chest film if you look for it. Do this first when reviewing any chest X-ray on an intubated patient. Ventilation of only one lung will lead to hypoxia in a compromised patient.

The ideal position for an ETT is below the clavicles and at least 1 cm above the carina. To find the carina, identify the slope of the right and left main bronchi. The carina is where the two lines meet in the midline.

Bones

Look at each rib in detail. This can be done by tracing out the upper and lower borders of the ribs from the posterior costochondral joint to the point where they join the anterior costal cartilage at the mid-clavicular line. The individual internal bone patterns can then be assessed.

The ribs in children are soft and pliable, and only break when subjected to considerable force. Even greater force is required to fracture the first rib or to break multiple ribs. Consequently, the presence of these fractures should stimulate you to look for other sites of injury both inside and outside the chest. Fractures in children's rib bones are hard to see while fresh unless there is displacement. Diagnosis is often made a week or so later if an X-ray is taken then, when the calcifying new callus is seen.

Finish assessing the bones by inspecting the visible vertebrae and the clavicles, scapulae and proximal humeri.

Thoracic spine injuries may be overlooked on a chest radiograph. Abnormal flattening of the vertebral bodies,

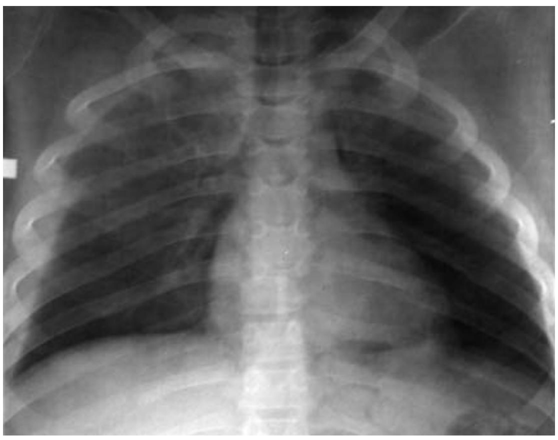

FIGURE 7.3.B.5 Vertical fracture of the thoracic spine.

widening of the disc spaces, or gaps between the spinous processes or pedicles may be seen. On the antero-posterior views, increased vertical or horizontal distances between the pedicles or spinous processes indicate an unstable fracture, as shown in Figure 7.3.B.5.

If there are rib fractures in the first three ribs, these may be associated with major spinal trauma and great vessel injury.

Cartilage and soft tissues

Lungs

In a well-centred film, the lungs should appear equally black on both sides. Compare the left and right lungs in the upper third, middle third and lower third of the chest.

Check that the lungs go all the way out to the rib cage (i.e. that there is no pleural effusion or pneumothorax). A lung that is black on one side may be due to a pneumothorax or air trapping. A lung that is white on one side may be due to collapse, pulmonary haemorrhage, contusion or effusion (including haemothorax).

On the supine film, blood or fluid lies posteriorly, giving a generalised greyness to the lung, rather than the typical meniscus sign seen on the erect film. At the apex of each lung, an effusion displacing the lung downward may indicate spinal injury or major vessel damage.

A suspected tension pneumothorax should be treated clinically in the emergency situation, without confirmatory X-ray.

On a supine film, the air in a simple pneumothorax rises anteriorly and may only be evident from an abnormal blackness or 'sharpness' of the diaphragm or cardiac border. The standard appearances of a pneumothorax, where there is a sharp lung edge and the vessels fail to extend to the rib cage and the lung edges, may not occur in the supine film.

The heart

The cardiac outline should lie one-third to the right of the midline and two-thirds to the left of the midline. If the film is not rotated, which should be checked, mediastinal shift is due to the heart being either pushed from one side or pulled from the other. For example, mediastinal shift to the left may be due to a pneumothorax, air trapping or effusion on the right side, or collapse of the left lung.

All emergency major trauma X-rays are taken in the supine position because of the seriousness of the patient's condition, often using portable X-ray machines. The X-ray tube is near to the patient and the heart is anterior with the film posterior. The heart in this situation appears abnormally magnified (widened), and the cardiothoracic ratio is difficult to assess on supine AP films.

The mediastinal cardiac outline should be clear on both sides. Any loss of definition suggests consolidation (de-aeration) of adjacent lungs. A 'globular' shape to the heart may suggest a pericardial effusion. Tamponade is managed clinically. A cardiac ultrasound scan is useful in equivocal cases.

The upper mediastinum

In the teenager the mediastinum should appear as narrow as in an adult. In children under the age of 18 months, the normal thymus is large, causing a confusing and often 'sail-shaped' upper mediastinal shadow. A normal thymus may touch the right chest wall, left chest wall, left diaphragm or right diaphragm, making it very difficult to exclude mediastinal pathology. Fortunately, mediastinal widening due to aortic dissection or spinal trauma is very rare in small children.

In the older child involved in trauma, mediastinal widening may mean aortic dissection, or major vessel or spinal injury. Ultrasound scanning will be helpful (if available).

Diaphragms

The cardiophrenic and costophrenic angles should be clear on both sides. The diaphragms should be clearly defined on both sides, and the left diaphragm should be clearly visible behind the heart. Loss of definition of the left diaphragm behind the heart suggests left lower lobe collapse, an abnormal hump suggests diaphragmatic rupture, and an elevated diaphragm suggests effusion, lung collapse or nerve palsy.

At the end of the systematic ABCD review of the X-ray, check again in the key areas shown in the following list:

- Behind the heart: left lower lobe consolidation or collapse.
- Apices: for effusions, pneumothorax, rib fractures and collapse or consolidation.
- Costophrenic and cardiophrenic angles: fluid or pneumothorax.
- Horizontal fissure: fluid or elevation (upper lobe collapse).
- Trachea for foreign body (and ETT).

Pelvic X-ray

A single, antero-posterior pelvic view is sufficient.

Adequacy and alignment

It is very important to have the pelvic film positioned as a true antero-posterior (AP) view, as rotation causes interpretation problems. In a true AP film the tip of the sacrum will be aligned with the symphysis pubis.

The whole of the pelvis from the top of the iliac crests to the ischial tuberosities and both hip joints should be seen. The femoral necks shown to the level of the trochanters should be included.

Bones

The pelvis is composed of the sacrum, innominate bones (iliac wings), ischium and pubic bones. These come together to form a Y-shaped cartilage in the floor of the acetabulum. In young children, the joint between the ischium and the pubis (ischiopubic synchondrosis) is commonly seen and may simulate a fracture.

FIGURE 7.3.B.6 Normal pelvis in a young child.

FIGURE 7.3.B.7 Multiple pelvic fractures.

The pelvis is reviewed as a number of rings on the two-dimensional film. These include the pelvic brim, the two obturator rings and both acetabular fossae. The rings should appear smooth and symmetrical in a well-centred film (*see* Figure 7.3.B.6, which shows a normal child pelvis). The femoral necks must be checked for fracture. Figure 7.3.B.7 shows a pelvis with multiple fractures, at major risk of serious pelvic bleeding as large vessels are torn with the force shown by the widespread fractures.

Cartilage and soft tissues

Minor rotation, hip flexion or rotation will distort the fat plane and make assessment of soft-tissue displacement difficult. Abnormal widening of the obturator fat pad may indicate a pelvic side wall haematoma.

The paediatric pelvis is held together by cartilage. Separation through the cartilage of the sacro-iliac joint, the symphysis pubis or the 'Y' cartilage of the acetabular floor may occur without apparent bony injury. Comparison of both hips and sacro-iliac joints on a well-centred film may show this. On a well-centred film the distance between the femoral head and the floor of the acetabulum 'crescent' should be symmetrical – it is abnormal in effusion or dislocation of the hip joint.

7.3.C The child with a head injury

BOX 7.3.C.1 Minimum standards

- ABC and neurology and maintenance of oxygenation and blood pressure with control of environmental temperature while exposing and examining the whole patient.
- Emergency burr-hole by an experienced operator if available.
- Parenteral antibiotics.
- Mannitol or hypertonic saline (2.7% or 3%).
- Anticonvulsants.

Introduction

The primary aim of the management of traumatic brain injury is to prevent secondary brain injury, which results from failure to maintain adequate oxygenation and optimal blood pressure in the head-injured child, in addition to the brain swelling which is the usual response of the child's brain to injury. This aim is made more difficult by the presence of other injuries which may be reducing oxygenation and causing shock. Severity of brain injury in toddlers and children can be measured by using the Glasgow Coma Scale (GCS). The GCS score ranges from 3 to 15. A GCS score of 14–15 is categorised as minor brain injury, a score of 9–13 as moderate brain injury, and a score of 3–8 as severe brain injury.

The GCS is based on eye opening (E), best motor response (M) and verbal response (V).

Scores for best eye response (4)

1 None
2 Eye opening to pain
3 Eye opening to verbal command
4 Eyes open spontaneously

Scores for best verbal response (5)

1 None
2 Incomprehensible sounds
3 Inappropriate words
4 Confused conversation
5 Orientated

Scores for best motor response (6)

1 None
2 Extension to pain (decerebrate)
3 Flexion to pain (decorticate)
4 Withdrawal from pain
5 Localises pain
6 Obeys commands

Children's Coma Scale

Scores for best eye response (4)

1 None
2 Eye opening to pain
3 Eye opening to verbal command
4 Eyes open spontaneously

Scores for best verbal response (5)

1 Alert, babbles, usual words
2 Less than usual words spontaneous irritable cry
3 Cries only to pain
4 Moans to pain
5 No response to pain

Scores for best motor response (6)

1 Spontaneous or obeys verbal command
2 Localises to pain or withdraws to touch
3 Withdraws from pain
4 Abnormal flexion to pain (decorticate)
5 Abnormal extension to pain (decerebrate)
6 No response to pain

Another factor that must be documented is pupillary size and reaction to light. This helps when lateralising brain injury and its progress.

Major diffuse brain injury

Cerebral oedema is the most likely pathological process following serious head injury in children. Intracranial haematomas are quite uncommon in childhood: they are more likely to be found in an adult patient. Even the presence of unequal pupils in a seriously head injured child may be a false localising sign, and does not have the same significance that this sign has in the adult head-injured patient.

The only measures that are of proven value are maintenance of adequate oxygenation and perfusion and the avoidance of adverse effects (see below). Removal of intracranial haematomas, if identified, is very helpful, but this pathology is much less frequently found in the paediatric population, where cerebral oedema predominates. A CT scan (if available) will identify any haematoma. **Artificial ventilation, tracheostomy and more sophisticated medical measures designed to control raised intracranial pressure may be of value, but require evacuation to a fully equipped and staffed children's neurointensive care unit.**

In the absence of such a facility, the best strategy is to concentrate on optimising the care of the unconscious patient with attention to:

- preservation of the airway
- maintenance of adequate ventilation
- avoidance of hypotension by maintaining the circulating volume with normal Ringer-lactate or Hartmann's solution
- the maintenance of appropriate fluid and electrolyte balance, avoiding hypotonic IV fluids, hyponatraemia and hypoglycaemia
- avoidance of fever > 38°C. Use rectal paracetamol: child 1–5 years 125–250 mg/dose up to 4 doses in 24 hours; 5–12 years 250–500 mg/dose maximum 4 doses; 12 years–adult 500 mg/dose maximum 4 doses
- maintaining the patient in a 20-degree head-up position with no neck flexion and with the head in the midline
- if there is deterioration of the GCS score, giving an IV infusion of mannitol 0.25–0.5 g/kg
- mannitol can be repeated later but there is a decreasing response to this treatment. Alternatively, hypertonic saline can be used (2.7% or 3% at a dose of 3 mL/kg). This may not be associated with a 'rebound' brain swelling as occurs with mannitol and does not induce a diuresis like mannitol but rather augments plasma volume
- care of the skin, bladder and bowel.

Fluid restriction is not indicated, but fluid overload should be avoided.

If transfer or evacuation is required within the first 48 hours after injury, endotracheal intubation and mechanical ventilation are desirable. Steroids are of no value and increase the risk of intercurrent infection. Antibiotics are reserved for patients with evidence of sepsis. Anticonvulsant drugs are only given if there are seizures.

Intracranial haematomas

Only 6 in 1000 patients will develop a significant intracranial haematoma following a non-missile head injury. **The most useful guide to the development of an intracranial haematoma is deterioration in the level of consciousness.** The presence of inequality of the pupils will help to identify the lesion. **The ideal investigation is CT (if available).** If CT is not readily available, burr-hole exploration on the same side as the injury as the dilated pupil and the opposite side to any motor weakness is justified in the hope of finding an extradural or subdural clot. **However, burr-holes must only be made by a skilled surgeon using appropriate equipment.**

Emergency temporary reduction of raised intracranial pressure can be achieved by one or more of the following medical measures:

- mannitol 20% by IV infusion over 20 minutes (0.25–0.5 g/kg). This can be repeated as required but response becomes progressively lessened
- Alternatively, hypertonic saline can be used (2.7% or 3% at a dose of 3 mL/kg). This may not be associated with a 'rebound' brain swelling as occurs with mannitol and does not induce a diuresis like mannitol but rather augments plasma volume
- intubation and artificial ventilation to keep $PaCO_2$ around 4 KPa.

An extradural clot will always be beneath the site of trauma. The place to make the burr-hole is therefore at the site of any external site of injury. This may be known from the history, or may be found by shaving the entire scalp in search of bruises, grazes, lacerations or soft-tissue swelling. A plain skull radiograph (if available) may show a fracture, and if so the burr-hole should be made at the site of the fracture. If there are none of the above-mentioned clues, then 'blind' burr-hole exploration will be required. This should commence on the side of the dilated pupil, or on the side of the pupil that dilated first.

Three standard burr-holes can be made: subtemporal, frontal and parietal. It is crucial to make the sub-temporal burr-hole low enough in the middle cranial fossa. The correct position is immediately above the zygoma at the midpoint between the outer canthus of the eye and the external auditory meatus. If an extradural clot is found, the burr-hole must be extended as either a craniectomy or a craniotomy. The margins should extend sufficiently far to uncover the entire clot, which can then be evacuated by suction. Bleeding meningeal arteries can be controlled with diathermy or by under-running with a suture. Bleeding from major venous sinuses can be controlled by haemostatic gauze and by hitching the adjacent dura to the surrounding pericranium with sutures. Diffuse meningeal oozing will stop spontaneously if it is not tampered with; the application of hydrogen peroxide or warm saline packs may help. When the clot has been evacuated and the bleeding has stopped, it is essential to hitch the dura around the perimeter of the bone opening to the adjacent pericranium in order to prevent recurrence. In very young children, it may be better to pass sutures through small drill holes in the surrounding bone. If a craniotomy has been made, the bone flap is replaced.

If no extradural haematoma is found at any of the burr-hole sites, the dura should be opened cautiously. If there is a subdural clot, a craniotomy is necessary. It is safer to make multiple short dural incisions rather than a wide dural opening. It is difficult to be certain whether a tense dura is due to subdural clot or brain swelling. Most acute subdural clots are associated with quite severe brain injury, and a wide dural opening is very likely to be followed by massive uncontrollable extrusion of the brain material.

Post-operatively, anaesthesia can be reversed unless the patient is to be evacuated to another facility. If a significant clot has been found, there should be a prompt improvement in the level of consciousness.

In a baby with severe signs of rapidly progressive raised intracranial pressure following a closed head injury, it is reasonable to search for an acute subdural haematoma by passing an adult (18-gauge) lumbar puncture needle into the subdural space through the anterior fontanelle or through a diastased coronal suture. The baby is wrapped in a sheet and held supine by an assistant so as to secure the head, the arms and the trunk. The entry point is either at the most lateral extremity of the anterior fontanelle or at a point in line with the pupil, whichever is the furthest from the midline. **In a conscious child, local anaesthesia must first be applied.** The needle is passed at a shallow angle, in an anterior direction, through the skin and then through the relatively resistant dura. The trochar is removed from the needle and any subdural fluid allowed to drain spontaneously. The needle is then withdrawn and the puncture hole in the skin closed with a suture.

Skull fractures

Most skull fractures heal without treatment, but they should be observed for 24 hours in case an intracranial haematoma occurs unless a CT scan has shown no intracranial bleeding. Fractures which are compound, either externally (i.e. the overlying scalp is broken) or internally (i.e. there is a fracture into a paranasal sinus or into the middle ear) require attention.

Externally compound fractures

- Like all wounds, these should be explored to remove all dead tissue and foreign material. This is the most effective means of preventing infection. Operation should be performed as soon as possible. Simple wounds can be explored under local anaesthetic, but more complex wounds will require general anaesthesia.
- Depressed fractures may require elevation to ensure that the full extent of the wound, including the brain substance, has been cleaned and that the dura is repaired if it has been torn. If the wound is less than 24 hours old and not heavily contaminated, the bone fragments can be replaced. If the wound is older than 24 hours or is heavily contaminated, it is safer to discard the bone fragments.
- Antibiotics are not generally required, as it is the mechanical debridement of the wound that is the crucial step. However, compound depressed skull fractures that have occurred in any setting, especially an agricultural or rural one, may be contaminated with *Clostridium tetani* and are best covered with 5 days of IV benzylpenicillin (for children aged 1 month to 12 years, 50 mg/kg every 6 hours by slow injection, and for those over 12 years, 2.4 grams every 6 hours) with anti-tetanus active immunisation and toxoid as appropriate (*see* Section 7.3.A). Animal bites, especially from dogs, will be contaminated with *Pasteurella multocida* and should be covered with ampicillin IV (40 mg/kg 8-hourly up to a maximum of 4 grams/day). If surgery is delayed for more than 24 hours, antibiotics should be given.

The scalp has excellent vascularity and every effort should be made to preserve scalp. Once significant areas are lost, complex skin flaps will be required. Split-skin grafts will not take on bare calvarial bone. If substantial areas of full-thickness scalp are lost, as in burns or attacks by large animals, a useful technique is to make multiple burr-holes, leaving the dura intact. Over the course of a few weeks the florid granulation tissue that grows out of the burr-holes will form a satisfactory base to accept split-skin grafts.

Internally compound fractures

- These carry the risk of CSF fistula and meningitis.
- Prophylactic antibiotics are not indicated.
- Most CSF rhinorrhoea or otorrhoea will resolve spontaneously, but cases persisting for longer than 2 weeks will require formal repair. This will involve referral to a higher centre with facilities for CT scanning and neurosurgical expertise.
- Meningitis complicating traumatic CSF rhinorrhoea or otorrhoea is usually caused by *Streptococcus pneumoniae*, and should be treated for 2 weeks with IV benzylpenicillin (at the dose stated above) or IV cefotaxime (for children under 12 years, 50 mg/kg every 6 hours and for those over 12 years 1–3 g every 6 hours. It is an absolute indication for surgical repair to prevent further episodes.

Penetrating injuries

Children are especially prone to suffering penetrating injuries because of the thin nature of the immature skull, especially around the orbit. **Such wounds require exploration through their full extent to prevent brain abscess.**

Missile injuries require removal of all foreign material wherever feasible. High-velocity penetrating brain injuries from modern military weapons are invariably fatal because of the extreme forces involved, and these patients, along with those who are in deep coma following even low-velocity gunshot wounds, will not make a useful recovery, so **only palliative care is appropriate**.

Early traumatic epilepsy

Epileptic seizures in the first 48 hours after injury are common in children. Except in infants they do not, in isolation, indicate the presence of an intracranial haematoma. Most seizures are self-limiting and simply require airway protection. An anti-epileptic drug should be given to prevent further fits. It is important to remember that the child with an acutely injured brain will be exquisitely sensitive to the respiratory depressant effects of diazepam or lorazepam. These are best avoided unless there is no alternative, when they must be used to stop the convulsion, which will worsen the effects of the head injury.

When using either diazepam or lorazepam, always have a functioning bag-mask resuscitator immediately available. The main side effect of these drugs is apnoea or hypoventilation, but it is short-lived, and a few minutes of bagging with the bag-mask will result in spontaneous respiration restarting. The safest drug is paraldehyde administered per rectum (0.4 mL/kg up to 1 year of age, then one mL per year of age up to a maximum of 10 mL). Unfortunately, it is becoming increasingly difficult to obtain as it is not manufactured widely. Paraldehyde can be diluted with an equal volume of olive oil. It can be given using a plastic syringe if given immediately, otherwise by glass syringe. Do not use paraldehyde if it has a brown colour or smells of acetic acid.

A longer-acting drug must also be given at the same time and maintained. The most appropriate are **phenobarbitone** for children aged less than 5 years (load 15 mg/kg slowly IV, then a total of 5 mg/kg/day starting dose up to a maximum of 6 mg/kg/day IV, or orally in two divided doses 12 hours apart) and **phenytoin** for those aged over 5 years, administered IV initially (load 15 mg/kg IV over 20 minutes, followed by a further 10 mg/kg IV over a further 20 minutes if the first dose is unsuccessful). Then give 2.5 mg/kg every 12 hours IV over 20 minutes initially, increasing up to a maximum of 7.5 mg/kg every 12 hours (with each dose given over 20 minutes if IV). Phenytoin can also be given orally.

7.3.D Electrical injury

BOX 7.3.D.1 Minimum standards

- ABC.
- ECG monitoring.
- Sodium bicarbonate.

Introduction

Electrical injuries usually occur in the home, and involve relatively low currents and voltage. The mortality from electrical injuries from high-power external sources such as electrified railways is high, and death is immediate.

Other injuries may occur during the event. For example, the patient may fall or be thrown. Therefore a full trauma assessment must be undertaken.

Pathophysiology

Alternating current (AC) produces cardiac arrest at lower voltages than does direct current (DC). Regardless of whether the electrocution is caused by AC or DC, the risk of cardiac arrest is related to the size of the current and the duration of exposure. The current is highest when the resistance is low and the voltage is high.

Current

The typical **effects of an increase in current** are as follows:

- **Above 10 mA:** Tetanic contraction of muscles may make it impossible for the patient to let go of the electrical source.
- **Above 50 mA:** Tetanic contraction of the diaphragm and intercostal muscles leads to respiratory arrest, which continues until the current is disconnected. If hypoxia is prolonged, secondary cardiac arrest will occur.
- **From 100 mA to 50 A:** Primary cardiac arrest may be induced. (The defibrillators that are used in resuscitation deliver around 10 A.)
- **From 50 A to several 100 A:** Massive shocks cause prolonged respiratory and cardiac arrest and more severe burns. A lightning strike is a massive direct current of very short duration which can depolarise the myocardium and cause an immediate asystole.

Resistance

The resistance of the tissues determines the path that the current will follow. Generally, the current will follow the path of least resistance from the point of contact to earth. The relative resistance of the body tissues is, in increasing order, as follows: tissue fluid, blood, muscle, nerve, fat, skin, bone. Electrocution generates heat, which causes a variable degree of tissue damage. Nerves, blood vessels, the skin and muscles are damaged most. Swelling of damaged tissues, particularly muscle, can lead to a crush or compartment syndrome that requires fasciotomy. Water decreases the resistance of the skin and will increase the amount of current that flows through the body.

Voltage

High-voltage sources such as lightning or high-tension cables cause extremely high currents and severe tissue damage. However, very high voltages can cause severe superficial burns without damaging deeper structures (flash burns and arcing).

Primary assessment and resuscitation

Call for help and disconnect the electricity **in a safe manner**.

Be aware that high-voltage sources can discharge through several centimetres of air.

Airway

The upper airway should be opened and secured, especially if this is compromised by facial or other injuries. The cervical spine should be immobilised if there is a strong possibility of an unstable fracture.

Breathing

If the patient is not breathing, give rescue breaths using a mouth-to-mouth technique if no equipment is available (e.g. in the home) and, if available, a bag and mask with high-flow oxygen through an attached reservoir. If the patient is breathing but cyanosed, or low oxygen saturation is present, give inspired oxygen to maintain SaO_2 (if a pulse oximeter is available) in the range 94–98%.

Circulation

If the patient appears lifeless despite the rescue breaths, commence chest compressions and continue cardiopulmonary resuscitation (CPR) as described in Section 1.12 until help arrives. In the resuscitated or non-arrested patient who has been brought to hospital, after ABC assessment and management, the entry and exit point of the current should be sought in order to gain a picture of the sort of possible internal injuries that could have occurred. Children with significant internal injuries have a greater fluid requirement than one would suspect on the basis of the area of the external electric burn.

Secondary assessment and emergency treatment

Other injuries should be treated in an appropriate and structured manner (*see* Section 7.3.A).

Associated injuries are common in electrocution. Almost all possible injuries can occur as a result of falls or being thrown from the source. Burns are particularly common, and are caused either by the current itself or by burning clothing. Tetanic contraction of muscles can cause fractures, subluxations or muscle tearing.

Other problems

Burns cause oedema and fluid loss. Myoglobinuria occurs after significant muscle damage, and acute renal failure is a possibility. In this case, it is important to maintain a urine output of more than 2 mL/kg/hour in a child or 60 mL/kg/hour in a pregnant woman or girl with the judicious use of diuretics such as mannitol and appropriate fluid loading. Alkalisation of the urine with sodium bicarbonate, 1 mmol/kg in a child (1 mL/kg of 8.4% solution or 2 mL/kg of 4.2% solution) or 50 mmol in pregnancy increases the excretion of myoglobin.

Arrhythmias can occur up to a considerable time after the electrocution, and continuous ECG monitoring is helpful (if available).

7.3.E Drowning

BOX 7.3.E.1 Minimum standards

- ABCD and **early** basic life support.
- Early management of hypothermia: radiant heat/hot-water bottles.
- Low-reading thermometer.
- Orogastric or nasogastric tube.
- High-dependency care (if available).

Introduction

Definition

'Drowning' is defined as 'a process resulting in primary respiratory impairment from submersion/immersion in a liquid medium'.

According to WHO data, in 2004 there were 388 000 known deaths as a result of drowning worldwide, although the WHO considers this to be a massive underestimate. For children under the age of 15 years, drowning is the leading cause of accidental death worldwide. The low- and middle-income countries account for 96% of unintentional drowning deaths, and over 60% of the world's drowning events occur in the Western Pacific Region and South-East Asia, although the above figures do not include the massive loss of life from floods and tsunamis and from water transport accidents.

Pathophysiology

Bradycardia and apnoea occur shortly after submersion as a result of the diving reflex. As apnoea continues, hypoxia and acidosis cause tachycardia and a rise in blood pressure. Between 20 seconds and 5 minutes later, a breakpoint is reached, and breathing occurs. Fluid is inhaled and on touching the glottis causes immediate laryngeal spasm. After a variable but short period of time the laryngospasm subsides and fluid is aspirated into the lungs, resulting in alveolitis and pulmonary oedema. Hypoxia is by this time severe and the patient will have lost consciousness. Bradycardia and other dysrhythmias can also occur and may be fatal (ventricular fibrillation is rare).

Hypoxia is thus the key pathological process that ultimately leads to death, and needs to be corrected as quickly as possible.

Children who survive because of interruption of this chain of events not only require therapy for drowning, but also assessment and treatment of concomitant hypothermia, hypovolaemia and injury (particularly spinal). Major electrolyte abnormalities due to the amount of water swallowed seldom occur.

The type of water is associated with infections with unusual organisms, and aspiration of water contaminated with petroleum products can lead to a severe respiratory distress syndrome.

Submersion injuries are generally associated with hypothermia. The large body surface area to weight ratio in infants and children puts them at particular risk. Hypothermia may have a protective effect against the neurological sequelae following hypoxia and ischaemia, but is also associated with life-threatening dysrhythmias, coagulation disorders and susceptibility to infections.

The initial approach to the drowning patient focuses on the correction of hypoxia and hypothermia, and the treatment of associated injuries, which are common in older children and often overlooked. Cervical spine injury should always be suspected in drowning victims for whom the mechanism of injury is unclear, although these are rare (0.5% overall, and much rarer in children under 5 years).

Remember:

- Small children can drown in small volumes of water (e.g. in a bucket or shallow pool).
- Not all drowning is accidental (consider the possibility of abuse or neglect).
- Other injuries may be present.
- Other illnesses may have resulted in the drowning (e.g. epilepsy).
- Consider the possibility of drug or alcohol abuse.

Properties of water

- Water can be fresh (hypotonic) or salty (hypertonic).
- Water can conceal hidden dangers, such as trauma, entrapment, tide and flow, and contamination.
- Water can act as a solid at high-impact velocity.
- Water may be only one of several problems affecting the child (consider alcohol, drugs, child abuse, epilepsy, trauma, etc.).

Problems that may be present at drowning

- Hypothermia.

- Hypoxia.
- Pulmonary oedema.
- Hypotension.
- Ventricular arrhythmias and cardiac arrest.
- Cerebral depression, coma and hypoxic–ischaemic brain injury.
- Other injuries, especially spinal and head injuries.
- Electrolyte disturbances.
- Ingestion of alcohol, anticonvulsant drugs, etc.
- Pre-existing epilepsy.

Primary assessment and resuscitation

Call for help and move the victim from the water as quickly as possible without risk to the rescuer, in order to allow CPR and ABC to proceed.

Rescue of the victim in a vertical position may lead to cardiovascular collapse due to venous pooling. However, horizontal rescue in the water must not be allowed to delay the rescue.

The initiation of **early and effective basic life support is vital**. ABC reduces the mortality drastically and is the most important factor for survival. Five rescue breaths must be given as early as possible even in shallow water, if this can be done without risk to the rescuer. Mouth-to-nose ventilation may be easier in this situation. Basic life support (*see* Section 1.12) then proceeds according to the standard paediatric or maternal algorithm, even in hypothermia. The presence of cardiac arrest can be difficult to diagnose, as pulses are difficult to feel. If there are no signs of life, chest compressions should be started and continued with a rate of 15 compressions to two breaths.

Airway and manual in-line cervical spine control (if there is a major suspicion of unstable neck injury) are the first steps. Following submersion, the stomach is usually full of swallowed water. The risk of aspiration is therefore increased, and the airway must be secured as soon as possible on arrival at a healthcare facility. The best airway protection is usually provided by endotracheal intubation using a rapid sequence induction, once in a hospital setting. Following this, an oro- or nasogastric tube should be inserted.

Breathing: commence and continue mouth to mouth or mouth to mouth and nose ventilation.

Circulation: commence and continue chest compressions in the ratio 15 compressions to 2 ventilations until a satisfactory output is achieved, confirmed by palpation of a pulse or signs of life (i.e. breathing, movement or gagging).

Keep the victim as warm as possible. Remove wet clothing and wrap in dry garments/towels if this can be done by bystanders without interrupting CPR.

If in a hospital setting or professional help has arrived, advanced life support protocols can be followed if necessary (*see* Section 1.13).

Respiratory deterioration can be delayed for 4–6 hours after submersion, and even children who have initially apparently recovered should be observed for at least 8 hours. Keep the oxygen saturation in the range 94% or higher. Once the circulation is restored, take blood for haemoglobin, electrolytes (if available) and cross-matching. If the patient is in shock, give 10 mL/kg of Ringer-lactate or Hartmann's solution. Reassess and repeat if required. Give fluids warmed to body temperature if possible.

Disability and neurological examination (AVPU scale).

Exposure and temperature control: the core temperature measurement is best taken with a low-reading thermometer.

Secondary assessment and emergency treatment

Ensure that there are no other injuries requiring treatment. Examine the patient from head to toe. Any injury may have occurred during the incident that preceded immersion, including spinal injuries (*see* Sections 4.2.D and 7.3.A). Older children or pregnant women may have ingested alcohol and/or drugs.

Hypothermia

A core temperature reading should be obtained as soon as possible, and further cooling prevented. Hypothermia is common following drowning, and adversely affects resuscitation attempts unless it is treated.

The advantages of endotracheal intubation in hypothermia (if a skilled person is available) outweigh the small risk of precipitating arrhythmias. Not only are arrhythmias more common, but some, such as ventricular fibrillation, may be refractory to treatment at temperatures below 30°C, when defibrillation should be limited to three shocks (*see* Section 1.13) and inotropic or anti-arrhythmic drugs should **not** be given.

If defibrillation is unsuccessful, the patient should be warmed to above 30°C as quickly as possible, when further defibrillation may be attempted. The dose interval for resuscitation drugs is doubled between 30°C and 35°C. Resuscitation should be continued until the core temperature is at least 32°C or cannot be raised despite active measures.

Once above 32°C the temperature should ideally rise by 0.25–0.5°C per hour to reduce haemodynamic instability. Most hypothermic patients are hypovolaemic. During rewarming, vasodilatation occurs, resulting in hypotension which requires warmed IV fluids, but it is important not to give too much and risk circulatory overload and pulmonary oedema. Continuous monitoring of the pulse rate, respiratory rate and liver size, and auscultation of the lungs looking for crepitations that might suggest pulmonary oedema, are essential. Therapeutic hypothermia (32–34°C) for at least 24 hours has been shown to improve the neurological outcome in some patients, and may be of benefit in children who remain comatose, but requires high-level intensive care facilities.

Rewarming strategies

External rewarming

- Remove cold wet clothing.
- Supply warmed dry blankets.
- If these are not immediately available, place the child in skin-to-skin contact with an adult (kangaroo-type care).
- Warm air system (fan heaters).
- Heating blanket.

Core rewarming

- Warm IV fluids to 39°C to prevent further heat loss.
- Beware rewarming shock. Do not allow the temperature to rise > 37°C.

Monitoring

- Core temperature.

- Vital signs: heart rate, respiratory rate, blood pressure, capillary refill time and pulse volume.
- ECG tracing (if available).
- Glucose, electrolytes, and **blood gases (if available)**.
- Basic blood clotting tests.
- Chest X-ray.
- Urine output and urinalysis.
- Blood culture.

Prophylactic antibiotics are often given after immersion in severely contaminated water. Fever is common during the first 24 hours, but is not necessarily a sign of infection. Gram-negative organisms, especially *Pseudomonas aeruginosa*, are common, and *Aspergillus* species have been reported. If an infection is suspected, broad-spectrum IV antibiotic therapy (e.g. cefotaxime) should be started after blood and sputum cultures (if available).

Keeping the patient normoglycaemic is important for the neurological outcome.

Prognosis

The outcome is determined by the duration of hypoxic–ischaemic injury and the adequacy of initial resuscitation. It is assumed that hypoxic brain damage is reduced when the brain cools before the heart stops. No single factor can predict good or poor outcome in drowning reliably. However, the following factors may give an indication of outcome.

Immersion time

Most children who have been submerged for more than 10 minutes have a very small chance of intact neurological recovery or survival.

Time to basic life support

Starting basic life support at the scene greatly reduces mortality, whereas a delay of more than 10 minutes is associated with a poor prognosis.

Time to first respiratory effort

If this occurs within 3 minutes after the start of basic cardiopulmonary support, the prognosis is good. If there has been no respiratory effort after 40 minutes of full cardiopulmonary resuscitation, there is little or no chance of survival unless the child's respiration has been depressed (e.g. by hypothermia, medication or alcohol).

Core temperature

Pre-existing hypothermia and rapid cooling after submersion also seem to protect vital organs and can improve the prognosis. A core temperature of less than 33ºC on arrival and a water temperature of less than 10ºC have been associated with increased survival. This effect is pronounced in small children because of their large surface area to weight ratio.

Persistent coma

A persistent GCS score of less than 5, or a score of U on the AVPU scale, indicates a poor prognosis.

Type of water

Whether the patient was in salt or fresh water has no bearing on the prognosis.

When to stop resuscitation

- Immersion time: most children who do not recover have been submerged for more than 10 minutes.
- If the first gasp occurs between 1 and 3 minutes after cardiopulmonary resuscitation, the prognosis is good.
- Intact survival has been reported after cold submersion for 1 hour.
- Survival has been reported after 6.5 hours of cardiopulmonary resuscitation.
- A child has been revived from a body temperature of 15°C **but** cool-water drowning does not have the protection offered by ice-cold water.
- Failure to restore a perfusing rhythm within approximately 30 minutes of rewarming to 32–35°C makes further efforts unlikely to be successful.
- **Resuscitation should not be discontinued until the core temperature is at least 32°C or cannot be raised.**

Resuscitation should only be discontinued out of hospital if there is clear evidence of futility, such as massive trauma or rigor mortis.

7.3.F Heat stroke and hypothermia

BOX 7.3.F.1 Minimum standards

Heat stroke

- ABC.
- Shock treatment.
- Ice packs.
- Fans.

Hypothermia

- Skin-to-skin contact with carer.
- Warm blankets and clothing.
- Heated blanket.
- Infra-red warming lamp

Heat stroke

Clinical signs

- Confusion.
- Tachycardia.
- Fever (> 40°C)
- Hot dry skin.
- Tachypnoea.
- Hypotonia.

Pathophysiology

- Neurological impairment.
- Renal insufficiency.
- Disseminated intravascular coagulation.
- Acute respiratory failure.

- May have underlying infection predisposing to heat stroke.

Treatment

- **Urgent cooling:** Aim to cool the patient within 30 minutes. Remove clothes, spray with cool water, use a fan if available, and apply ice packs to the neck, axillae and groin. **It is especially important to cool the head.**
- Provide system support as necessary.
- Give fluids intravenously, especially if there is respiratory failure.
- Give oxygen.
- In hot climates, each hospital should have a cool room (ice or air-conditioned) for emergency treatment.

Hypothermia: prevention and treatment

Hypothermia occurs in association with drowning, and it may also occur during sepsis, especially in the very young child. Malnourished children in particular have a low metabolic rate. The thermoneutral temperature is 28–32°C. At 24°C they can become hypothermic. Those with infection or extensive skin lesions are at particular risk. A hypothermic malnourished child should always be assumed to have septicaemia.

Signs

The signs of hypothermia are a core temperature (oral) < 35.5°C (with low reading thermometer). If axillary temperature is < 35°C or does not register, assume hypothermia.

Routine prevention

- Cover all sick children with clothes and blankets unless they are febrile.
- Keep the ward doors and windows closed to avoid draughts.
- Avoid wet nappies, clothes or bedding.
- Do not wash very ill children. Others can be washed quickly, ideally with warm water, and dried immediately.
- Avoid making a sick or injured child cold when undertaking medical examinations.

Emergency treatment of hypothermia

- Immediately place the child on the carer's bare chest or abdomen (skin to skin) and cover both of them. Give the mother a hot drink to increase her skin blood flow.
- If no adult is available, clothe the child very well (including the head) and put them near a lamp or radiant heater, or use a warming blanket if one is available.
- Immediately treat for hypoglycaemia (*see* Section 5.8.B), and then start normal feeds if appropriate to the child.
- Consider sepsis, and give condition- and age-appropriate antibiotics.
- Monitor the temperature every 60 minutes until the temperature is normal (> 36.5°C).

7.3.G Landmine injuries

BOX 7.3.G.1 Minimum standards

- ABC resuscitation.
- Shock management.
- Analgesia.
- Anti-tetanus immunisation and immunoglobulin.
- Prostheses that are changed as the child grows.

Patterns of injury

- **Injuries caused by stepping on to a buried blast mine or improvised explosive device (IED):** traumatic amputation of the detonating limb, with fragment and minor blast damage to the other leg (most common injury).
- **Injuries caused by fragmentation landmine or IED:** widespread fragment injury to the limbs and trunk.
- **Injuries caused by close-proximity detonation of a landmine or IED in the hand or close to the face:** amputation of the hand or arm, plus damage to the face, eyes and head. Usually occurs in mine clearers or in those handling weapons.

Some mines are scattered from aircraft or by shells to lie on the surface of the ground. These weapons are unstable and likely to explode when handled. Unexploded ordnance, such as grenades, can also explode if handled, resulting in the same pattern of injury. Recently IEDs have been placed next to roads and pathways, causing similar injuries.

Specific problems in children

- Children sustain a higher level of injury per gram of explosive than adults, because of their smaller body mass. A small antipersonnel mine of approximately 30 grams, which would normally require a below-knee amputation in an adult, may result in an above-knee amputation in a child.
- Children are susceptible to close-proximity detonation injuries, because of their tendency to pick up and play with objects that they find.

Treatment

- Initial surgical management follows the basic principles of resuscitation (*see* Section 7.3.A).
- In injury caused by stepping on a buried blast mine or IED, airway maintenance is not usually a problem, as the child is frequently conscious.
- As with all injured children, fear and bewilderment due to pain and the unfamiliar surroundings can be distressing for all involved.
- In close-proximity detonation injury, airway maintenance can be a problem. The patient is often unconscious and there may be damage to the upper airway from the blast. A tracheostomy may be required.
- Benzylpenicillin and anti-tetanus toxoid should be administered in all cases.
- Anaesthesia can be achieved using a ketamine infusion (*see* Section 1.15 for pain relief).

Injury from stepping on to a buried blast mine or IED: technique of amputation

- On the operating table, a thorough wash with warm clean water and a scrubbing brush will get rid of the gross contamination and general soiling of the limbs prior to formal skin preparation.
- **Always use an above-knee orthopaedic tourniquet to minimise peri-operative blood loss**, which is proportionally greater in children than in adults.
- Perform a standard amputation according to International Committee of the Red Cross surgical guidelines. Remember the following points:
  - The muscles are usually contused more proximally by blast damage than may be initially apparent.
  - Dirt and contamination can be propelled up tissue planes by the blast. An amputation through the blast damage can leave contamination in the wound.
  - Make a bulky myoplasty to cover the bone end using the medial gastrocnemius below the knee, or the medial vastus above the knee. Leave generous skin flaps, as the muscle in the stump will swell considerably post-operatively.
- Make an anterior bevel to the bone when dividing it, and file the edges down.
- Let the tourniquet down when the amputation is completed, to check haemostasis before applying the dressing.
- Perform thorough wound toilet of the injuries to the other leg. Explore all wounds and excise contaminated tissue. Leave these wounds open to be closed or skin grafted at 5 days post-operatively.
- **Never close the amputation stump primarily**. Lightly pack the open stump with gauze and apply a bulky dressing. Write on the dressing the date for wound inspection (usually at 5 days post-operatively).
- Do not take the dressing down on the ward unless the patient manifests signs of systemic toxicity (i.e. fever, tachycardia, foul-smelling dressing).
- Give blood only if the haemoglobin level falls to less than 8 grams/dL.
- Give IV benzylpenicillin for 48 hours (50 mg/kg 6-hourly), then orally for a further 3 days (12.5 mg/kg four times daily).
- Give appropriate tetanus prophylaxis (*see* Section 7.1).
- Inspect the wound at 5 days. If the tissue is healthy and not infected, close with interrupted non-absorbable sutures over a drain. Leave the sutures in for 3 weeks.
- Early physiotherapy is crucial to success, especially to eliminate flexion contracture of the below-knee amputation.
- Refer early to a prosthetic workshop for casting. Children will need several sets of prostheses as they grow.

7.3.H Gunshot wounds

BOX 7.3.H.1 Minimum standards

- ABC resuscitation.
- Shock.
- Analgesia.
- Anti-tetanus immunisation and immunoglobulin.
- Penicillin.
- X-rays and ultrasound.
- High dependency care.

Introduction

Although the end of the Cold War led to a reduction in the risk of conflict in Europe, numerous conflicts continue to rage in the developing world. Many of these conflicts are between ill-disciplined or irregular armies who often specifically target civilian populations in defiance of the Geneva Conventions. In this process, children are inevitably susceptible to sustaining gunshot wounds.

The International Committee of the Red Cross has drawn attention to the global proliferation of weapons. For example, there are estimated to be as many as 125 million AK47 assault rifles in circulation worldwide. As conflicts resolve, these weapons become marketable commodities and spread to neighbouring states, where they become the criminal's weapon of choice. The net result of this is injury to the civilian population, including children.

Ballistics

The science of ballistics addresses aspects of missile and bullet flight and relates these to the potential for injury. The following issues are relevant to the mechanism of wounding:

- When a bullet impacts on tissue it will impart some of its kinetic energy to that tissue.
- This will cause the tissue to accelerate away from the track of the projectile, resulting in a **temporary cavity**.
- Once the bullet has passed, the inherent elasticity of the tissues will cause the temporary cavity to collapse, leaving some degree of **permanent cavity** along the track.

The extent to which cavitation occurs is governed by the amount of kinetic energy imparted to the tissues by the projectile. The equation governing this is as follows:

$$\text{kinetic energy} = \tfrac{1}{2}\, m\, (V_1^2 - V_2^2)$$

where m is the mass of the projectile, V_1 is the velocity on entering the tissues and V_2 is the velocity on exiting. The degree to which the projectile's velocity is attenuated while transiting the tissues is dependent upon the diameter of the bullet, its orientation and flight characteristics on impact, and the nature of the tissue itself.

Categories of gunshot wounds

In practice, the masses of most commonly used bullets are similar, and thus the velocity of the projectile largely defines the injury potential. In this regard, gunshot wounds can largely be divided into three categories depending on the nature of the weapon used.

Handguns

- The commonest types of handgun feature a bullet with a diameter of 9 mm and a muzzle velocity of around 1000 feet/second.
- Only a small temporary cavity is formed, and the injury is essentially confined to the bullet track.
- Provided that the bullet has not transected any major structures, the degree of injury may only be slight.
- Some of the bullets for these types of weapon are designed to deform on impact. These are the hollow or soft- (lead-) tipped bullets. On impact they tend to flatten, presenting a greater surface area to the direction of travel, thus resulting in an increased transfer of energy and greater wounding effect.

Shotguns

- The cartridge contains multiple pellets of a specified diameter.
- This diameter can range from 1 mm ('birdshot') to 10 mm ('buckshot').
- Once fired, the pellets disperse in a cone-shaped pattern.
- The degree and rapidity of dispersion are proportional to the size and number of pellets as well as the diameter of the shotgun barrel at the muzzle.
- Due to their aerodynamics, the velocity of individual pellets will attenuate over short distances, even in air. Furthermore, the conical dispersion leads to a rapid decline in the number of pellets that will hit a particular target as the range increases.
- The above factors lead to this weapon being virtually ineffective at ranges over 50 metres.
- A severe pattern of injury is seen at close range. Although each pellet may only be travelling at low ballistic velocity, the combined effect of multiple pellets is a formidable destructive force, shredding the tissues and causing massive disruption.

Military assault rifles

- These weapons typically have a bullet 7.62 mm in diameter that leaves the weapon at a speed of around 3000 feet/second.
- Rifling of the barrel sets the bullet spinning, which, combined with the increased velocity, leads to greater accuracy at long range.
- Rather than following a uniform flight path, the bullet has a periodic motion, oscillating around its flight axis with the movements of precession, nutation and yaw.
- The very much greater kinetic energy of these bullets leads to a much larger temporary cavity than is seen in low-velocity munitions.
- The sub-atmospheric pressure in the cavity will tend to suck in clothing and other debris from outside the wound, causing contamination.
- The shock front of accelerating tissue, propagating away from the point of impact, causes stretching and tearing of the tissues, cellular disruption and microvascular injury.
- The margin of tissue around the cavity, termed the **zone of extravasation**, is full of haemorrhage, has little tendency to further bleeding and, if muscle, shows no tendency to contract when stimulated. This tissue is non-viable and will become a culture medium for infection if left *in situ*.
- The shock wave itself can cause fracture of bone and intimal disruption of major vessels.
- The oscillating nature of the bullet trajectory can cause it to 'tumble' on impacting with the tissues. When this occurs, due to the non-uniform motion, even greater proportions of the kinetic energy are transmitted. The resulting tissue acceleration can lead to the exit wound made by such a bullet being very much larger than the entry wound.
- The nature of the tissue being transited has a great impact on the extent of damage occurring. Relatively elastic, compressible tissue such as lung propagates the shock wave to a much lesser extent than dense, fluid-filled tissue such as liver. Therefore a high-velocity bullet may transit lung causing only contusion, whereas transiting solid organs causes gross disruption.

Treatment

Although it is clearly impossible to cover the treatment of gunshot wounds to every possible anatomical structure in the body, there are some themes common to all such injuries. Most of the wounds encountered will be to the limbs, as gunshot wounds to the head, chest and abdomen have a high rate of on-scene mortality.

Protocols for treating gunshot wounds have been adopted and publicised by the International Committee of the Red Cross (ICRC), who have extensive experience of treating such injuries as part of their war surgery programmes.

Initial measures

The initial measures in the treatment of gunshot wounds are similar to those for any severe injury.

- General assessment and resuscitation of the patient, addressing potentially life-threatening conditions according to ABC priorities (compressing exsanguinating haemorrhage, airway, breathing, circulation), is the priority (*see* Section 7.3.A).
- The degree to which fluid resuscitation should be carried out has been controversial. An initial bolus of 10 mL/kg in a child or 500 mL in pregnancy of Ringer-lactate or Hartmann's should be given and the response to this initial fluid challenge assessed. The concern is to avoid restarting massive bleeding again from disrupting a just-clotting wound by increasing peripheral perfusion. So until the patient can be in a position to have any torn vessels managed, i.e. be in an operating theatre with competent staff, and receive a blood transfusion, crystalloid fluid management remains the minimum that keeps vital organs perfused.
- Give analgesia as required (usually IV morphine) (*see* Section 1.15).
- Apply dressings to the open wounds.
- Undertake emergency splintage of fractures.
- Antibiotics: the ICRC recommend IV benzylpenicillin at a dose appropriate to the size of the child (usually 50 mg/kg IV 6-hourly) and in pregnancy 600–1200 mg IV 6-hourly.
- Give tetanus toxoid and antitetanus serum.
- Appropriate radiographs of the injured areas should be taken.

Wound assessment

Before proceeding to surgical treatment, the following aspects of the wound need to be assessed:

- From the history, the nature of the weapon used (if known).
- The site of the entrance wound (and exit wound, if present).
- The sizes of the entrance and exit wounds.
- Cavity formation.
- The anatomical structures that may have been transited.
- Distal perfusion.
- Presence of fractures.
- Degree of contamination.

Wound debridement and management

This involves removal from the wound of any dead and contaminated tissue which if left would become a medium for infection. It is most relevant to high-energy-transfer (high-velocity) wounds, which feature large cavities and considerable amounts of dead tissue and contamination.

- Wound debridement should be a planned procedure with prior consideration given to the position of the patient and the type of anaesthesia required.
- For limb wounds, a pneumatic tourniquet should be used where possible to reduce blood loss.
- Skin incision decompresses the wound and allows swelling of the tissues without constriction.
- Where possible, the incisions should be longitudinal and not cross joints.
- Skin is a resilient tissue, so only minimal excision is usually necessary.
- Dead and contaminated tissue should be excised.
- Dead muscle is dusky in colour, shows little tendency to bleed, and does not contract to forceps pressure.
- Foreign material should be excised from the wound. However, the obsessive pursuit of small metallic debris, such as that from a disintegrating bullet or shotgun pellets, is not worthwhile.
- Bone fragments denuded of soft-tissue attachment (muscle or periosteum) should be removed as, if left in the wound, they will become infected and form osteomyelitic sequestrae.
- There should be no primary repair of nerve or tendon. Where obviously divided, these structures should be marked (with suture) for later repair.
- At the end of the procedure, the debrided wound should be washed with copious quantities of saline and then a dry bulky sterile dressing applied.
- Some low-energy-transfer (low-velocity) wounds, such as those from most handguns, because of the minimal cavitation and zone of extravasation, do not need the extensive debridement and excision outlined above. These wounds can, in certain circumstances, be managed without surgery.

Delayed primary closure

Once wound debridement has been undertaken, the patient can be returned to the ward and the following regime followed:

- Continued analgesia.
- Benzylpenicillin; IV 50 mg/kg every 4 hours for the first 24 hours and then orally for a further 4 days (12.5 mg/kg four times daily).
- Monitoring of the patient for signs of sepsis; check their tetanus status.
- The dressing should be left in place on the ward and only removed when the patient returns to theatre after an interval period for **delayed primary closure**.
- The ICRC recommend an interval period of 5 days, but most recent practice tends towards shorter periods of 48–72 hours.
- The only indication for return to theatre and dressing removal before this interval period has elapsed is an offensive dressing combined with signs of patient sepsis. The most common cause of this situation is an inadequate initial wound excision.

In the process of delayed primary closure:

- The dressing should be removed in theatre under appropriate anaesthesia.
- If clean, the wound can be closed, or if skin cover is deficient, split-skin grafted.
- If there is evidence of infection, further debridement/excision can be undertaken and the process repeated, aiming for delayed closure after a further 5 days.
- Following closure, rehabilitation of the injured part can commence.

Specific features relating to certain anatomical sites

- Wounds of the head and neck, by virtue of the enhanced vascular supply to these areas, can safely be closed or reconstructed at the initial operation.
- Wounds to major vessels need to be reconstructed primarily.
- Breaches of the dura, pleura and peritoneum should, where possible, be closed at initial surgery.
- Most gunshot wounds to the chest can be treated with tube thoracostomy alone.
- Penetration within 5 cm of the midline of the thorax or abdomen is associated with a risk of injury to the great vessels or heart.
- Gunshot wounds to the head that transit the cranial cavity carry a very poor prognosis, especially if from a high-energy-transfer weapon.
- Penetrating gunshot wounds of the abdomen are associated with a more than 85% chance of bowel or major organ transit. Exploratory laparotomy is therefore virtually mandatory.

Conclusion

Gunshot wounds from any type of weapon represent a severe injury. Some understanding of ballistics can help in the assessment of these injuries. Treatment according to basic principles, such as those recommended by the International Committee of the Red Cross, can lead to a satisfactory outcome even with limited clinical resources.

7.3.I.a Ingestion burns

BOX 7.3.1.A Minimum standards

ABCD management.

- IV steroids.
- Stomal feeding.
- Oesophageal dilation/stenting.
- Oesophageal reconstruction.

Introduction

Oral and oesophageal burns occur in three groups of patients: unintentional ingestion of hot or caustic liquids by young children, or by people of any age with delayed development (poor supervision plays an important part in each of these two groups), and ingestion to cause intentional self-harm.

Types of ingestion burns

Hot fluids

- Burns from drinking hot fluids are relatively rare in developmentally normal children, but can occur in those with learning difficulties.
- Normally only the mouth is burned.
- Swelling and blistering can be very rapid, and require an oral or nasal (preferred) airway.
- Swelling usually goes down within 48 hours, and the need for further treatment is unusual.

Caustic fluids

- Burns from drinking caustic fluids are much more severe.
- In general, caustic alkali solutions are more damaging to tissues than acids.

Immediate treatment

- In the home or at the place where ingestion occurred, the **immediate** drinking of a small amount of milk (this is futile after 30 minutes) may have some beneficial effect in the case of ingestion of solid or granular alkalis, but not for liquid alkalis or for acids.

Hospital treatment

- Assess Airway, Breathing and Circulation. If there are signs of respiratory distress with stridor, the airway must be urgently secured. Intubation is difficult and may cause perforation, so a cricothyroidotomy followed by a tracheostomy may be needed.
- **Do not make the child vomit**, as burning fluid causes further damage when passing up the oesophagus.
- **Do not pass a tube into the stomach**, as this may perforate the oesophagus. A gastrostomy will usually be needed
- **Do not attempt to neutralise the chemical** (e.g. by giving acid for alkali ingestion, or alkali for acid ingestion), as this will cause a high-temperature reaction that will further damage the tissues.
- **Do not give more milk or give water**: it is too late and may precipitate vomiting and more damage to the oesophagus.

Definitive treatment

The only way to assess the oesophageal damage is by flexible oesophagoscopy. If there are significant signs of inflammation, steroids are often used, and there is some evidence that they can reduce the severity of any developing stricture. The route will have to be parenteral (hydrocortisone 4 mg/kg every 6 hours, maximum dose for children under 2 years is 25 mg, for those under 5 years is 50 mg, and for those over 5 years is 100 mg per dose). The length of treatment is not identified, but should be short (3–4 days) in view of the effect of steroids on healing and immunity.

Significant stricture formation will need reconstructive surgery or a gastrostomy (see below).

Complications

- Serious burning, particularly of the oesophagus, can lead to perforation, and in the later stages to strictures.
- Acute perforation of the oesophagus is frequently fatal; treat by drip and suction and then thoracotomy if severe.
- Late stricture during and after the healing phase is a very common problem after ingestion of caustic fluids.
- Mild cases can be treated by later dilatation of the oesophagus.
- **More severe cases may require an oesophagectomy, followed by a stomach pull-up or small bowel replacement.**
- However, if the stricture reduces the ability of the child to eat, a feeding gastrostomy tube passed through the abdominal wall directly into the stomach may be needed to provide nutrition.

Prevention

- Parents and teachers must be informed about the need to keep dangerous fluids out of the reach of children.
- Never put chemicals in the wrong bottles or containers.

7.3.I.b Burns in children and in pregnancy

BOX 7.3.1.B Minimum standards

- ABC management.
- Analgesia.
- Antiseptic dressings.
- Anti-tetanus immunisation.
- Antibiotics.

Summary of actions (more information on each action below)

- Primary assessment and resuscitation according to ABC. If there are signs of developing or actual airway obstruction, call for an anaesthetist, open the airway and consider early intubation before swelling and total respiratory obstruction occur. Observe closely for shock.

- Take a very brief history, and consider whether there could be other injuries or medical conditions.
- Make a rapid assessment of the burn area, take care with clothing removal.
- If there are clearly more than 10% burns, establish an IV cannula and give IV analgesia (morphine according to age and weight *see* Section 1.15).
- Commence either Ringer-lactate or Hartmann's solution IV in the following volumes in mL:

$$\text{burn (\%)} \times \text{weight (kg)} \times 4 \text{ per day for a child}$$

$$\text{burn (\%)} \times \text{weight (kg)} \times 2 \text{ to } 4 \text{ per day in pregnancy}$$

- Fluid is given over the first 24 hours, backdated to the time of the burn. Half of the fluid should be given (in hourly divided doses) during the first 8 hours, and the second half in the next 16 hours, again in hourly doses. This is **in addition to** maintenance fluids which can be given later and orally if the child is able to take these (see below). Any fluid boluses given IV to treat shock should be **included** in the additional fluid for the burn and subtracted from that calculated as described above.
- Normal (0.9%) saline can be used if Ringer-lactate or Hartmann's solution are unavailable, but be aware that, especially in larger volumes, normal saline causes a hyperchloraemic acidosis which is detrimental to sick or injured patients.
- Even if there are less than 10% burns, consider IV opiate analgesia if the patient is clearly distressed by pain.
- Do not give oral fluids immediately.
- Make an accurate assessment of the area of the burn and draw its position on a chart (*see* Table 7.3.I.B.1 and Figure 7.3.I.B.1).
- Estimate the depth of the burn.
- Establish, and if necessary update, the anti-tetanus status of the patient.
- Consider and decide whether an escharotomy is necessary for circumferential burns on a limb or the chest that may cause tissue necrosis from compression by swelling tissues or restriction of ventilation.
- Dress the burned areas, or treat any area that is going to be kept exposed.
- Consider and decide whether the patient needs admission (for a child, with their parent).
- Commence oral fluids if the patient can drink. If not, add the maintenance fluids to those given for the burn as calculated above. In burns over 8% divide the calculated daily maintenance requirement by 24 and give it on an hourly basis either orally or IV.
- Decide whether the patient requires urinary catheterisation (over 30% burns, or burns with complications).

Introduction

The skin is a barrier to infection and evaporative fluid loss. It is a sensory organ and it regulates temperature through sweating.

- The severity of a burn depends both on the area of the body involved and on the depth of the burn.
- The majority of burns in children occur in those under 2 years of age and are caused by hot fluids or flames.
- Other causes include electricity, chemicals, radiation and frostbite.
- Burns are more common where there is poverty from overcrowding and unsafe heating and cooking practices.

Definition of terms

Erythema or first-degree burn: This causes an increase in skin capillary blood flow. In pigmented skin it is often difficult to recognise, but is characterised by pain, and a slight thickening and change in texture of the surface of the skin with later partial or complete desquamation occurring some days afterwards. **The important feature is that blistering does not occur, and fluid is not lost from the circulation. Intravenous fluids are therefore not needed for the burn.** It heals without scarring within 2–10 days.

Superficial partial-thickness burn: This is skin in which there is early (within 1 hour) blistering following the injury, associated with pain. If the blisters are removed **(do not remove them)**, the exposed surface is shiny, loses pigmentation in pigmented races, and is extremely painful. Pressure on the surface causes blanching, which on release of the pressure instantly becomes red again. It heals within 7–14 days with mild pigmentation change or scarring.

Deep dermal burn: Red blood cells leave the capillaries and become fixed in the dermis. In non-pigmented skin, therefore, the redness does not blanch on pressure. This is much more difficult to diagnose in pigmented skin, but the skin becomes thicker and harder in the area. Blistering occurs later, or may not occur at all. If the burn is in the deeper part of the dermis, the heat breaks down the red cells and the area becomes white with no blanching present. Removal of the blistering, if it has occurred, leaves a bed that is wet and shiny, but has only mild discomfort as the nerve endings have been damaged. It heals within 14–21 days with scarring which is often hypertrophic. Grafting will usually be required.

Both of the last two categories may be called a second-degree burn, but as the treatment may be different, the type that is present should be accurately diagnosed.

Deep burn: All elements of the skin and the skin hair follicles, sweat glands, etc. are destroyed. The skin is either white or charred brown. No blistering occurs. **It is painless on examination.** Severe scarring occurs and grafting will always be required. **This may be called a third degree burn.** A burn involving tissue damage occurs at temperatures above 48°C and after only 1 second at 70°C.

Capillary permeability is increased for up to 48 hours, and is maximal at 8 hours. With large burns there is increased blood viscosity, haemoglobinuria may occur, and there is a loss of protein, which needs to be corrected by adequate nutrition.

First aid

Cold water rapidly applied is the best first aid. The quicker this is done, the better. The longer the skin is in contact with the flame or hot fluid, the greater is the extent and depth of burning. The best first aid in all situations, except those involving electricity, is cold water or other cold fluid (e.g. milk) applied as soon as possible. It is less important whether the water is sterile or not, and it should be applied before the clothes are removed, as removal can often take some time. Cold water reduces the severity of the burn as it removes thermal energy, and also reduces pain. It should ideally be applied for approximately 10 minutes, but no longer. Following this, the burn should be covered with clean sheets or towels or 'clingfilm' plastic wrapping.

If the cause of the burn is electricity, it is important that the patient is isolated from the electricity supply or that it is turned off before cold water is applied, otherwise greater damage may be caused.

Following the period of cooling with water, **the patient needs to be kept warm**, otherwise **hypothermia can result**, particularly in young babies.

Primary assessment

- Assessment of a burn must be carried out in the same way as assessment of any other injury.
- It is quite possible that the burn is not the major injury or problem when the patient is seen. For instance, it may have been an epileptic attack that caused the burn, or the patient may have fallen or jumped from a burning house, or been involved in a road traffic accident and therefore has multiple fractures and/or a head injury.
- **Special issues regarding burns in pregnancy.** Any burn affecting more than 20% total body surface area (TBSA) is a serious risk to the mother and fetus. In a mother with a burn > 70–80% of the TBSA mortality is 50–90%. If the burn affects < 30% TBSA the prognosis is good for both fetus and mother and depends on the management of complications such as hypoxia, hypotension and sepsis.

ABC

Airway and Breathing

- If either of these is compromised, call for an anaesthetist and open the airway. Early endotracheal intubation may be required.
- If flame inhalation has occurred (see below for more information on inhalation burns), the airway tends to close very rapidly, making intubation very difficult. Apart from the history, the signs to observe are altered voice or presence of stridor, singeing of the nasal hairs, and deposition of soot in the throat or nose.
- Remove any constricting clothing and place the patient in dry and clean sheets or towels.
- Give additional inspired oxygen if SaO_2 is < 94% or the patient is cyanosed.
- If breathing is inadequate, use a bag-valve-mask and consider intubation if the airway is compromised or may imminently become so.
- Chemical damage may occur from highly irritant gases, which can lead to progressive respiratory failure.
- Many plastics and modern materials give off cyanide, which may be absorbed into the blood stream.
- Carbon monoxide is the most common poison produced in fires.

Circulation

- Fluid is lost through the capillaries following a burn. Shock takes time to develop. In minor burns this is a local phenomenon, but **in severe burns all of the vascular bed becomes leaky**. Assess the total body surface area (TBSA) affected (see below).
- A patient with a burn of less than 10% of the total body surface area can normally cope by having their oral intake increased. However, this is not an absolute figure, and in particular if the patient is vomiting, IV fluid may be necessary for a smaller burn. Similarly, if safe IV fluid is not available, a burn of up to 25% may have to be managed with increased oral fluids alone. When oral fluids are being used, either in combination with IV therapy or alone, only small regular doses of fluid should be given by mouth.
- For burns that are 5% or larger, oral fluids should be an electrolyte solution (ORS).
- Fluid loss is greatest in the first 12 hours, causing disturbances in fluid and electrolyte composition.
- For burns of 10% or more, secure IV access and replace fluids with warmed Ringer-lactate or Hartmann's each containing 5 or 10% glucose (see below for calculating TBSA and the Appendix for how to make up solutions containing glucose).

Management of the circulation in pregnancy

A pregnant woman requires 2 to 4 mL per kg per 1% of body surface area burnt to be given over the first 24 hours in addition to baseline maintenance fluids. Half of this volume is given in the first 8 hours, half in the next 16 hours. *The quantity of fluid given in the first 8 hours must include any fluids given as a resuscitation bolus for shock.*

- Monitor urinary output (should be > 30 mL per hour).
- *Assess the need to deliver the fetus.* Fetal survival is poor in burns affecting > 50% TBSA. In view of the high mortality in mothers with such extensive burns, those in the second or third trimester should be delivered as soon as possible after admission as fetal survival is not improved by waiting and the presence of the fetus increases the risk to the mother. Abortion is common in patients with burns > 33% TBSA, especially during the second trimester. Fetal loss during the third trimester can be expected with extensive burns unless delivery occurs. Dexamethasone to reduce respiratory distress syndrome in a preterm infant (Section 3.1) is not contraindicated in the presence of extensive burns.

Management of the circulation in childhood

Children usually require 4 mL per kg per 1% body surface area burnt (TBSA) to be given over the first 24 hours in addition to baseline maintenance fluids. Half of this volume is given in the first 8 hours, half in the next 16 hours. *To avoid circulatory overload, the quantity of fluid given in the first 8 hours must include any fluids given as a resuscitation bolus for shock*.

For example, if there is a 20% burn × 15 kg child × 4 = 1200 mL of Ringer-lactate or Hartmann's solution. Give 600 mL in the first 8 hours from the time of the burn.

Intravenous fluid management

- IV Ringer-lactate or Hartmann's solution or 0.9% saline (if the former two are not available) is necessary in large burns because of the loss of the intravascular component of extracellular fluid. **Glucose 5% alone and glucose in 0.18% saline are dangerous and can lead to hyponatraemia and water overload.** However, especially in young children, watch for hypoglycaemia, which can be prevented by adding glucose to any crystalloid solution (e.g. 50 mL of 50% glucose in a 500-mL bag of crystalloid will give a 5% solution).
- Ideally, give IV fluids by peripheral or external jugular vein; in an emergency, in shock or where rapid sequence induction for intubation is needed, intra-osseous or

central venous lines may be needed, but the latter can increase the risk of infection.

- If the patient is in shock, in a child give 10 mL/kg as an IV bolus as rapidly as possible and in pregnancy give a 500 mL IV bolus and then reassess and repeat if they are still shocked, up to a maximum of three boluses.
- Wherever possible, long IV lines should not be used, as this increases the risk of septicaemia.
- Both natural colloids (i.e. albumin solution and plasma) and artificial colloids (e.g. Haemaccel, and various starch derivatives) are available. The former have risks of transmitting infection and are expensive, and the latter have not been well studied for resuscitation of burns, but are cheaper.
- Blood transfusion may be needed if anaemia develops.
- It is essential that not too much IV fluid is given, as it may lead to pulmonary and/or cerebral oedema, together with an excessive extravascular deposition of fluid. Crystalloid resuscitation can also lead to 'compartment syndrome' because of the increasing pressure within the muscular compartments and it is important to observe for pain, particularly in the lower legs.
- The amount of fluid loss from burns decreases over the first 48–72 hours after the injury. The amount of fluid to be given initially therefore depends on how long before admission the burn occurred. Following this, the assessment of the resuscitation can be made by a combination of the clinical picture, i.e. degree of dehydration, the blood haematocrit and the urine output aim for 2 mL/kg/hour of urine in a child and 30 mL/hour in pregnancy.
- It is essential that accurate and updated fluid input and output charts are kept throughout. For major burns (over 30%), hourly haematocrit (or haemoglobin) and urine outputs are helpful in the first 24 hours, decreasing in frequency thereafter. For burns between 10% and 30%, 4-hourly tests are normally sufficient.
- In larger burns (greater than 30%), burns involving the genitals, and burns in young normally incontinent female children, a urinary catheter is essential. In males, a urinary bag can be used. A catheter may also be necessary if fluid resuscitation is not proceeding well to give an accurate picture of the urine volume produced hourly. Catheters can lead to infection and should be removed as soon as possible.

Enteral fluid management

- Start oral or nasogastric feeding as soon as possible after admission. If a child is being breastfed, this should continue.
- Although thirst is common, giving too much free fluid orally may induce vomiting.
- For burns between 5% and 10% the daily requirement of the patient's oral intake should be increased by 50% to allow for the burn (given on an hourly basis).
- The normal oral requirement of a child can be calculated as 100 mL/kg for the first 10 kg, 50 mL/kg for the next 10 kg, and 25 mL/kg for any weight up to the total weight of the child. The normal daily fluid requirement in pregnancy is 1500–2500 mL.
- This may need to be increased by 10% or 20% in hot climates.
- The oral fluid given should ideally be ORS. If this is not available, diluted milk is acceptable.
- If all is well after 24 hours, free fluids can be given, but careful input and output charting will continue to be required.

Maintenance of body temperature: burnt children can lose heat rapidly.

Feeding

- Early feeding (especially breastfeeding) reduces the risk of gastric stress ulcer formation and of stasis. It is recommended therefore that small quantities of food are given either orally or with a thin-bore nasogastric tube. The latter can be used to give milk or other similar high-protein foodstuffs.
- Parenteral nutrition is strongly contraindicated, as this leads to a high risk of septicaemia in burns patients.

Burn area and depth

TABLE 7.3.I.B.1 Body proportions at different ages for burns assessment (%)

Percentage surface area at:					
Area on diagram	**0**	**1 year**	**5 years**	**10 years**	**15 years**
A	9.5	8.5	6.5	5.5	4.5
B	2.75	3.25	4.0	4.5	4.5
C	2.5	2.5	2.75	3.0	3.25

Area of burn

Estimation of the area of a burn is based on either Wallace's rule of nines, or on charts (*see* Table 7.3.I.B.1 and Figures 7.3.I.B.1 and 7.3.I.B.2). In addition, the area of the patient's open palm is approximately 1% of the total body surface area. Wallace's rule of nines is applicable to children over 14 years of age and to adults. For newborn babies it can be modified by adding 9% to the area of the head and subtracting 9% from the area of the legs. For every additional year of age, 1% is subtracted from the head and added to the legs until, at the age of 10 years, approximately adult proportions has been reached.

In pregnancy the abdomen represents a larger proportion of the TBSA.

The area of the patient's hand can be used for estimating the size of small burns, but can also be used to estimate the areas that are unburned in extensive burns, and this can then be extracted from the rule of nines figures (e.g. if 2% of an arm is unburned, the area of burn on that arm will be 7%).

- It is very common for inexperienced people to overestimate the size of a burn.
- **Erythema must not be included**, as fluid is not lost.
- The decision as to whether or not to start IV fluids is

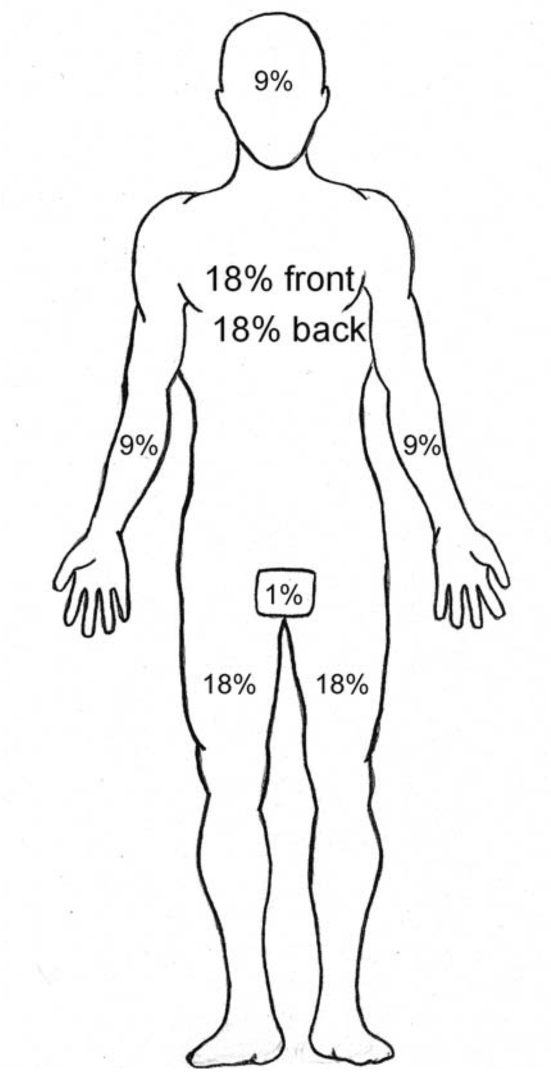

FIGURE 7.3.I.B.1 Wallace's 'rule of nines' for burns assessment in children over 14 years of age and adults.

dependent on this initial assessment, and on whether there are other injuries or medical conditions.
- **An overestimate may mean that far too much fluid is given.**

Depth of the burn
The depth of the burn is based on history, appearance and examination.
- Flame or hot fat burns are almost always deep.
- Hot water burns (scalds) may be superficial or deep dermal.
- The appearance can be altered if more than a few hours old, or by the application of various first-aid treatments.
- First assess capillary return. Prompt capillary return means a superficial burn.
- Then test sensation. Is it increased (in a superficial partial thickness burn), reduced (in a deep dermal burn) or absent (in a full-thickness burn)?
- The test is done by using a sterile hypodermic needle. In older children, and in pregnancy, it is possible to ask whether they can tell the difference between the sharp and the blunt ends when these are lightly applied to

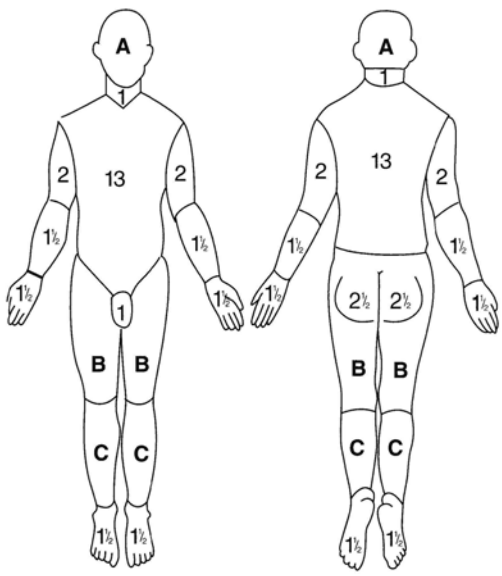

FIGURE 7.3.I.B.2 Body proportions at different ages for burns assessment.

the burn. In younger children the best way of doing the test is to wait until the child is sleeping or has their eyes closed, and then very gently touch what appears to be the deepest part of the burn. If there is a sudden startle reflex, it is probably a superficial partial-thickness burn. A slow awakening indicates a deep dermal burn, and if it is possible to put the needle into the burn without any response it is likely to be a deep burn.
- In full thickness burns the area is insensitive to pain and may appear dirty or white (the eschar).
- A simple test to distinguish between partial and full thickness burns is to pull a hair out: if it comes out easily the burn is full thickness.

Many superficial burns become deeper during the first 48 hours after their occurrence, and need to be reassessed at 48 hours.

Inhalational injury
This includes:
- thermal damage
- asphyxiation
- pulmonary irritation.

Thermal damage
- This is usually limited to the oropharyngeal area.
- The exceptions are injuries caused by steam, volatile gases, explosive gases or aspiration of hot liquids.

Asphyxiation
Combustion utilises oxygen in the burning environment, leading to hypoxia. The **production of carbon monoxide** within the burning environment causes further tissue hypoxia by:
- decreasing the oxygen-carrying capacity of the blood
- shifting the oxyhaemoglobin saturation dissociation curve towards the left
- decreasing myocardial contractility.

The highest possible concentration of oxygen should be given.

Cyanide gas can be released during the combustion of plastics, polyurethane, wool, silk, nylon, nitrites, rubber and paper products. It is 20 times more toxic than carbon monoxide, and can cause immediate respiratory arrest.

Methaemoglobinaemia occurs due to heat denaturation of haemoglobin, oxides produced in fire, and methaemoglobin-forming materials such as nitrites. Rarer than cyanide and carbon monoxide toxicity, this decreases the oxygen-carrying capacity of the blood and causes a shift of the oxyhaemoglobin dissociation curve to the left, similarly to carboxyhaemoglobin (HbCO). Again treat with high concentrations of oxygen.

Pulmonary irritation

- Direct tissue injury.
- Acute bronchospasm.
- Activation of the body's inflammatory response system.

Evidence of inhalational injury

- Burns around the mouth.
- Soot in the mouth or nostrils.
- Carbonaceous sputum.
- Singed facial or nasal hairs.
- Facial burns.
- Oropharyngeal oedema.
- Changes in the voice (hoarseness), and stridor.
- Altered mental status.
- History suggesting confinement in a smoke-filled environment.

Symptoms may be delayed until 24–36 hours after injury. Secure the airway by endotracheal intubation before dangerous obstruction develops.

Deliver high-flow supplemental oxygen. Inhalation of hot gas normally does not injure distal airways, as the heat-exchange capacity of the upper airway is excellent. Distal airway injury is more likely to be due to the direct effects of the products of combustion on the mucosa and alveoli.

Treatment of skin surface burns

Analgesia

In all cases of shock, or potential shock, IV opiate analgesia should be given (*see* Section 1.15).

Oral analgesia is ineffective, and **IM analgesia can be very dangerous** because when the circulatory volume is re-established and muscle blood flow recommences, the child can become overdosed. Opiate overdose can be reversed with naloxone given intravenously (*see* Section 1.15).

Treatment of the burn itself

Minor burns

The best definition of a minor burn is one that can be treated as an outpatient.

Hospital admission

A child with a burn should be admitted unless it is completely safe for them to be treated as an outpatient. If possible, isolate the child in a warm clean room.

The following patients require admission:

- all airway burns or patients with a history of smoke inhalation
- burns of more than 5% TBSA in children and in pregnancy
- deep burns more than 5 cm in diameter
- moderate burns of the face, hands or perineum
- circumferential burns of the thorax or extremities*
- electrical burns (*see* Section 7.3.D)
- where there is inadequate social support in the home
- where there is any suspicion of non-accidental injury.

***If circumferential full-thickness burns involving the extremities or the chest are present, escharotomy may be necessary.**

Dressings

Because a burn is normally caused by hot fluids or flame, the burn wound is initially sterile.

Hands should be washed and sterile gloves should be worn by all members of the team whenever the patient is being touched.

Ideally plastic aprons should also be used to prevent cross-infection during dressings, etc.

The purposes of a dressing are:

- to maintain sterility
- to relieve pain
- to absorb fluid produced by the burn wound
- to aid healing.

Placement of the dressing

- The layer of the dressing closest to the wound should be **non-adherent** (e.g. paraffin gauze) and may contain an antiseptic, such as silver sulphadiazine, although the evidence that antiseptics are useful to prevent infection and promote healing is ambiguous.
- On top of this dressing should be placed a layer of gauze and then sterile cotton wool to absorb fluid.
- The whole dressing should be held in place by a bandage.

Dressing changes

- Every time a dressing is changed, there will be pain, and the delicate reforming epithelium will be injured.
- **Therefore dressings should not be changed on a daily basis**, particularly in a superficial partial-thickness wound. The initial change should be at approximately 48 hours after the burn, when dressings come off easily, the maximum amount of fluid has been discharged from the wound, and it is possible to reassess the wound for area and depth.
- **Effective pain relief is vital at dressing changes or the child will come to dread the procedure.** Providing an anaesthetist is present, ketamine provides excellent brief anaesthesia of up to 15 minutes with an IV injection (over 1 minute) of 250–500 microgram/kg ketamine. For longer anaesthesia, an infusion will be needed. A safer alternative, especially in pregnancy, is oral morphine (*see* Section 1.15 for doses) given about 30 minutes before the anticipated dressing change.
- If at the first dressing change the wound is still a superficial partial-thickness burn, the second dressing is left for a further 8 days, by which stage healing should have occurred.
- If the wound is deeper, a decision as to whether to

operate must be made (see below), but the second dressing can still be left for at least a week.
- If surgery is not possible or appropriate, dressings can be done initially on a weekly basis but increased to two or three times a week as greater infection and discharge develops.
- Take a sample for microbiology (if available).

Tetanus

Anti-tetanus prophylaxis should be given at the earliest possible time.

TABLE 7.3.I.B.2 Guide to tetanus immunoglobulin and tetanus toxoid use in wounds

History of tetanus vaccination		Type of wound	Tetanus vaccine booster (see below)	Tetanus immunoglobulin
≥ 3 doses	< 5 years since last dose	All wounds	No	No
	5–10 years since last dose	Clean minor wounds	No	No
		All other wounds	Yes	No
	> 10 years since last dose	All wounds	Yes	No
< 3 doses or uncertain		Clean minor wounds	Yes	No
		All other wounds	Yes	Yes

In pregnancy, if the woman has not previously been vaccinated, give two doses of TT/Td one month apart.

Antibiotics

- Haemolytic *Streptococcus pyogenes* and *Pseudomonas aeruginosa* are the most common serious infections.
- In most burns, *Staphylococcus aureus* is also present, but does not need treatment unless it is invasive. If it is, flucloxacillin or cloxacillin is more appropriate than penicillin.
- Antibiotics should only be given when there are signs of infection.
- *Streptococcus pyogenes* should be treated with benzyl penicillin and flucloxacillin if found on a swab or suspected clinically (e.g. lymphangitis).
- *Pseudomonas aeruginosa* can be treated with ceftazidime, piperacillin, aztreonam, gentamicin or tobramycin.

Surgery

The surgical treatment of burns can be divided into four time zones:
- Immediate: within hours.
- Early: within days.
- Medium term: within weeks.
- Long term: within years.

Immediate surgery

There are two operations which may need to be done within hours of the burn:
- Tracheostomy:
  - Whenever possible this operation should be avoided, as an endotracheal tube usually gives better results and less mortality (depending on available intensive care).
  - An emergency tracheostomy for a severely swollen oral, pharyngeal or laryngeal airway is a very high-risk operation if the airway has not already been secured. It is better to use a mini-tracheostomy through the cricothyroid membrane.
  - Tracheostomy has a high mortality because of infection, displacement, lung-volume loss and tube blockage.
- Escharotomy:
  - A deep circumferential full-thickness burn of the limb, or even occasionally the trunk, can act as a tourniquet to that area.
  - Very early release (i.e. within 2 hours) is necessary to prevent severe and irrecoverable muscle and nerve damage. This can be done without any anaesthetic because the deep burn has no sensation.
  - The incisions should not overlie superficial bone or tendons, but need to go down to the fascia.
  - For more severe burns, and in particular high-voltage electrical burns, appropriate incisions are needed to decompress the deep compartments as well.
  - Urgent decompression of deep compartments may be required in severe high-voltage electrical burns, which can damage the underlying muscle with no skin damage visible except at the entry and exit points.

Early surgery

- Early surgery for deep dermal and deep burns has been shown to give better functional and cosmetic results with less risk of infection than allowing the natural processes of the body to remove the dead tissue.
- However, it is a technique that is difficult to learn from books, and often requires blood transfusion. Therefore if tangential excision is to be used without previous experience, only a small area should be attempted.
- Blood loss can be very rapid.
- An experienced anaesthetist is important.

Medium-term surgery

When wounds are granulating, thin split-skin grafts (ideally perforated or meshed) can be taken to cover the granulating areas.

Late surgery

Reconstruction to release contractures, and to improve both function and appearance, is best carried out, where possible, in a specialist centre.

Facilities and personnel

- All serious burn patients are best cared for in specialist burns units with a trained team of personnel. This includes all widespread second or third degree burns and burns significantly involving the face, hands and genitals.

- For larger burns, ideally single rooms are most appropriate, and these should be kept warm at all times. It is extremely important that they are clean and that insects, etc. are controlled.
- One of the most serious problems is cross-infection between patients, and adequate plastic aprons, gloves and hand-washing facilities must be available for all staff and relatives.
- In the early stages of burn resuscitation, and after surgery, nursing should be on a one-to-one basis (if available).

Psychology

- There are frequently major psychological consequences to major burns. First, there is a long and often painful stay in hospital. Secondly, there is the loss of function and appearance that can result from the burn injury.
- There are often psychological consequences for the parents of a burnt child, both as a result of the guilt about allowing the accident to happen, and from having to come to terms with the often major alterations in appearance and function of their child.

Prevention

- The best solution to the problem of the burn injury is prevention.
- Use antenatal classes, posters in village halls and talks in school.
- The causes of burns in children will vary in different communities, and prevention should be directed at local causes.
- If possible:
  - limit the temperature of water coming from domestic taps
  - do not cook on the floor
  - keep children away from boiling water, coffee, tea, etc. In many communities these are the commonest causes of scalds.

Features of burns that suggest child abuse

Burns are a common feature of child abuse and the clinician should have a high degree of awareness both of the physical appearance of inflicted burns and also of the developmental stage of the child to see if the injury is compatible with that stage.

Burns are sometimes used as a punishment in child rearing practices. Children with developmental delay are at particular risk of burns, both accidental and intentional.

Physical signs:

- Pattern burns that suggest contact with an object of a specific shape, such as an iron.
- Cigarette burns.
- Stocking, glove or circumferential burns.
- Burns to the genitals or perineum.

7.4 Poisoning

BOX 7.4.1 Minimum standards

- ABC, oxygen and glucose.
- Naloxone.
- Activated charcoal.
- Paediatric ipecacuanha.
- Wide-bore gastric tubes.
- Desferrioxamine.
- N-acetylcysteine.
- Sodium bicarbonate.
- Vitamin K.
- Exchange transfusion.
- Atropine.
- Pralidoxime.
- d-Penicillamine.
- EDTA.

Introduction

The World Health Organization (WHO) definition of poisoning is the injury or destruction of cells by the inhalation, ingestion or absorption of a toxic substance. Key factors that predict the severity and outcome of poisoning are the nature, dose formulation and route of exposure of the poison, co-exposure to other poisons, the state of nutrition of the child or their fasting status, age, and pre-existing health conditions.

Mortality: Low- and middle-income countries have 91% of the world mortality from poisoning as reported by WHO in 2004.

Accidental poisoning is most common in the 12–36 months age group.

Intentional overdose may be a cry for help, rather than a serious attempt at suicide. However, all children and young people who take intentional overdoses should have a full psychiatric and social assessment and always be admitted to hospital if facilities are available.

Drug abuse may be misuse of alcohol or abuse of volatile substances or more potent recreational drugs, such as ecstasy, LSD or opiates.

Deliberate poisoning of children by adults is rare. It may be associated with depressive illness or may be part of a spectrum of abuse inflicted on the child (*see* Section 7.6).

Clinical diagnosis and management

Symptoms and signs of poisoning

These can include:

- respiratory distress

- acidotic breathing
  - tachycardia or flushing
  - cardiac arrhythmias
  - hypotension
  - diarrhoea
  - vomiting
  - drowsiness or coma
  - convulsions
  - ataxia
  - pupillary abnormalities
  - hypoglycaemia
  - acidosis.

The presentation may be more general, such as sudden unexplained illness in a previously healthy child, or unusual behaviour. Remember that there may not be a history of poisoning, so when taking a history ask specifically about access to prescribed drugs, local medicines, household substances, berries and plants.

Management of poisoning

First aid

- Remove the patient from the source of the poison. This mainly applies to fumes (e.g. in a house fire).
- Wash contaminated skin and eyes with water.
- **Never** try to induce vomiting with salt or by inserting an object into the pharynx.

Primary assessment and resuscitation

Identify life-threatening emergencies and the early signs of a seriously ill child using the structured ABC approach (*see* Section 1.11).

The whole assessment should take less than a minute. Treat any problems with the ABC approach as they are found.

An alternative approach to emergencies such as this is the Emergency Triage and Treatment (ETAT) approach, if it is practised at your hospital.

Once Airway, Breathing and Circulation are recognised as being stable, or have been stabilised, definitive management of specific conditions can proceed. During definitive management, **reassessment of ABCD at frequent intervals will be necessary to assess progress and detect deterioration.**

Secondary assessment and emergency treatment

Identify the substance ingested or inhaled, if at all possible. Ask the following questions:

- What medicines, domestic products, berries and plants has the child had access to?
- How much has been taken?
- When did the child have access to these substances?
- Is the container or a sample available? This will be helpful at the hospital.
- Are other children involved?
- What symptoms has the child had?

Use National Poisons Information Centres or Internet references, if these services are available, to obtain information on the side effects, toxicity and treatment needed.

Hypoglycaemia: Test blood glucose levels for all patients, and if hypoglycaemia is present, treat with a sugar drink orally if the patient is conscious. If they are unconscious give by IV or intraosseous routes 2 to 5 mL/kg 10% glucose over 3 minutes then 5 mL/kg/hour to keep blood glucose at 5–8 mmol/litre. In pregnancy, dilute 50 mL of 50% glucose with 50 mL of Ringer-lactate, Hartmann's or 0.9% saline and give IV over 5 minutes followed by an IV infusion containing 5% glucose (*see* Appendix). If blood glucose testing is not available, then treat for hypoglycaemia if this diagnosis is possible (especially in infants and young children).

Convulsions: Treat convulsions in children with diazepam 300–400 micrograms/kg IV or IO slowly or 500 micrograms/kg per rectum.

In pregnancy the loading dose of diazepam is 2 mg increments IV every 2 minutes up to 10 mg. The maintenance dose is diazepam 40 mg in 500 mL of Ringer-lactate or Hartmann's solution, titrated to keep the mother sedated but able to be woken and without hypoventilation. Maternal respiratory depression may occur when the dose exceeds 30 mg in 1 hour. Alternatively, in pregnancy the loading dose diazepam is 20 mg in a 10-mL syringe. Remove the needle, lubricate the barrel and insert the syringe into the rectum to half its length. Discharge the contents and leave the syringe in place, holding the buttocks together for 10 minutes to prevent expulsion of the drug. Alternatively, the drug may be instilled in the rectum through a catheter.

Ensure close observation after treatment with diazepam at any age, and make sure that a bag-valve-mask of suitable size is available and the staff giving the diazepam know how to use it.

Opiate or methadone overdose: If an opiate or methadone overdose is suspected, give naloxone.

- IV dose for children aged 1 month to 12 years: 10 micrograms/kg; if there is no response, give 100 micrograms/kg (review the diagnosis if there is still no response).
- Give patients over 12 years of age and in pregnancy 400 microgram–2.0 mg; if there is no response, repeat every 2–3 minutes up to a maximum of 10 mg (then review the diagnosis).

Remember that naloxone has a short half-life and further boluses or an infusion of and further boluses or an infusion of 10–20 micrograms/kg/hour or more may be required. Give this treatment even if poisoning is only suspected (because of the presence of such drugs in the home) because breathing is shallow or the patient has stopped breathing. If the patient is hypoventilating or has stopped breathing, ventilate with bag-valve-mask before giving the naloxone as hypercapnia with naloxone can cause arrhythmias, acute pulmonary oedema, seizures or asystole.

Minimising the effects of the ingested substance as quickly as possible

If the substance is **non-toxic** give oral fluids liberally.

If the substance is **corrosive**, there may be serious injury to the mouth, throat, airway, oesophagus or stomach (*see also* Section 7.3.I.a). The most dangerous substances are sodium or potassium hydroxide cleaning fluids (e.g. toilet cleaners). Others include bleach and other disinfectants. Serious oesophageal injury can result in perforations and mediastinitis, later leading to oesophageal strictures. The presence of burns within the mouth is of concern, and suggests that oesophageal injury is possible. Stridor suggests laryngeal damage. **No emetic should be given.** Milk or water given as soon as possible may be of benefit, especially with solid caustics such as sodium hydroxide crystals. If there is a severe stricture it may be necessary to bypass the oesophagus with a gastrostomy tube. Ideally, flexible endoscopy should be performed to identify injury, but this may not be available. A perforated oesophagus will lead to mediastinitis and should be treated with gastrostomy and prophylactic antibiotics (cefuroxime and metronidazole).

In a few instances, specific **antidotes** are advised. These should only be given when full information on the poison is available from a Poisons Centre. **Never give salt to induce vomiting.**

For all other poisons except heavy metals, iron, alcohol and domestic products give activated charcoal if this is available (1 gram/kg suspended in water for a child and 50 gram in pregnancy). The sooner it is given the better (preferably within 1 hour of ingestion of the poison). Repeat after 4 hours if a sustained-release drug has been taken. If charcoal is not available and a potentially life-threatening dose of poison has been taken (particularly of iron), give paediatric ipecacuanha (10 mL for those aged 6 months to 2 years, and 15 mL for those aged over 2 years, plus a glass of water) to induce vomiting. **Do not give ipecacuanha if the child has a decreasing level of, or impaired, consciousness. Do NOT give if corrosive solutions have been ingested or if kerosene, turpentine or petrol have been ingested, as they could be inhaled following vomiting, resulting in lipoid pneumonia.**

Gastric lavage with a wide-bore orogastric tube should be used only if a potentially life-threatening dose has been taken, and provided that the airway is protected. It should not be used if there is a decreasing level of, or impaired, consciousness without airway protection. **It should not be used for poisons containing hydrocarbons or corrosives.** Lavage cycles of 15 mL/kg are usually appropriate. Gastric lavage is not an effective way of removing most poisons, and may wash tablets into the duodenum. In a small child the size of nasogastric tube that can be inserted will almost certainly be too small to allow tablets to be drawn through it. Liquid preparations may be evacuated in this way, but in most cases they will have left the stomach within an hour, which is likely to sooner than the child reaches hospital.

Treat symptoms as they arise.

Child abuse: Always remember that an older child or adult may have given the child drugs intentionally. This is child abuse, and if there is the slightest suspicion of this, the appropriate child protection procedures should be instituted if they are available. The child should be admitted (*see* Section 7.6).

Admit all patients with symptoms or signs attributable to poisons, all patients who have ingested iron, pesticides, corrosives, paracetamol (unless blood testing shows a low level of drug), salicyclate, narcotic drugs or tricyclic antidepressant drugs, all who allege deliberate ingestion, and any cases in which child abuse is suspected.

Commonly ingested drugs

Local medicines

- These are often prescribed for diarrhoea and vomiting. They may cause profound acidosis and respiratory distress. They can also cause paralytic ileus.
- Treat the metabolic disturbance.
- Consider using a nasogastric tube.

Iron

- Poisoning is usually the result of taking iron tablets prescribed for another family member. Even two or three adults' tablets can cause serious symptoms in a small child.
- Iron poisoning causes severe gastrointestinal effects, with vomiting, diarrhoea, gastrointestinal bleeding and metabolic acidosis. Subsequently after 12–24 hours there is encephalopathy, liver damage and circulatory collapse.
- Late effects include scarring of the stomach, which may produce pyloric stenosis.
- **If available, a serum iron level at 4 hours of more than 300 micrograms/dL indicates significant poisoning.**
- X-ray may show the number of tablets. **In a child aim to remove as much as possible by induced vomiting with ipecacuanha.**
- Gastric lavage with a wide-bore orogastric tube may also remove significant amounts of iron if it is still in the stomach, but there is also a risk that the lavage may wash the tablets through into the bowel. Do not use gastric lavage in pregnancy.
- Desferrioxamine should be given by deep IM injection, 1 gram for children under 12 years and 2 grams for those over 12 years and in pregnancy. IM doses of desferrioxamine of desferrioxamine of 1–2 g should be repeated every 12 hours until serum iron is normal (serum iron less than iron binding capacity). If the patient is very ill, give an IV infusion of desferrioxamine 15 mg/kg/hour up to a maximum dose of 80 mg/kg in 24 hours. Usually reduce the rate after 6 hours.

Paracetamol

- Paracetamol poisoning can lead to liver and renal failure (*see* Section 5.6.C and Section 5.7.B).
- Induce vomiting and, if possible, measure the paracetamol level.
- Give N-acetylcysteine or methionine as soon as possible, ideally within 8 hours of ingestion. If the patient is conscious and tolerating oral fluids, and within 8 hours of ingestion, give methionine orally (for children under 6 years, give 1 gram every 4 hours for four doses; for those aged 6 years or over and in pregnancy, give 2.5 g every 4 hours for four doses).
- If the patient presents more than 8 hours after ingestion or cannot be given an oral preparation, give IV N-acetylcysteine (initially as a loading dose of 150 mg/kg over 15 minutes, then as an IV infusion of 50 mg/kg over 4 hours, and finally as 100 mg/kg IV over 16 hours). An oral form of N-acetylcysteine is available (give a loading dose of 140 mg/kg, and then 70 mg/kg every 4 hours for 16 doses).

Salicylates

- Salicylate poisoning produces acidotic-like breathing, vomiting and tinnitus.
- Hyperventilation is due to direct stimulation of the respiratory centre and produces respiratory alkalosis, but also there is a metabolic acidosis from ketosis. Consequently, the hyperventilation is extreme.
- A fever may occur.
- There is peripheral vasodilatation.
- Moderate hyperglycaemia develops.

There is delayed gastric emptying, so give activated charcoal if available (1 gram/kg in a child and 50 gram in pregnancy and repeat after 4 hours) even if more than 4 hours after ingestion. If charcoal is not available, induce vomiting.

Give sodium bicarbonate 1 mmol/kg IV as 4.2% over 4 hours to correct acidosis and aid excretion of salicylate.

Give sufficient IV fluids to compensate for hyperventilation, and give sufficient glucose to minimise ketosis, but regularly monitor blood glucose levels.

Monitor electrolytes carefully and avoid hypokalaemia and hypernatraemia.

In very severe cases, **peritoneal haemodialysis (if available) is ideal**. In its absence, exchange transfusion may help.

Benzodiazepines

Flumazenil is a specific antagonist. The initial dose is slow IV 10 micrograms/kg; repeat at 1-minute intervals up to a maximum of 40 micrograms/kg (2 mg maximum dose). If necessary this can be followed by an infusion of 2–10 micrograms/kg/hour (not recommended in children who have received long-term benzodiazepine treatment for epilepsy). In pregnancy give 200 micrograms IV then 100 micrograms per minute IV up to a maximum total of 1 mg until reversal has occurred.

Tricyclic antidepressants

- In overdose these cause drowsiness, ataxia, dilated pupils and tachycardia.
- Severe poisoning results in cardiac arrhythmias (particularly ventricular tachycardia) and severe hypotension and convulsions.

In children induce vomiting, perform gastric lavage and administer charcoal as described above, **but first protect the airway if the patient is drowsy. In pregnancy only administer charcoal**.

Treat convulsions as for any status epilepticus (*see* Section 5.16.E).

Monitor the ECG (if available) continuously.

Arrhythmias can be reduced by using IV phenytoin which must be diluted only in 0.9% saline. Phenytoin is given as a loading dose of 15–20 mg/kg over 30–45 minutes (maximum dose 2 grams) and then 2.5–7.5 mg/kg 12 hourly. The maximum infusion rate is 1 mg/kg/minute (maximum 50 mg/minute). A lidocaine infusion (10–50 micrograms/kg/minute) is an alternative to phenytoin.

Alkalinisation of the intravascular compartment has been shown to reduce the toxic effects on the heart. Give sodium bicarbonate 1–2 mmol/kg slowly. This can be repeated if necessary.

The aim is to increase the arterial pH to 7.45–7.5.

Where there is severe cardiac toxicity, prolonged external cardiac massage may keep the patient, especially a child, alive long enough for the effects of the drug to wear off.

Poisonous household and natural products

Petroleum compounds such as kerosene, turpentine and petrol

Do not induce vomiting.

- If inhaled these may cause hydrocarbon (lipoid) pneumonia, leading to a cough, and respiratory distress with hypoxaemia due to pulmonary oedema and lipoid pneumonia. A chest X-ray is essential in all cases.
- If large amounts are ingested they may cause encephalopathy.
- Additional inspired oxygen may be required.
- An antibiotic may be needed, but only for secondary chest infections.
- Dexamethasone may help in lipoid pneumonia.

Organophosphorus compounds and carbamates

- Insecticides such as malathion, chlorthion, parathion, TEPP and phosdrin can be absorbed through the skin, lungs or gastrointestinal tract.
- Symptoms are due to excessive parasympathetic effects caused by inhibition of cholinesterase, and include excessive secretions of mucus in the lungs (bronchorrhoea) with ensuing respiratory distress and sometimes wheezing, salivation, lacrimation, bradycardia, sweating, gastrointestinal cramps, vomiting, diarrhoea, convulsions, blurred vision and small pupils, muscle weakness and twitching, progressing to paralysis, and loss of reflexes and sphincter control.

Treatment aims to remove poison from:

- the eyes: use copious irrigation
- the skin: remove contaminated clothing and wash the skin
- the gastrointestinal tract: give activated charcoal 1 gram/kg and repeat after 4 hours.

Admit all cases, as some effects do not appear until a late stage.

In severe cases, particularly where there is bronchorrhoea, give **atropine in a child** 20 micrograms/kg IV or IM every 5–10 minutes until the skin becomes flushed and dry, the pupils dilate and tachycardia develops (that is atropinisation has occurred: maximum dose 2 mg). In pregnancy give 600 micrograms and repeat in doses of 300 micrograms as needed.

- A specific cholinesterase reactivator can also be given as follows, and ideally within 12 hours of ingestion (it is ineffective after 24 hours).
  - **Pralidoxime** 30 mg/kg diluted with 10–15 mL of water by IV infusion at a rate not exceeding 5 mg/minute. It should produce an improved muscle power in 30 minutes. It can be repeated once or twice as required and as is shown to be effective, or an infusion of 8 mg/kg/hour can be used. Maximum dose is 12 gram in 24 hours.
- **Assisted ventilation** may be required (if available).

Bleach (3–6% sodium hypochlorite)

Do not induce vomiting.

- Symptoms: burning sensation, vomiting and abdominal discomfort.
- Treatment: liberal fluids and milk.

Corrosive agents

Do not induce vomiting.

- Oven cleaners (30% caustic soda).
- Kettle descalers (concentrated formic acid).
- Dishwashing powders (silicates and metasilicates).
- Drain cleaners (sodium hydroxide).

- Car battery acid (concentrated sulphuric acid).

Symptoms: considerable tissue damage to the skin, mouth, oesophagus or stomach; late strictures may occur. Treatment consists of washing the skin and mouth to dilute the corrosive fluid (*see* Section 7.3.I.a).

Lead poisoning

This is usually a chronic form of poisoning. The lead can come from paint, lead piping or car batteries. In some cultures, lead-containing substances may be applied to the skin for cosmetic purposes (e.g. Surma in India).

- Early signs are non-specific (e.g. vomiting, abdominal pain, anorexia).
- Anaemia is usually present.
- Prior to encephalopathy with raised intracranial pressure, there may be headaches and insomnia.
- Peripheral neuropathy may be present.
- X-rays may show bands of increased density at the metaphyses.
- Harmful effects on the kidneys result in hypertension, aminoaciduria and glycosuria.
- There is a microcytic hypochromic anaemia with punctate basophilia.
- The diagnosis is made by showing a marked increase in urinary lead levels after d-penicillamine, and elevated blood lead levels.

Treatment

- Treat by first removing the source of ingested lead.
- A diet rich in calcium, phosphate and vitamin D (plenty of milk) should be given if possible.
- In cases of lead encephalopathy, give an IV infusion of edetate calcium (EDTA) in 5% glucose or normal saline, 20 mg/kg every 6 hours for 5–7 days at a concentration of no more than 30 mg/mL. Give over an hour.
- Boluses of mannitol 250–500 mg/kg IV over 30–60 minutes may also be required for raised intracranial pressure while the above is given.

Poisonous plants

- Usually only small quantities are ingested.
- Recent reports describe nicotine poisoning by absorption through the skin in children who are tobacco pickers.

Treatment: For ingested poisonous plants this consists of activated charcoal and supportive therapy.

Carbon monoxide poisoning

- Toxic effects are due to hypoxia.

Treatment: Move the patient from the source and give them 100% oxygen as soon as possible (the half-life of carbon monoxide is 5 hours in room air, but only 1.5 hours in 100% oxygen). The patient may look pink but is hypoxaemic, so base the duration of oxygen treatment on other clinical signs of hypoxia rather than on cyanosis, which will be masked. For similar reasons, pulse oximeters will give falsely high readings. ABCD management according to APLS may be required.

- Cerebral oedema may develop.
- **Hyperbaric oxygen treatment may be helpful (if available).**

Volatile substance abuse ('sniffing')

This mainly occurs in the age range 11–17 years and is a group activity. Substances that are sniffed or sprayed into the respiratory system are numerous. The commonest are solvent-based adhesives ('glue sniffing'), butane gas, cleaning fluids, aerosols and fire-extinguisher substances.

Clinical features

- Sores around the mouth and nose.
- Smell of solvents on the clothes and breath.
- All of the features of ethyl alcohol intoxication, plus extreme disorientation, hallucinations and sudden 'unexplained' death
- Accidents can occur secondary to volatile substance abuse, for example falling from height, drowning, suffocation and inhalation of vomit.

Management

- Remove the child from the atmosphere of solvent.
- Admit them to hospital.
- Treat symptomatically.
- Arrange expert psychological and emotional support.

Laboratory investigations in poisoning

These are often expensive and/or very time consuming to perform. They should only be requested if the result will alter the management of the patient. Many hospitals in resource-limited countries will not have these facilities.

Alcohol

- Blood alcohol estimations are useful if:
  - there is an indication that methyl alcohol has been ingested
  - the patient is very drowsy or comatose and there is doubt whether sufficient alcohol has been ingested to explain the symptoms.
- Blood glucose levels should be measured in all cases of alcohol ingestion in children.
  - Do a blood glucose stick test first, and if this is low, a quantitative glucose analysis should be requested.

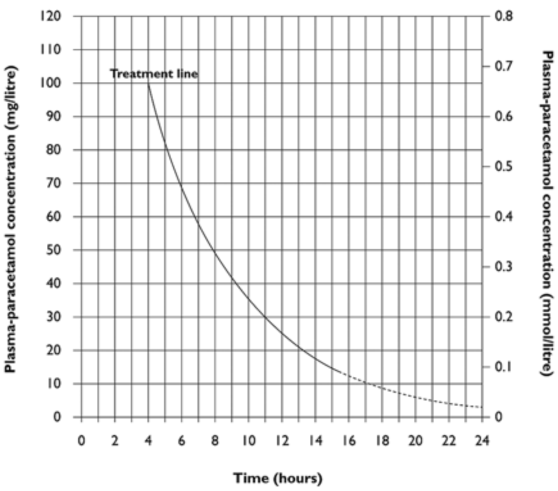

FIGURE 7.4.1 Graph for N-acetylcysteine use in paracetamol poisoning. This Crown copyright material is reproduced by permission of the Medicines and Healthcare Products Regulatory Agency under delegated authority from the Controller of HMSO.

– If in doubt, give glucose 2–5 mL/kg of 10% glucose IV if unable to drink or unconscious, otherwise give a sugary drink.

Interpretation

Peak blood levels of alcohol occur 30–60 minutes after ingestion.

Iron

Patients who have ingested iron should ideally have a plasma iron level estimated before desferrioxamine is given. Serum levels of over 300 micrograms/dL are associated with moderate toxicity, levels of over 500 micrograms/dL with serious toxicity, and levels over 1 mg/dL with death.

Interpretation

Patients with acute iron poisoning have significant increase in plasma iron levels within 2 hours of over-dosage. Initial serum levels of less than 90 micromol/litre are supportive but not absolute evidence of mild poisoning. Normal serum iron levels are in the region of 10–30 micromols/L (80–180 micrograms/dL).

Paracetamol

Take blood samples at least 4 hours after ingestion of paracetamol.

Interpretation

A plasma level that falls above the treatment line at different times indicated in the graph of paracetamol level against time (*see* Figure 7.4.1) indicates moderate to severe poisoning. Treat with N-acetylcysteine. Lower thresholds for treatment are indicated if the patient is on enzyme-inducing drugs or alcohol is taken habitually.

7.5 Envenomation

BOX 7.5.1 Minimum standards

- Mono- and polyspecific antivenoms.
- Chlorphenamine.
- Anticholinesterase (only if appropriate for the region).
- Analgesia.
- Prazosin (only if appropriate for the region).
- Heart failure treatment.

Introduction

Envenoming by snakes, scorpions, spiders or marine venomous animals is common in many areas of the tropics. Children are particularly at risk; they may be attracted to venomous creatures and do not recognise the danger that they represent. Envenoming is often more severe and more rapid in children because the ratio of the amount of venom to body weight is much higher.

A clear-cut history of envenoming is often not present. Some bites are not recognised at the time of the event; other children will be too young to explain what has happened. Envenoming should always be considered in any child with an unexplained illness, particularly if there is severe pain, swelling or blistering of a limb, or if the child is bleeding or shows signs of neurotoxicity.

Prevention

Discourage children from handling snakes, scorpions or spiders or touching marine animals. They should be taught to avoid putting their hands down holes, and to carefully check their shoes and clothing before dressing. Keeping grass short around dwellings, use of sensible footwear, keeping dwellings insect-free, and taking care when swimming can all help to prevent injury by venomous animals.

Snakebite

There are a large number of species of venomous snakes throughout the world. These can be divided into three main categories: **vipers**, **elapids** and **sea snakes**. The pattern of envenoming depends upon the biting species. Therefore clinicians need to know about the snakes present in the region in which they work. **Only 50–70% of patients who are bitten by venomous snakes develop signs of envenoming.**

Major clinical effects following snakebite can be categorised as follows:

- **Local effects:** pain, swelling or blistering of the bitten limb. Necrosis at the site of the wound may sometimes develop.
- **Systemic effects:**
  - Non-specific symptoms: vomiting, headache, collapse.
  - Painful regional lymph node enlargement indicating absorption of venom.
  - Specific signs: non-clotting of blood; bleeding from gums, old wounds and sores.
  - Neurotoxicity: ptosis, bulbar palsy and respiratory paralysis.
  - Shock: hypotension.
  - Rhabdomyolysis: muscle pains and black urine.

Vipers most commonly cause local swelling, shock, bleeding and non-clotting blood.

Elapids cause neurotoxicity and usually minimal signs at the bite site (with the exception of some cobras which also cause necrosis).

Sea snakes cause myotoxicity and subsequent paresis.

Exceptions to this general rule do occur. For example, some vipers cause neurotoxicity and some Australasian elapids also cause non-clotting blood and haemorrhage.

First aid outside hospital

- Reassure the patient. Many symptoms following snakebite are due to anxiety.
- Avoid harmful manoeuvres such as cutting, suction or the use of tourniquets.
- Immobilise and splint the limb. Moving the limb may increase systemic absorption of venom.
- Apply a pressure bandage if tissue necrosis is rare following snakebite in your region, particularly if rapid transport to hospital is not possible. This is especially important for snakes that cause neurotoxicity. Apply a crepe bandage over the bite site and wind it firmly up the limb. **This can only be recommended on a geographical basis, not a clinical one, as necrosis is not apparent initially.**
- Transport the patient to hospital as soon as possible.
- If the snake has been killed, take it with the patient to the hospital.

Diagnosis and initial assessment

- Carefully examine the bitten limb for local signs.
- Measure the pulse, respiration rate, blood pressure and urine output. Blood pressure and other signs of shock (*see* Section 5.5) must be watched for if children are unwell, are bleeding or have significant swelling; shock is common in viper bites.
- Look for non-clotting blood. This may be the only sign of envenoming in some viper bites. The 20-minute whole-blood clotting test (WBCT20) is an extremely easy and useful test. It should be performed on admission and repeated 6 hours later.

WBCT20 test

- Place a few millilitres of freshly sampled blood in a new clean dry glass tube or bottle.
- Leave undisturbed for 20 minutes at ambient temperature.
- Tip the vessel once.
- If the blood is still liquid (i.e. unclotted) and runs out, the patient has hypofibrinogenaemia ('incoagulable blood') as a result of venom-induced consumption coagulopathy.

Look carefully for signs of bleeding which may be subtle (e.g. from gums, old wounds or sores). Bleeding internally (most often intracranial) may cause clinical signs.

- Look for early signs of neurotoxicity, such as ptosis (children may interpret this as feeling sleepy), limb weakness, or difficulties in talking, swallowing or breathing.
- Check for muscle tenderness and myoglobinuria in sea snake bites.
- Take blood for:
  - haemoglobin, white cell count and platelet count
  - prothrombin time, APTT and fibrinogen levels (if available)
  - serum urea and creatinine
  - creatine phosphokinase (CPK) (reflecting skeletal muscle damage) (if available).
- ECG (if available).

Hospital or health centre management

General management

- Observe the patient in hospital for at least 24 hours, even if there are no signs of envenoming initially. Review regularly, as envenoming may develop quite rapidly.
- Nurse the patient on their side with a slight head-down tilt to prevent aspiration of blood or secretions.
- Avoid IM injections and invasive procedures in patients with incoagulable blood.
- Give tetanus prophylaxis. Routine antibiotic prophylaxis is not required unless necrosis is present.

Antivenom

Antivenom is indicated for signs of systemic envenoming. Evidence for its efficacy in severe local envenoming is poor, but it is usually indicated if swelling extends over more than half of the bitten limb. Monospecific (monovalent) antivenom may be used for a single species of snake, and polyspecific (polyvalent) antivenom for a number of different species. The dose of antivenom depends upon the manufacturer's recommendations and local experience.

Children require exactly the same dose as pregnant women (the dose is dependent upon the amount of venom injected, not body weight).

- Dilute the antivenom in two to three volumes of 5% glucose or Ringer-lactate or Hartmann's or 0.9% saline and infuse over 45 minutes to an hour. The infusion rate should be slow initially and gradually increased. Note that doses of antivenom vary considerably; always follow the instructions enclosed with the antivenom.
- Draw up adrenaline in a syringe ready for use.
- Observe the patient closely during antivenom administration. Common early signs of an antivenom reaction include urticaria and itching, restlessness, fever, cough or a feeling of constriction in the throat.
- Patients with anaphylaxis should be treated with adrenaline (epinephrine). In a child give 10 micrograms/kg IM (*see* Section 5.1.B) and in pregnancy give 1 mL of 1 in 1000 adrenaline (1 mg) (*see* Section 5.1.B). An antihistamine, such as chlorphenamine, 200 micrograms/kg IM or IV, should also be given.
- Unless life-threatening anaphylaxis has occurred, antivenom can cautiously be restarted after this treatment.
- Routine adrenaline prophylaxis may reduce the incidence of antivenom anaphylaxis, but should not generally be used.
- Monitor the response to antivenom. In the presence of coagulopathy, restoration of clotting depends upon hepatic resynthesis of clotting factors. Repeat WBCT20 and other clotting studies if available, 6 hours after antivenom. If the blood is still non-clotting, further antivenom is indicated. After restoration of normal clotting, measure clotting at 6- to 12-hour intervals, as a coagulopathy may recur due to late absorption of venom from the bite site.

The response of neurotoxicity to antivenom is less predictable. In species with predominantly postsynaptically acting toxins, antivenom may reverse neurotoxicity, and failure to do so is an indication for further doses. However, the response to antivenom is poor in species with presynaptically acting toxins.

Other therapy

- Excise sloughs from necrotic wounds. Skin grafting may be necessary. Severe swelling may lead to suspicion of a compartment syndrome. Fasciotomy should **not** be performed unless there is definite evidence of raised intra-compartmental pressure (> 45 mmHg) (if measurable), and any coagulopathy has been corrected. **Clinical assessment for compartment syndromes is often misleading following snakebite. Therefore objective criteria are helpful.**
- Blood products are not necessary to treat a coagulopathy if adequate antivenom has been given.
- Endotracheal intubation or even tracheostomy should be considered to prevent aspiration if bulbar palsy develops; this is often obvious when difficulty in swallowing leads to pooling of secretions.
- If there is uncontrolled bleeding in the absence of antivenom, give fresh blood, vitamin K in a child 300 micrograms/kg IV and in pregnancy vitamin K 10 mg IV/IM and fresh-frozen plasma 10 grams/kg IV (if available).
- Paralysis of intercostal muscles and diaphragm requires artificial ventilation. This can be performed by manual bagging with a bag-valve mask and may need to be maintained for days, using relays of relatives if ventilators and skills are not available.
- Anticholinesterases may reverse neurotoxicity following envenoming by some species.
- Maintain careful fluid balance to treat shock and prevent renal failure.
- Some cobras spit venom into the eyes of their victim. Rapid irrigation with water will prevent severe inflammation, and 0.5% adrenaline (epinephrine) drops may help to reduce pain and inflammation.

Scorpion stings

In some areas of the world, scorpion stings are more common than snakebites and cause significant mortality. The stinging scorpion is not often seen. A number of different species have broadly similar clinical effects. The major feature of envenoming is severe pain around the bite site, which may last for many hours or even days. Systemic envenoming is more common in children and may occur within minutes of a bite. The major clinical features are caused by activation of the autonomic nervous system (*see* Table 7.5.1).

Severe hypertension, myocardial failure and pulmonary oedema are particularly prominent in severe envenoming.

TABLE 7.5.1 Scorpion stings

Clinical features of scorpion stings	
Tachypnoea	Muscle twitching and spasms
Excess salivation	Hypertension
Nausea and vomiting	Pulmonary oedema
Lacrimation	Cardiac arrhythmias
Sweating	Hypotension
Abdominal pain	Respiratory failure

Management

- Take the patient to hospital immediately; delay is a frequent cause of death.
- Control the pain with infiltration of 1% lignocaine around the wound or give systemic opiates (with care) (*see* Section 1.15).
- Scorpion antivenom is available for some species. Give intravenously in systemic envenoming, but IM injection has been used with good effect if there is no alternative.
- Prazosin is effective for treating hypertension and cardiac failure (orally 10–15 micrograms/kg two to four times a day increasing to control blood pressure to a maximum of 500 micrograms/kg/day for under 12 years and 20 mg/day over 12 years). The patient should be lying down for the first 4–6 hours of treatment in case there is a sudden fall in blood pressure.
- Severe pulmonary oedema requires aggressive treatment with diuretics and vasodilators (*see* Section 5.4.B).

Spider bites

Three main genera of spiders cause significant envenoming in the tropics. Each causes different clinical effects, but fatal envenoming is rare.

- **Widow spiders** (*Latrodectus* species) are found throughout the world. Severe pain at the bite site is common. Rare cases develop systemic envenoming with abdominal and generalised pain and other features due to transmitter release from autonomic nerves. Hypertension is characteristic of severe envenoming (see use of prazosin above). Antivenom is available in some regions, and is effective for relief of pain and systemic symptoms. Opiates are also useful for the treatment of pain (*see* Section 1.15).
- **Recluse spiders** (*Loxosceles* species) have a wide distribution and cause bites in which pain develops over a number of hours. A white ischaemic area gradually breaks down to form a black eschar over 7 days or so. Healing may be prolonged, and occasionally severe scarring occurs. The efficacy of antivenom and other advocated treatments (dapsone, steroids and hyperbaric oxygen) remains uncertain.
- **Banana spiders** (*Phoneutria* species) occur only in South America. They usually cause severe burning pain at the site of the bite, but in severe cases may cause systemic envenoming with tachycardia, hypertension, sweating and priapism. Polyspecific antivenom is available.

Marine envenoming

Venomous fish

Many different venomous fish may sting children if they stand on or touch the fish. Systemic envenoming is rare. Excruciating pain at the site of the sting is the major effect.

- Regional nerve blocks and local infiltration of 1% lignocaine may be effective (*see* Section 1.24).
- Most marine venoms are heat-labile. Immersing the stung part in hot water is extremely effective for relieving the pain. Care should be taken to avoid scalding, as the envenomed limb may have abnormal sensation. The clinician should check the water temperature with their own hand. Asking the patient to immerse their non-bitten limb may help to avoid scalding.

Jellyfish

Venomous jellyfish have large numbers of stinging capsules (nematocysts) on their tentacles which inject venom when the tentacles contact skin. Pain and wheals are the usual effects but, rarely, systemic envenoming can be life-threatening. Many of the nematocysts will remain undischarged on tentacles that adhere to the victim. Therefore rubbing the area of the sting will cause further discharge and worsen envenoming.

- In box jellyfish stings, pouring vinegar over the sting will prevent discharge of nematocysts. For most other jellyfish, seawater should be poured over the stings and the adherent tentacles gently removed. Ice is useful for pain relief.
- Box jellyfish stings may occasionally be rapidly life-threatening. Antivenom is available and can be administered intramuscularly.

Further reading

A Kasturiratne, AR Wickremasinghe, N de Silva *et al*. (2008) The global burden of snakebite: a literature analysis and modelling based on regional estimates of envenoming and deaths. *PLoS Medicine*, **5**, 1591–604.

World Health Organization (2010) *Guidelines for the Prevention and Clinical Management of Snakebite in Africa*. www.snakebiteinitiative.org

DJ Williams, J-M Gutiérrez, JJ Calvete *et al*. (2011) Ending the drought: new strategies for improving the flow of affordable, effective antivenoms in Asia and Africa. *Journal of Proteomics*, **74**, 1735–67.

7.6 The child who has been ill treated, abused or exploited

BOX 7.6.1 Minimum standards

- Knowledge of the in-country legal framework for child protection.
- Understanding of cross-cultural child-rearing practices.
- Links between health services, police child protection teams and/or social services in place.
- Access to X-rays and blood clotting measurements.
- Access to forensic advice.
- Access to photography services, with secure storage of images.
- Healthcare workers trained to recognise signs of physical and sexual abuse.

Children's rights

Article 19 of the United Nations Convention on the Rights of the Child states that children (people less than 18 years of age) have a right to be protected from being hurt and maltreated physically and mentally. It goes on to state that governments should ensure that children are properly cared for and should protect them from violence, abuse and neglect by their parents or anyone who looks after them.

Child abuse results in actual or potential harm to the child's health, survival, development or dignity in the context of a relationship of responsibility, trust or power with the abuser.

Healthcare workers have a major responsibility in contributing to the prevention and recognition of childhood ill treatment. This poses particular challenges for healthcare workers when they work with children and families from different belief systems and cultural backgrounds. They may find that they have to care for street children, child soldiers, and children separated from their parents by civil strife and unrest, and find themselves making difficult judgements about how a child can be best protected when they have few if any points of reference, and only limited contact with other agencies.

The basic principles of the investigation of child maltreatment are that:

- the welfare of the child is paramount
- multi-agency/multi-sectored collaboration is needed
- agencies must work together within the legal framework of the country (where this is in place).

Child maltreatment or abuse involves acts of omission and commission which result in harm to a child. It can occur in the family, in the community or in institutions (e.g. schools, hospitals, churches, mosques, temples, clubs, orphanages or other institutions). It encompasses:

- exploitation through trafficking for sexual or other forms of slavery
- exploitation through enforced prostitution
- physical abuse
- emotional abuse
- neglect
- sexual abuse
- fabricated induced illness (FII)
- conscription as child soldiers.

Features of presentation of a child to hospital which suggest possible ill treatment or abuse

- Delay in seeking medical help for an injury or serious clinical symptoms or signs (e.g. bleeding).
- A history that is vague or rehearsed, with inconsistencies and significant changes on re-telling or following questioning.
- No explanation of the cause of the injury.
- Repeated attendance at healthcare facilities (this may suggest fabricated or induced illness, FII; see below).
- Parents or carers being evasive or hostile.
- A history of injury that is inconsistent with the child's age and/or developmental skills.

- A 'collusion of silence', or one parent implicating the other.
- Accusations that the child is a witch, or that witchcraft has been perpetrated by others.
- The presence of other injuries, or a previous history of unusual injury.
- Child appearing sad, withdrawn, anxious or frightened ('frozen watchfulness'), or over-compliant.
- Child may indicate the abuser.

Particular consideration needs to be given to children with disabilities who may be unable to communicate about their ill treatment, and where their presentation may be misattributed to their disability.

Children who suffer abuse are often threatened by being told that they will be to blame if the family is separated. Fear of what might happen to them may result in children between the ages of 4 and 10 years colluding with the abusive parent.

Physical abuse/ill treatment (non-accidental injury)

Physical abuse can be defined as any act resulting in a non-accidental physical injury, including not only intentional assault, but also the results of excessive or violent punishment. Physical abuse occurs when a person deliberately injures a child or young person.

Around 25–50% of all children report being physically abused, according to the World Health Organization (WHO).

Physical abuse usually coexists with emotional abuse, and sometimes accompanies sexual abuse. However, in some settings, physical chastisement (especially of older children) continues to be considered part of 'good parenting' and important for instilling discipline in a community's children. In many countries, laws define which childhood punishments are considered excessive or abusive.

Some classifications define physical abuse as an injury that produces a mark. However, this does not take into consideration the emotional effects of physical abuse. The number and size of the bruises are helpful in distinguishing between mild and serious abuse. Any assault on a child is unacceptable and constitutes child abuse. A small bruise in a baby may predict future serious or fatal abuse.

Typical injuries include the following:

- lash marks, especially on the trunk, legs and hands
- bruises, especially on the face, scalp, and on or behind the ears and on the buttocks
- certain patterns of bruises, such as fingertip marks or bruises in the shape of the implement used, or multiple bruises of different ages. However, current scientific evidence concludes that we cannot accurately date a bruise from clinical assessment or from a photograph.
- Burns, including branding and scalds, especially when these are bilateral and/or symmetrical (e.g. buttocks or face held against a hot object such as a radiator, or both hands or feet or buttocks scalded as a result of the child being immersed deliberately in hot water). A pattern suggesting a cigarette burn or burns is also important, but be careful about the possibility of impetigo, which may mimic such burns (impetigo heals quickly and without scarring with antibiotic treatment, topical if a small area and systemic if widespread, whereas burns heal more slowly and may scar)
- injuries to the mouth (especially a torn frenulum)
- bleeding from the mouth or nose in an infant (indicating the possibility of intentional suffocation)
- adult bite marks
- bony injuries, especially in non-ambulant children; skull fractures, spiral fractures of the humerus, rib fractures in young children and multiple fractures of different ages, epiphyseal separation at the end of long bones, periosteal separation and haematomas
- inflicted head injury (especially in infants) involving tearing of the superficial veins over the brain and retina, causing subdural and retinal haemorrhages: this can be fatal, or may cause physical and mental impairment and visual loss.
- failure to thrive due to neglect (category 2) or deliberate starvation (category 3)
- induced illness, including suffocation or poisoning.

Figure 7.6.1 shows the common injury sites for both accidental and abusive injuries.

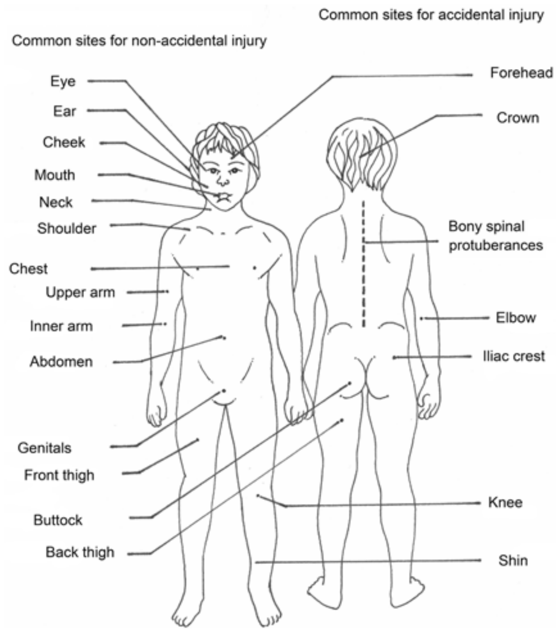

FIGURE 7.6.1 Common sites for (a) non-accidental (abusive) injuries and (b) accidental injuries.

Particular care needs to be taken when interpreting skin marks in settings where traditional practitioners use cupping, coining, scarification or tattooing treatments.

Children are more likely to be killed or to experience violence in their own home than outside it. The triad of violence against a partner (usually the female partner), child abuse and substance misuse (drugs and/or alcohol) is a common association. There is a strong correlation between domestic violence and child abuse.

Emotional and psychological abuse

This can occur as isolated incidents, as well as within a pattern of failure over time on the part of a parent or caregiver to provide a developmentally appropriate and supportive environment. This has a high probability of damaging the child's physical or mental health, or their physical, mental, spiritual, moral or social development.

This category should be used where it is the main or only apparent form of abuse.

Emotional and psychological abuse includes the restriction of movement, patterns of belittling, blaming, threatening, frightening, name-calling, scapegoating, persistent criticism, discriminating against the child compared with their siblings, ridiculing them, and other non-physical forms of rejection or hostile treatment.

This type of abuse can be difficult to recognise. Concerns are frequently raised by a child's extended family, neighbours, or nursery or school staff. All abuse involves some emotional abuse, but emotional abuse may exist independently. Emotional abuse occurs when, for example, there is:

- emotional unavailability of the parent or carer (e.g. when they are preoccupied with their own needs because of mental health problems, substance abuse problems, or work commitments)
- failure to allow the child to interact normally socially with others.

The consequences of emotional abuse vary with age and with its duration, and may include the following:

- Impaired physical development: these children often fail to reach their optimum potential in terms of growth; this improves when the child is placed in a more nurturing environment.
- Impaired cognitive development, including speech and language delay, poor concentration and academic underachievement.
- Behavioural abnormalities, such as anxious attachment, lack of social responsiveness, expressionless face, fear of speaking, eagerness to please, attention seeking, overactivity or 'hyperactivity', no wariness with strangers, hunger for human contact, inability to form relationships, self-injurious or self-stimulating behaviours, hoarding and stealing of food, pica, enuresis and encopresis, and bizarre behavioural patterns (sometimes there is autistic-like behaviour).
- Impaired psychological development, especially with regard to speech and language: aggression, emotional unresponsiveness, emotional instability, impaired social development, low self-esteem, dependency and separation anxiety, serious social difficulties, underachievement, negative self-evaluation, poor concentration, and poor academic performance or school attendance.
- Psychiatric disorders: emotional maltreatment and abuse have been described in association with three psychiatric disorders of childhood:
  - depression
  - reactive attachment disorder of infancy
  - multiple personality disorder.

  In general, these children become sad, dejected and withdrawn.
- Medical problems include the following:
  - failure to thrive
  - recurrent and severe nappy rash
  - generally unkempt appearance, with poor hygiene
  - recurrent minor infections.

Neglect

Neglect includes both isolated incidents and a pattern of failure over time on the part of a parent or other family member to provide for the development and well-being of the child (where the parent is in a position to do so) in one or more of the following areas.

Neglect is persistent failure to meet a child's essential needs by inattention or omitting basic parenting tasks and responsibilities in all aspects of their needs (health, hygiene, clothing, education, and social, emotional, mental, spiritual and moral needs). It also includes failure to provide appropriate nutrition, shelter and safe living conditions.

Examples include lack of supervision, with failure to protect the child from dangers (e.g. cold temperatures, sunburn, drowning) due to poor supervision and attention to safety in the home (e.g. not providing stair gates or locks on windows), failure to thrive, and failure to meet the child's emotional needs for love, affection and stimulation.

Neglect is seen as the persistent failure of a parent or carer to meet a child's developmental, basic physical and/ or psychological needs by omission of basic parenting. It results in serious impairment of the child's physical health, psychological well-being and development. It may coexist with other forms of ill treatment.

The parents' or carers' own problems (e.g. learning difficulties, mental and physical health problems, poverty, inappropriate housing) can all contribute to this. In unstable settings, such as armed conflict, there may be significant security issues that contribute to their inability to provide a safe environment for their children.

Child sexual abuse (CSA)

Introduction

This is the involvement of children in sexual activity to which they cannot consent. Another definition could be any activity in which an adult or older child uses a younger child in a sexual way.

In addition to direct sexual contact between adult and child (including intracrural, oral, vaginal or anal sex and the masturbation of an adult), it includes the use of penetrative instrumentation, the production of pornographic imagery of children, exposing a child to indecent acts or pornography, and other voyeuristic practices. Very young children may also be trafficked for use in the sex industry, and older children may be groomed for prostitution.

Sexual abuse is a serious global problem that transcends economic or social barriers. Poverty, emotional deprivation and lack of education often mean that young people are powerless to avoid being trapped both in sexually abusive situations and in domestic violence. However, it is universally true that sexual abuse is most often suffered at the hands of a neighbour, family friend or a trusted person, including a parent. A significant power differential usually exists between victim and abuser. This fact is important when examining situations of sexual behaviour between children themselves.

In legal terms there are two types:

1. when a stranger or someone the child knows abuses the child
2. incest: when a relative by blood or by law abuses the child.

Some facts about CSA

- Child sexual abuse is a problem in all socio-economic classes.

- Boys are also sexually abused.
- Abusers are usually people whom the child knows.
- It is **never** the child's fault if they are sexually abused.
- Women can also be abusers.
- Abusers cannot be recognised by their physical appearance.
- Sharing the experience of abuse with someone who is supportive and understanding helps the victim deal with it.
- Very young children can be abused in this way.
- A child who is abused at a very young age will also be affected by it, even if they forget the particular episode.
- CSA is rarely accompanied by violence and physical force.
- The main motive behind sexual abuse is not sexual frustration but to gain 'power' and 'control'.

Worldwide, 40–47% of sexual assaults are reported to involve girls under the age of 15 years. In Tanzania, almost 30% of adolescents undergoing abortions had been impregnated by men aged 45 years or older. In India, a study in 2007 reported that over 50% of children had been subjected to sexual abuse, and in 21% of cases this was of a severe nature. That study also reported that children living on the street or in institutional care were most vulnerable to sexual abuse.

Rape and impregnation as a weapon of war is now well recognised as a distressing and complex issue arising in countries where conflict is endemic.

Physical symptoms of CSA

Sexual abuse may go undetected for years because the symptoms are vague and easily attributed to other factors, such as the arrival of a new sibling in the home or family breakdown. Abuse may come to light abruptly when a child says something inappropriate or makes a direct allegation (disclosure) when in a situation in which they feel safe, sometimes to a friend or teacher at school.

Physical symptoms are unusual and vague. Unexplained episodic dysuria and frequency or genital soreness are most often recalled in retrospect. Sexually transmitted disease and pregnancy may make the diagnosis irrefutable in some cases. Obvious pain, bleeding and signs of acute physical trauma to the genital and anal area are rarely presenting features, and usually accompany violent and reckless assaults, often by a stranger.

Other symptoms include difficulty in walking, gastrointestinal disturbances (including nausea), eating disorders, abdominal pain, and in the genital area pain, itching, visible injury, discharge, infection or difficulty urinating.

Bruises, cuts and other injuries on any part of the body for which the cause is not clear and the child cannot give a full explanation may be present. Sexually transmitted diseases may occur at the time of abuse or lie dormant for months or even years, only to flare up in adolescence or adulthood.

There may be a noticeable fear of a particular person or place, sudden bedwetting or soiling, preoccupation with sexual acts, and a change of language or re-enacting their experiences with other children. Nightmares, withdrawn behaviour, changes in appetite and a decline in school achievement are not uncommon.

Other behavioural effects include the following:

- persistent and inappropriate sexual play with peers, toys, animals or self
- sexual themes and fears in the child's artwork, stories and play
- sexual understanding or behaviour beyond that expected for the child's developmental stage
- self-harm or hurting others, including fire setting and cruelty to animals
- fear of being alone, of going home, or of particular places and people
- running away from home
- drug and/or alcohol use
- adolescent prostitution or sexual promiscuity
- suicidal feelings and attempts.

Parents should be concerned if a child appears to have unexplained expensive objects or financial resources. The grooming process often involves making a child feel cherished and creating dependency by offering them quality time, treats and gifts; in older children, the grooming process often includes encouragement to indulge in and provision of cigarettes and alcohol.

These effects may be symptoms of something other than CSA, but the possibility of CSA should always be explored.

Most of the symptoms relate to long-term psychological damage. Young adults find it difficult to make intimate relationships and to trust others. Alcohol and drug dependency, anxiety disorders, self-harming and suicidal ideation may be linked to sexual abuse, especially at the hands of a trusted adult such as a parent. The traumagenesis of sexual abuse has been extensively described by Finklehor. He proposed four dynamics; traumatic sexualisation, powerlessness, betrayal and stigmatisation.

Clinical examination and physical signs

Clinical assessment of the sexually abused child should ideally be conducted by trained and experienced professionals, and preferably a specialist forensically trained doctor or nurse. The environs of the clinical space should be child friendly and the examination unhurried. All examinations should consider the global health needs of the child first; the needs of law enforcement should not be paramount.

Careful history taking is the first step, and if prosecution is being sought, the history should be obtained without risk of contamination, either directly from the child before a recording witness or in the child's absence from the adult who knows first-hand what the child has said. The history should be elicited with free recall and by posing indirect questions (e.g. 'Tell me why you are here' or 'Is there something that has upset you? Can you talk about it?').

Children will feel less threatened if other aspects of their health are also examined at the same time. The normal child health enquiry about growth, diet, systems enquiry and school function is important. Clinical examination of the child should also be holistic, and incidental findings should be relayed back to the parent and child appropriately. A whole body approach is more likely to promote a sense of healing than a prolonged focus on the genitals and anus.

Physical abuse and sexual abuse are seen together in around 15% of cases.

Physical signs of sexual abuse are uncommon even in long-standing, intrusive and painful abuse. Such subtle signs as may be present will be missed if the examiner does not encourage the child to be fully relaxed. The use of a high-quality lighting source is critical, as is the child's posture. The gold standard is the use of photo-colposcopy, which provides magnification, light and a recording of the findings.

Small children are best examined in the frog-leg position, assisted by someone whom they trust. The knee–chest position may have to be used to define the hymenal free edge. Gentle anterior traction on the labia usually suffices to open or stretch the orifice. Older and pubertal girls may benefit from the use of stirrups and a damp swab to identify deep clefts. This should be done after appropriate specimens have been collected for forensic analysis.

Criminal prosecution from sexual abuse allegations and forensic evidence gathering is a demanding process that requires strong links between law enforcement agencies and forensic examiners. Doctors and nurses who expect to provide such a service require training from experts in the field.

Essential reading for forensic practitioners should include *The Physical Signs of Child Sexual Abuse*, produced by the Royal College of Paediatrics and Child Health in the UK in collaboration with the Royal College of Physicians of London and the Faculty of Forensic and Legal Medicine. This document presents a review of all the substantial research into individual physical signs. It also presents guidance on best practice relating to examinations and healthcare (see the Further reading list at the end of this section for details).

Diagnosis of CSA

This is usually achieved following multi-agency assessment, the history and medical examination being only a part of the process.

Acute sexual assault findings (within hours or a few days):

- Bruising and swelling, abrasions and lacerations to the external genitals without a history of accidental trauma.
- Grip marks and bruising around the limbs.
- Cigarette or lighter burns around the breasts and pubic area.
- Bite marks, including suction bites around the breasts, abdomen and thighs.
- Petechiae around the eyes, tears to the oral frenulum, petechiae over the posterior fauces.
- Visible petechiae over the hymen, hymenal tears, haematomas and bleeding.
- Petechiae or bites over the glans penis and scrotum.
- Bruising, oedema and lacerations around the anal area (oedema usually resolves within 48 hours).
- Semen may be found in the vagina or rectum.
- Pregnancy is a major and not uncommon result.

'Chronic' sexual abuse findings (the most common presentation):

- Hymenal transections, deep clefts and notches in the posterior hymen, and loss or absence of posterior hymenal tissue are signs seen almost exclusively in the abused child.
- Significant tears can heal rapidly, but may leave mounds or adhesions on the hymen.
- The size of the hymenal orifice is too variable to be a guide to penetration, but a gaping orifice created by loss of the posterior hymen is significant.
- A mounded scar over the fourchette is evidence of significant stretching trauma in the absence of a history of accidental straddle injury.
- Hymenal injuries are never acceptable from a history of a straddle or other fall unless there is convincing evidence of direct penetration by an object.
- Small superficial notches, bumps and labial adhesions are not uncommon in non-abused girls.
- Anal findings are uncommon. They include marked sustained laxity and gaping, deep and poorly healing fissures and venous congestion. Such signs may be seen in non-abused children, and must be considered in the context of the history given.

Differential diagnoses

Several common naturally occurring conditions not due to abuse may give rise to a suspicion of sexual abuse but must be excluded.

Non-specific vulvo-vaginitis is the commonest. A frequent presentation in the pre-pubescent child, symptoms are of intermittent mild dysuria, redness and a sticky discharge. Symptoms are likely to relate to withdrawal of the maternal oestrogen effect, which makes some children intolerant of the use of strong detergents and poor hygiene practices. The use of loose-fitting underwear, gentle cleansing and the regular application of simple emollients usually provide relief of a condition that tends to recur until early puberty.

The presence of **pinworms** can cause genital symptoms, as can localised eczema in the napkin area. These require appropriate measures.

Infective vulvo-vaginitis presents with significant inflammation and pain, sometimes associated with upper airways infection, and often streptococcal in origin. If possible, bacterial cultures should be obtained before appropriate antibiotics are offered.

Lichen sclerosus et atrophicus is an uncommon skin disorder which may be associated with other autoimmune disease, including morphea in adults, but it tends to be a stand-alone diagnosis in children. It presents with fragility, haemorrhaging and bruising of the skin of the labia, dysuria and occasional urinary retention. Diagnosis is made easy by the classical picture of de-pigmentation in a figure-of-eight configuration associated with obvious skin fragility, and easy bleeding on stretching. Vigorous treatment with emollients is often adequate in mild cases, but topical steroids may be required to control severe signs and symptoms.

Retained foreign bodies can be the cause of intermittent bloodstaining and purulent or offensive discharge in very young children. It should be recognised that repeated insertion of foreign bodies into the vagina by a young child may be the presenting sign of learned or disturbed behaviour.

Constipation can give rise to intermittent anal bleeding and discomfort.

Inflammatory bowel disease may present with anal fissures, bleeding and discharge.

It is important to communicate to parents and other professionals that sexual abuse may not result in any physical findings, and that there are few signs which are absolutely diagnostic. Nevertheless, a medical examination following an allegation of sexual abuse may provide valuable forensic information as well as an opportunity for reassurance, treatment of infection, and access to wider therapeutic support.

Difficult judgements about how to proceed may have to be made in settings where female genital cutting is practised, and where legislation and/or community action against this practice is weak.

Fabricated and induced illness (FII)

This is the severe end of a spectrum of unusual or abnormal health-seeking behaviours in which significant harm is caused by a parent or carer (usually the mother), who deliberately fabricates signs or symptoms or induces illness in a child. Sometimes the abuse is the direct result of inappropriate and often invasive and unnecessary investigations or treatment by healthcare workers responding to the parent's fabricated accounts of non-existent illness. It is probably more common in developed than developing countries. The child is frequently brought for multiple medical assessments and investigations, the perpetrator (often the child's mother) denies knowledge of the causation of the illness, and the acute signs and symptoms cease when the child is separated from the perpetrator.

Healthcare workers in hospital are often the first professionals to suspect FII in a child on the basis of concerns about:

- being given erroneous or misleading information
- deliberate poisoning
- deliberate burns or damage to the skin
- the possibility of deliberate suffocation
- deliberate fabrication of fits
- removal of or tampering with medical monitoring equipment
- the introduction of foreign material into investigative tests.

Immediate action when ill treatment or abuse is suspected

- A detailed history and full medical examination are required (including inspection of the genitals). Where possible, obtain the consent of the parent or carer and the child to carry out the medical examination.
- If consent is withheld, work urgently within the legal framework of the country concerned to examine and protect the child in conjunction with police, social services or civil society organisations.
- Ensure that the child (if they are old enough and able to speak) is given the opportunity away from their parent or carer to say how they were hurt (disclosure), at the same time avoiding interference with any police investigation.

When responding to disclosure:

- Remain calm. An over-reaction will make the child feel even more frightened and ashamed.
- Believe the child.
- Listen in a non-judgemental way.
- Use the child's language.
- Tell the child that you are glad they have told you what happened.
- Reassure the child that they did nothing wrong.
- Explain to the child that abuse is an unfair thing that happens to children, without condemning the offender.
- Determine the immediate need for safety.
- Don't make promises that you cannot keep.
- Let the child know what you will do.
- Set in motion the process of getting help for the child.
- Take care of yourself.

Do's and don'ts of disclosure

Do use phrases like this: 'I believe you'; 'You did the right thing by telling someone'; 'I'm so sorry this has happened to you'; 'It's not your fault'; 'I will try to help you so that it won't happen again.'

Don't use phrases like this: 'Don't say such things!'; 'Are you sure it happened/is happening?'; 'Are you telling the truth?'; 'Why are you telling me?'; 'Why didn't you stop it?'; 'What did you do to make this happen?'

- Consider whether other children in the family may need to be examined and protected.
- Record a full history as it is spoken, and include an evaluation of the child–parent interaction.
- Carry out a careful examination in a well-lit room.
- Record the details of the history and examination legibly and contemporaneously in the child's medical notes. A form of the type available in the Appendix can be helpful.
- Include details of the child's demeanour and presentation, and their height and weight plotted on a centile chart. Ensure that an examination of the child's mouth, nose, ears and neck is undertaken, and complete a full systemic medical examination.
- Document any injuries on body diagrams (*see* Figure 7.6.1 and Appendix).
- Consider photo documentation (with the child's consent, if possible) of injuries, and ensure that the images can be stored safely and confidentially.
- Check whether the family is known to the police and/or social services.
- Consider whether any additional medical investigations need to be carried out (e.g. X-rays for bony injuries, a skeletal survey in children under 3 years of age, clotting studies) (*see* Table 7.6.2).
- Admit the child to hospital if observation or treatment is indicated, or to a place of safety if the child is considered to be at risk. Staff can then have the opportunity to talk further with the child.
- If the parents refuse to allow the child to be examined or admitted, urgent action to protect the child will be required within the legal framework of the country. This may mean referral to the duty social worker (if a referral has not already been made) or the police.

A thorough medical examination should include the following:

- observation of the child's demeanour
- height, weight and head circumference (in a preschool child) plotted on a centile chart
- examination of the mouth, nose, ears, neck and genitals
- inspection of skin surface for bruises, marks and cuts
- examination of the eyes for retinal haemorrhages (pupil dilatation may be needed) (*see* Section 5.15).
- systemic examination
- an assessment of the child's developmental age.

Investigations to exclude medical causes should include the following:

- full blood count, platelets and clotting screen
- a detailed skeletal survey (especially in children under 3 years) to look for new and old fractures; a chest X-ray including the upper arms can be very valuable for identifying rib and humerus fractures
- investigations to exclude vitamin D deficiency, if there are fractures
- CT or MRI scan of the brain (if available), if non-accidental head injury is suspected.

TABLE 7.6.2 Investigations in the differential diagnosis of child abuse

Injury	Differential diagnosis	Investigation
Bruising	Coagulation disorder, idiopathic thrombocytopaenic purpura/Henoch–Schönlein disease, haemorrhagic disease of the newborn, septicaemia, connective tissue disorders, birth marks, dyes, tattoos, drug reactions, self-inflicted injuries, traditional treatments	Full blood count, blood film, coagulation studies Chest X-ray Consider skeletal X-ray survey in children under 3 years of age Opinion of expert in skin diseases (if available)
Bites	Animal or human Adult or child	DNA skin swab (if available) Photography Forensic dental assessment (if available)
Fractures	Accidental injury, birth injury, infection, malignancy, osteogenesis imperfecta, osteopaenia, nutritional deficiencies (including rickets)	Chest X-ray X-ray skeletal survey in children under 3 years of age Bone scan (if available) Radiology advice Blood calcium, phosphate, alkaline phosphatase and vitamin D levels (if available) CT scan for head injury (if available)
Scalds and burns	Other skin pathologies (e.g. staphylococcal and streptococcal infection), drug reactions, allergic reactions to plants (e.g. euphorbias)	Skin swabs Dermatology opinion (if available)
Head injury/unexplained fits or coma	Coagulation disorder, epilepsy or febrile convulsion, cerebral malaria, meningitis, poisoning	Retinal examination after pupil dilatation (*see* Section 5.15) CT scan (if available)

TABLE 7.6.3 Differential diagnoses of genital and anal findings

Concerning sign	Differential diagnoses
Vaginal bleeding	Accidental injury, especially straddle injury, urethral prolapse, precocious puberty, lichen sclerosis atrophicus, foreign body in genital tract, severe vulvo-vaginitis
Rectal bleeding	Anal fissures caused by hard stool, inflammatory bowel disease, infective diarrhoea, rectal polyps, rectal prolapse
Vulvo-vaginitis	Poor hygiene, skin disease (e.g. eczema, lichen sclerosis), allergies to detergents/bath products

Additional considerations when performing examination of the genital and anal areas

- Ensure that a good light source is available, including the use of colposcopy, if this is available.
- Conduct interviews and examinations of children with another professional person present.
- Instrumental examination is not normally required in pre-pubertal girls. Assessment of the hymen in post-pubertal girls may require use of a cotton tip swab or other techniques.
- Knowledge of local practice with regard to female genital cutting and male circumcision is important when interpreting clinical findings.
- Interpretation of anal signs is difficult, and needs to be undertaken in conjunction with a careful history of the child's bowel pattern.
- If forensic facilities are available, ensure that clothing items and relevant swabs are taken in line with local protocols, and that a chain of evidence is maintained to the forensic laboratory.
- Assess whether swabs for sexually transmitted infection (*see* Section 6.1.J) need to be taken immediately or at a follow-up review.
- Consider whether a pregnancy test needs to be carried out.
- Consider whether emergency contraception is needed.
- Consider the risks of HIV infection and whether post-exposure prophylaxis is needed in line with local protocols. This will vary depending on knowledge of the assailant, the nature of the injuries, and the country's HIV prevalence rates.
- Consider whether hepatitis B immunisation (if available) is indicated.

Special issues concerning the management of sexual abuse

The child's immediate needs are as follows:

- **To feel believed and acknowledged:** All interaction with the child should convey this message. Intrusive questioning, especially questions that imply some measure of blame (e.g. 'Why didn't you tell earlier?') can cause a child to refuse to speak further and even retract previous statements. The protective parent or carer should be briefed about this risk.
- **To be safe from further harm:** Protection usually involves the statutory services (if they exist). Police and social workers should be part of the multidisciplinary process that assesses the child's safe custody. The safety of siblings must also be considered at this stage, if not before.
- **To have all their health needs met:** Their immediate needs are for reassurance that they are healthy, and that any changes in the genital area will heal. Care should be taken to use the right language to inform the parent and the child about these changes. The use of phrases such as 'no longer a virgin' is highly inappropriate in this context, and indeed anatomically inaccurate in most cases.

Attention must be given to detection and treatment of all acquired sexually transmitted infection, including HIV, preferably within 2 weeks of an acute assault and possibly at the same time as the examination for long-standing abuse.

Pubescent girls should be offered emergency contraception where indicated.

All incidental findings (e.g. anaemia, rashes, heart murmurs) and reported health problems should be attended to and followed up where necessary.

Forensic sampling in acute sexual assaults

A decision to undertake forensic sampling depends upon the following:

- Has contact abuse been reported? There is always a possibility of transferred material if there has been direct contact. Even if a condom was used, relevant lubricant or saliva may be detected.
- How long is it since the assault? If it is less than 72–96 hours, there is a possibility of trace material being found, especially within skinfolds.
- Has there been bathing or washing? Material may still be available, but this is less likely if the child has been washed thoroughly.
- How active is the child or adolescent? Children who are immobile for reasons of illness or disability may retain trace material well beyond the standard time, as drainage from the vagina is erratic.

What samples should be collected?

The history should guide the practitioner in deciding where trace material is likely to be found. The history may direct one to unusual sites (e.g. swabs may identify traces of adhesive from a victim who has alleged being strapped down with masking tape; microscopic rope fibres may be recovered from around the ankles or wrists). It is sensible to collect duplicate swabs from each area sampled.

In general, swabs lightly moistened with sterile distilled water should be used to collect material that is visibly dried on or speculatively present. Dry swabs are used in moist areas such as the mouth, glans penis, anus and vagina.

If the child is very young or an infant, semen or saliva may be present over a wide area (e.g. in the hair, armpits, abdomen, thigh creases). Damp swabs may be collected over all these areas in a young baby, whereas an adolescent is more likely to carry evidence over the breasts and in and around the vaginal area.

The use of an ultraviolet (UV) light in a dark room may help to identify both deposits of semen and saliva, and areas of deep trauma within the skin. These latter areas fluoresce because of disturbance of melanin, haemoglobin and collagen tissue. The UV light should be used with caution, as there is a risk of material denaturing with extended use.

An example of systematic head-to-toe trace evidence gathering could be as follows:

- hair combings over a sheet of white paper, then folded and placed in a special plastic bag*
- cut areas of hair if dried material is visible
- specialised tooth brushings between the teeth and gum swabs if there has been oral ejaculation
- finger nail scrapings if there was violent resisted assault *
- damp swabs pressed firmly and rolled over any bites noted around the neck or breasts
- swabs from the axillae and from within the umbilicus in a small infant
- pubic hair combings*
- external vulval damp swabs
- dry high vaginal swabs
- swabs from the glans penis, behind the foreskin and over the shaft for saliva
- damp peri-anal swabs
- dry rectal swabs
- all clothing bagged individually as removed
- tampons and sanitary towels similarly bagged.

Every item collected should be fully labelled, bagged and sealed by the receiving witness, most commonly a police officer. It is sensible to allow a brief interval between samples to ensure that earlier samples have been correctly dealt with.

* Forensic material obtained in this way is only relevant if the alleged perpetrator denies all contact with the victim, or is unknown and therefore also a potential serial offender. Finding the perpetrator's DNA in hair or other material on the victim is potent evidence in such cases.

Sexually transmitted diseases (STDs)

A sexually transmitted infection may be the presenting feature in sexual abuse. Children who have experienced contact sexual abuse should be screened for STDs. The screening programme should take local prevalence factors into account, as should the decision to offer prophylactic antibiotics or antiviral treatment (*see also* Section 6.1.J).

Neisseria gonorrhoeae (especially non-conjunctival gonococcus) is not an expected infection outside the neonatal period, and is strong evidence for sexual abuse.

Chlamydia trachomatis similarly usually implies sexual abuse. There is evidence for vertical transmission at birth, and limited research evidence for the persistence of asymptomatic colonisation beyond the first year of life.

The presence of either of these organisms, especially if symptomatic in mid-childhood and beyond, should raise the strongest suspicion of abuse, regardless of the presence of maternal infection.

Trichomonas vaginalis may cause an offensive discharge in adolescents, and is a strong marker for sexual activity, consensual or otherwise. It is not known to infect the pre-pubescent child, although it may be found colonising newborns from infected maternal secretions.

Human papillomavirus is a very common infection, and hand-to-skin transmission is so frequent that it is usually difficult to use this infection to resolve issues of sexual transmission. Transfer may be perinatal, and lesions may be seen in early childhood in the mouth and larynx. However, the presence of genital warts should mandate careful examination and screening for other STDs.

Herpes simplex virus (HSV) raises similar issues. Auto-innoculation and benign transfer cannot be excluded. Adolescents presenting with symptomatic genital HSV are likely to have had sexual contact. They need careful evaluation and screening for other STDs.

Treponema pallidum (syphilis) may be acquired through the placenta, and signs or symptoms of infection are highly unpredictable. Most studies in older children suggest transfer through sexual contact. The infection is exclusively sexually transmitted in adults. Sexual transmission should always be considered in a child presenting with symptoms. Infection in the parent does not exclude abuse.

Hepatitis B and hepatitis C are recognised as being sexually transferred in adults. There is insufficient research in children; however, screening of the sexually abused child is mandatory in high-risk situations, such as multiple or violent assaults and in high-prevalence regions.

Human immunodeficiency virus (HIV): The frequency of infection acquired through abuse will reflect the prevalence of HIV in the local population, and screening is strongly advised where the prevalence is high.

Screening for hepatitis and HIV will need to be timed to take account of time to seroconversion, which is usually a period of 6 or more weeks. Interval repeat screening for late conversion may be considered up to 12 weeks.

Most STDs can be screened for at 2 weeks from the date of contact.

Neisseria gonorrhoeae should be screened for at the first possible opportunity, preferably at the time of assessment if feasible, or within 48 hours.

Consideration should be given to hepatitis B vaccination if the child presents within a week or two after a penetrative assault.

Similar consideration may need to be given to HIV prophylaxis on occasion.

Long-term needs

Those children who are going through the criminal justice process will need extensive support and counselling.

In well-managed sexual abuse allegations, most young children appear to function well. However, the disruption to their lives and the loss of familiar adults and objects around them does have an impact on many, and it is important that their carers are briefed.

Children who have been brutally sexualised may not recover, and may seek inappropriate affection and contact which makes them difficult to parent. Others may suffer nightmares, phobias and other symptoms of anxiety. Long-term psychological input may be necessary.

Special issues involving sexual abuse

Child trafficking

In 1994, the United Nations General Assembly defined trafficking as the ‘illicit and clandestine movement of persons across national and international borders, largely from developing countries and some countries with economies in transition with the end goal of forcing women and girl children into sexually or economically oppressive and exploitative situations for the profit of recruiters, traffickers, crime syndicates, as well as other illegal activities related to trafficking, such as forced domestic labour, false marriages, clandestine employment and false adoption.’

It is estimated that in the last 30 years, trafficking in women and children in Asia for sexual exploitation alone has victimised over 30 million people.

Children are trafficked for a number of purposes, including:

- sexual exploitation
- adoption
- child labour
- child soldiers
- forced marriage
- body parts
- ritual sacrifice.

Parents are promised education or jobs for their children. Some children are simply captured, then traded for whatever commodity is in demand (domestic work, sex work, drug carrying or beggary).

Children who are displaced are highly vulnerable to sexual and physical abuse. They fear seeking help and often do not have the language to do so.

Different cultural situations produce different types of exploitation. In Asia, for example, girls as young as 13 years may be exported as mail-order brides, and in Thailand around 100 000 women and girls from border countries are imported into the sex trade. Large numbers of children are being trafficked in West and Central Africa, mainly for domestic work but also for sexual exploitation, to work in shops or on farms, or to be scavengers or street hawkers. Nearly 90% of these trafficked domestic workers are girls. Many of these girls are traded on into the Middle East and Europe.

The International Organisation for Migration (IOM) has produced an extensive document that comprehensively deals with all aspects of victim management (see Further reading section at the end of this section).

Advice, both for the country of origin and for the receiving country, is structured based on two principles:

- **The child’s interests are paramount.**
- **Above all, do no harm.**

The starting point is the assessment of risk both in the receiving country and in the country of origin if repatriated. Risk depends on numerous factors, including the following:

- the extent to which trafficking is controlled by organised criminal groups
- their known or estimated capacity to plan and implement reprisals against the victims and/or service delivery organisation staff
- the capacity of the local law enforcement agencies
- the extent of endemic corruption and how it adds to the level of risk.

It is critical that children have an appointed independent guardian who will act solely in their interest. Family members, including parents, may well be responsible or collusive in the trafficking, and drawing them in could greatly increase the risk of serious harm, including death, or re-trafficking. In some cultures it may be socially acceptable for the family to shun or even kill a girl for having brought disgrace on her family.

Trafficked women may give birth to children within their repressive conditions. These children will be at very high risk of emotional abuse and neglect and early introduction into commercial sex. Babies are at risk of homicide.

Services provided for trafficked children should reflect the following needs (adapted from the IOM Report):

- **Approaches that demonstrate respect and promote participation** (e.g. children being allowed to express their views in the language they speak best).
- **An understanding of the complex ways in which their past experience has harmed them**. Children who are trafficked are subjected to a persistently threatening and dangerous environment. In the face of this type of chronic abuse and stress, children and adolescents develop a personality that is suited for survival, but that is ill adapted to cope in normal non-threatening situations. Healthcare practitioners are responsible for employing health-promoting strategies, programmes and activities that recognise the child's level of development and help children and adolescents to reclaim and further develop their competencies for an active and meaningful life. This involves addressing a range of needs, including nutritional, physical and psychological development and education needs.
- **Tailoring services to meet the needs of each age group** and in ways appropriate to the age and characteristics of the child concerned, never merely following programmes designed for adults. They should be assessed and managed by professionals trained in child development. Medical assessments need to be child friendly and provided by people with expertise.
- **Implementing strategies aimed at mitigating the effects of past trauma and fostering healthier patterns of development**. One example of such strategies is stepwise early re-integration into education and into a peer group.

Rape as a weapon of war

The rape of adults and children of both sexes is a common phenomenon in conflict zones. As long ago as 1949, Article 29 of the Geneva Convention explicitly forbade degrading treatment, stating that 'Women shall be protected against any attack on their honour – especially rape, enforced prostitution and indecent assault.'

Rape as a crime against humanity was first prosecuted in the International Criminal Court in 2001 when three Bosnian Serbs were convicted of systematic sexual violence against Muslim women.

However, prosecution of these crimes by the relevant states has been negligible.

In Rwanda, the mass rapes of the Tutsi women and girls permanently destroyed the capacity to child bear for some, and forced others to bear children outside their ethnic group. Vast numbers of women and girls were rejected by their communities and became outcasts. Thousands of children witnessed the violence on their mothers and sisters.

As rape as a weapon of war demoralises and destabilises entire communities, it weakens ethnic communities and ties, and affects populations with the exploitation of the reproductive rights and abilities of its victims. When rape is employed instead of a bullet, the weapon continues to wield its power beyond the primary victim. The battlefield may be the body, but the target is civil society. 'Rape, as with all terror-warfare, is not exclusively an attack on the body – it is an attack on the "body-politic." Its goal is not to maim or kill one person, but to control an entire socio-political process by crippling it. It is an attack directed equally against personal identity and cultural integrity.'

Thus in 1998, rape as an act of genocide was the decision of the International Criminal Tribunal for Rwanda. Despite these major precedents, prosecution of sexual crimes by the relevant states has been negligible. Rape has been a major feature of the war in South Sudan and in the Democratic Republic of Congo. Children as young as 5 years of age have been deliberately targeted. There is also strong anecdotal evidence that young soldiers barely in their teens have been ordered into gang rape to prove their 'manhood'.

The provision of care for victims of mass sexual abuse at this level is a daunting task, and should involve major planning and resources. Emergency care for severe physical wounding in the course of the assaults is logistically difficult.

Pratt and Werchick recommend expanding access through 'mobile teams of rape specialists' that could not only provide treatment themselves, but also transport medical supplies and transfer knowledge to any staff already on the ground. Medications, including emergency contraception, hepatitis vaccine, STD prophylaxis and antiretroviral drugs, need to be available. Such teams will need to have access to surgical facilities, especially when very young children are involved.

Gang rape, the use of instruments and other violence increases the risk of HIV/AIDS transmission significantly; intercourse is accompanied by injuries and bleeding which increases the transmission of the virus compared with transmission during consensual sex. Internal vaginal and rectal injury can be very serious, and in the very young may be fatal.

According to Human Rights Watch, 'children were reportedly forced to hold their mothers down while they were raped'. It is not difficult to see that a significant range of service provision is required at several levels to deal with such traumatic damage in childhood.

Therapeutic services in isolation without intensive educational programmes and a whole-community approach are probably doomed to fail. Rape as a weapon of war activates cultural beliefs that result in the marginalisation of its victims, especially women and children, thus preventing those victims from receiving psychosocial support, and depriving them of income. Women and girls are considered to be damaged and 'contaminated'. Wives may be denounced by their husbands, blamed for the rape, and regarded as 'married' to their rapists. Thus communities see their raped women and children as enemies and place them outside their sphere of moral obligation. Some communities may demand that their wives and children leave their villages.

Empowering young children and their mothers by providing education, and the teaching of new skills leading to longer-term economic stability, are also areas that need careful planning. Provision of safe housing and basic needs may be all that is possible in the immediate aftermath of sexual violence.

Additional considerations when investigating fabricated and induced illness (FII)

- The investigative process must involve early and continuing collaboration between all agencies, with detailed information sharing. Strategy planning meetings involving professionals from health, social services, police, education and legal departments can be very helpful.
- Draw up a health chronology using all accessible sources of information.
- Gather forensic or witness information.
- A decision must be made by the multi-agency team as to whether it is necessary to separate the child from the suspected perpetrator by voluntary or legal means.
- A decision must be made by the multi-agency team as to how and when to confront the parents.
- Ensure the child's safety throughout the investigative process.
- Work within the country's legal framework.

Medical aftercare following childhood maltreatment

It is important that these children are offered follow-up in order to:

- monitor the child's overall progress
- ensure healing of injuries
- investigate and treat any acquired infection
- facilitate access to psychological therapeutic support.

Healthcare workers involved in the hospital care of children who have been abused may be asked to provide a police statement and to attend court as a witness.

Further reading

Child protection materials from the UK Royal College of Paediatrics and Child Health. www.rcpch.ac.uk/child-health/standards-care/child-protection/child-protection

Pinheiro PS. World Report on Violence against Children. Geneva: United Nations, 2006; pp. 1–19. www.unicef.org/lac/full_tex(3).pdf

Heise LL, Raikes A and Watts CH (1994) Violence against women: a neglected public health issue in less developed countries. *Social Science and Medicine*, **39**, 1165–79.

Finkelhor DA (2008) *A Sourcebook on Child Sexual Abuse*. London: Sage Publications.

International Organization for Migration (2007) *The IOM Handbook on Direct Assistance for Victims of Trafficking*. Geneva: International Organization for Migration.

Clifford C (2008) *Rape as a weapon of war and its long-term effects on victims and society.* Seventh Global Conference on Violence and the Contexts of Hostility, 2008, Budapest. http://ts-si.org/files/BMJCliffordPaper.pdf

Pratt M and Werchick L (2004) *Sexual Terrorism: rape as a weapon of war in Eastern Democratic Republic of Congo*. http://pdf.usaid.gov/pdf_docs/PNADK346.pdf

Appendix

Examination under child protection procedures: suspected physical and/or sexual abuse

Patient details (circle correct information)

Name: **Date of birth**............................... **Age:** MALE/FEMALE **Address** (prior to examination):	Date: Time: Place of examination:

Professionals involved in the assessment

Doctor's or nurse's name:	Police officer's name:
Social worker's name:	
School:	

Why was this examination undertaken?

Family and Social History
(including names, dates of birth, ages, occupations/schools, relationships)

History of any known medical problems

Examination
Persons present during examination

1.
2.
3.
4.

Examination of child

Age:	Years: Months:
Height/percentile	.........cm/.........
Weight/percentile	.........kg/.........
Head circumference/percentile	.........cm./.........

General appearance of child (any obvious neglect):

Significant comments made by the child or the parent/carer (record as accurately as possible):

Developmental assessment (circle correct answers):

Delayed development Yes/No

If Yes Severe /Moderate /Mild

Level of puberty: Pre-pubertal/Post-pubertal

General examination (use body maps for any injuries)
(include inspection of oral frenum and palate and scalp)

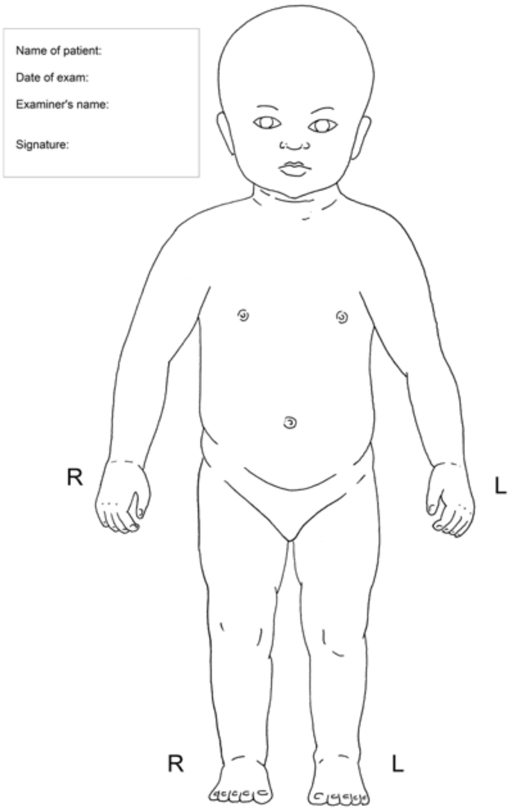

FIGURE 7.6.2 Diagram on which to mark signs of injury to the front of the body. Reproduced with permission from Southampton City Primary Care Trust.

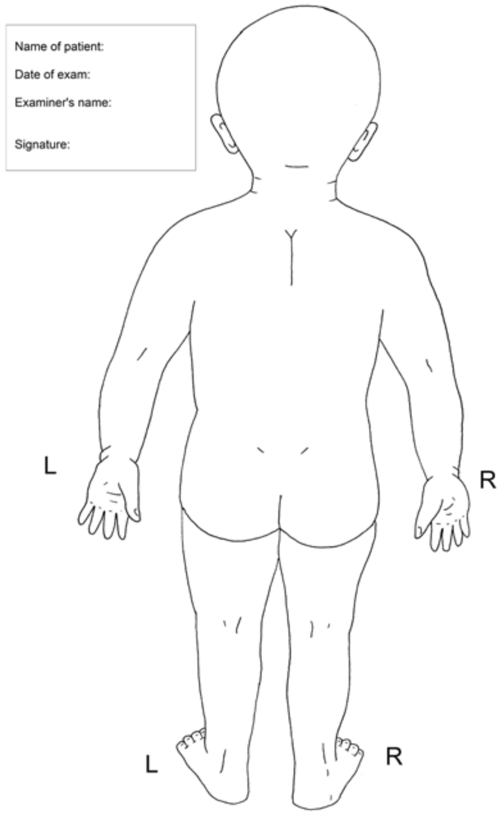

FIGURE 7.6.3 Diagram on which to mark signs of injury to the back of the body. Reproduced with permission from Southampton City Primary Care Trust.

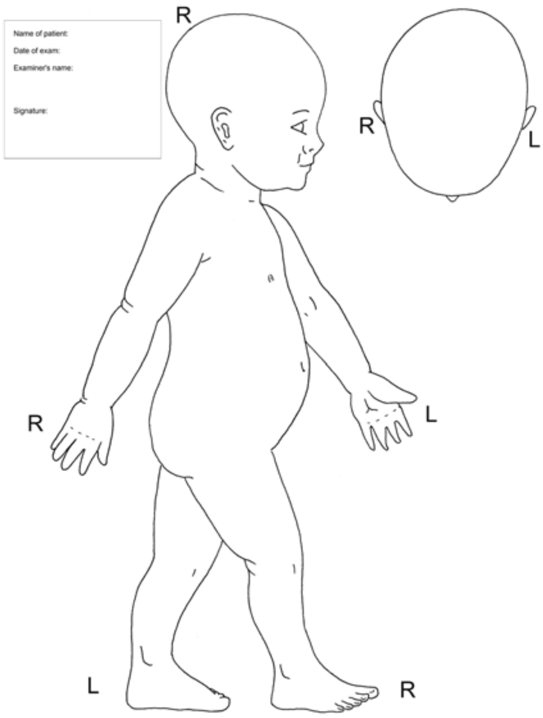

FIGURE 7.6.4 Diagram on which to mark signs of injury to the right side of the body. Reproduced with permission from Southampton City Primary Care Trust.

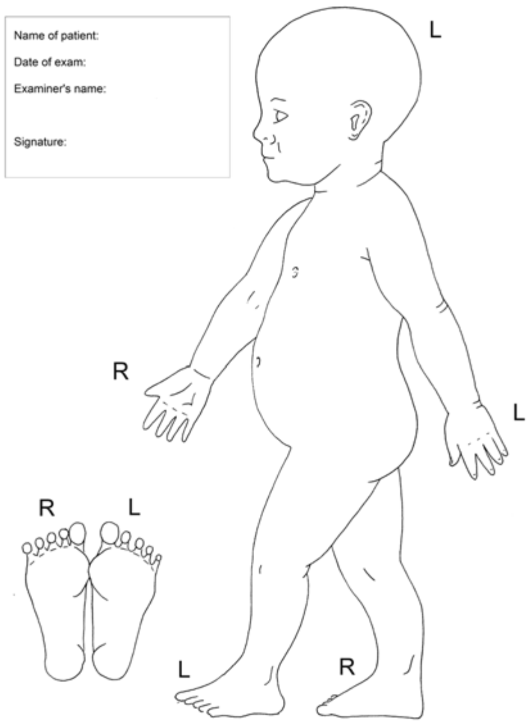

FIGURE 7.6.5 Diagram on which to mark signs of injury to the left side of the body. Reproduced with permission from Southampton City Primary Care Trust.

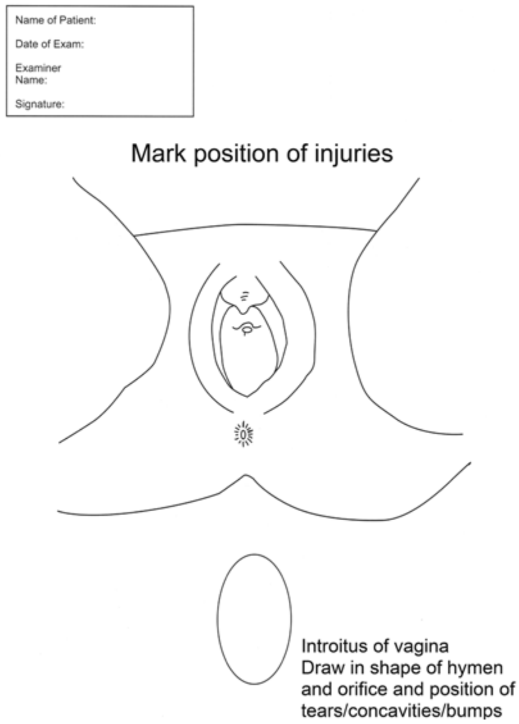

FIGURE 7.6.6 Diagram on which to draw the shape and position of any lesion on the female genitalia or anus. Reproduced with permission from Southampton City Primary Care Trust.

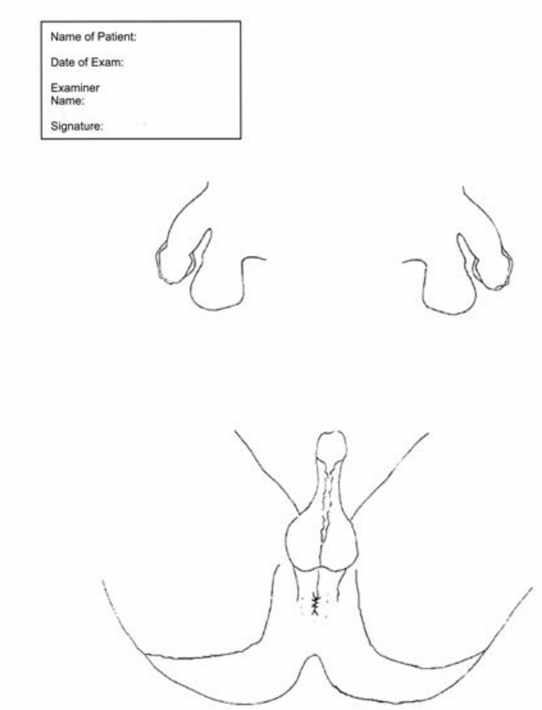

FIGURE 7.6.7 Diagram on which to draw the shape and position of any lesion on the male genitalia or anus. Reproduced with permission from Southampton City Primary Care Trust.

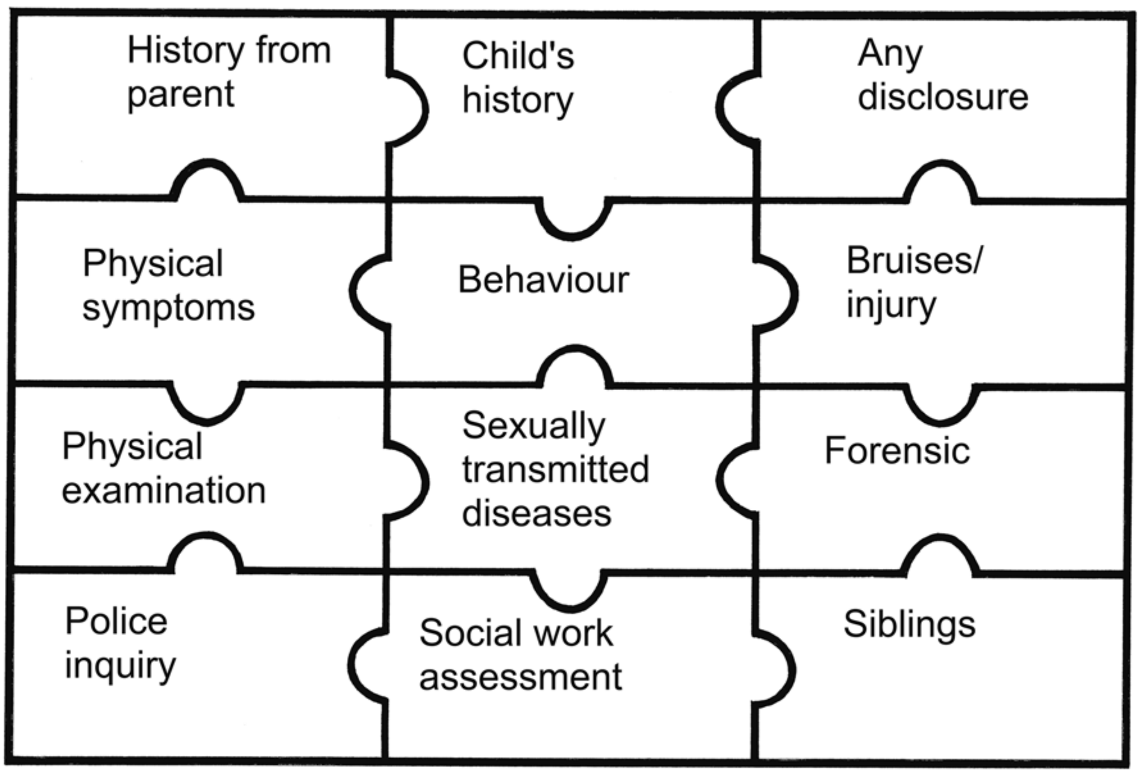

FIGURE 7.6.8 The Jigsaw of Child Abuse. (From Hobbs CJ and Wynne JM (1990) The sexually abused battered child. *Archives of Disease in Childhood* **65:** 423–427.)

Examination of female genitalia

Issue/area examined	Details
External genitalia	
Pubertal signs?	
Labial separation or traction used?	
Labial fusion?	
Urethral opening	
Labia minora	
Peri-hymenal tissues	
Posterior fourchette	
Perineum	
Hymenal opening	
Hymen	
Examination position	

Examination of anus

Issue/area examined	Details
Anal laxity/anal grip	
Anal folds	
Anal margin	
Surrounding tissues	
Examination position	

Examination of male genitalia

Issue/area examined	Details
Frenulum	
Urethral meatus/ Any discharge	
Signs of genital injury? Location	
Testicular swelling?	
Warts or skin disorders?	
Examination position	

Photographs taken of injuries
By whom: ....
Of what: ....

X-rays taken
Of what: ....

Forensic samples collected
By whom: .... Handed to whom: ....
List samples collected: ....
....
....

Screening for STDs
Date of tests: .... Results and date:
Tests taken: ....
....
....

Any other clinical investigation:

Summary and interpretation of significant abnormal findings:

Conclusions and doctor's or senior nurse's opinion:

Points discussed with social worker and parent/carer (and their opinion if applicable):

Arrangements for health follow-up for child (including investigations):

Signature: .... Date: ....

Circulation list for report:

Social worker: ....

Police: ....

Head-teacher at school: ....

Others (please specify): ....

Name(s) of other children possibly at risk of abuse:		
Surname	*First name*	*Date of birth*

Checklist after examination:

1 Have you been able to give a clear opinion on the case?
2 Have you considered alternative explanations for the findings?
3 Does the social worker understand your findings and opinion?
4 If the injuries are serious or indicate serious risk, have you considered the need for police involvement?
5 Are you happy with plans for the immediate safety of the child?
6 Are you in agreement with the proposed long-term management?
7 Is it important for you to attend the case conference? If so, make sure that the social worker knows this.
8 Have you recorded your discussions?
9 Have you written a care plan?