Approach to pain

Pain hurts!

Many patients who present to the ED are in pain. Ascertaining the site and characteristics of this pain is often very important in diagnosing the underlying problem. Relief of pain is an essential and urgent part of treatment and is usually the initial top priority for patients. Pain and distress may prevent patients from giving important details of the history and may prevent them from co-operating fully with investigations or treatment.

Standard assessment of pain

The traditional way to assess the severity of pain is to ask patients to grade the severity of their pain on a scale of 1 to 10. This simple linear system is useful in that it is easily understood by patients, who can convey the extent to which analgesia has worked by reporting changing scores over time. Establishing a pain score may work for most adults and some older children, but is not appropriate for younger children, adults with dementia, and patients with learning difficulties.

Assessment of pain in children

The numerical pain scale may be replaced by a 'faces scale' or 'pain ladder' (eg 'No pain at all'—'Stinging'—'Quite bad'—'Very bad'—'Worst ever'). Look for verbal and non-verbal clues that a child is in pain—formal scales are available such as the Alder Hey Triage Pain Score.

Assessment of pain in patients with dementia

The combination of impaired cognition and communication can make it difficult to establish if an older patient is in pain. Always consider this and remember to ask patients directly if they are experiencing any pain or discomfort. Look for signs of distress and/or agitation which are out of character with usual behaviour.

More pain than expected

If an injury or illness appears to be more painful than would be expected, consider if there are complications and/or reconsider the diagnosis. Examples in the context of trauma are:

- Severe pain despite immobilization of a fracture may be due to a vascular injury, compartment syndrome (see ➲ Crush syndrome, pp. 406–7), or a tight plaster (see ➲ Casts and their problems, pp. 430–1).
- Severe pain in patients with limb trauma where no injury is identified on X-ray may be due to missed fracture/dislocation (eg lunate dislocation, Lisfranc fracture/dislocation).
- Consider the possibility of infection (eg necrotizing fasciitis—see ➲ Necrotizing fasciitis, p. 244) or vascular compromise.
- Reflex sympathetic dystrophy (Sudeck's atrophy) may also cause severe pain starting a few days after relatively minor trauma.
- In the context of chest pain, consider aortic dissection (see ➲ Aortic dissection, pp. 96–7), and in abdominal pain, consider mesenteric infarction/ischaemia if the degree of pain is out of proportion to the physical signs.

Options for relieving pain

Analgesics

Before prescribing any drug, check what treatment has been taken at home and/or given prehospital. Consider interactions and allergies.

Splintage

Immobilizing fractures helps to relieve pain and ↓ analgesic requirements. Entonox® (see ➲ Analgesics: Entonox® and ketamine, p. 287) may help whilst a splint or cast is being applied.

Cold

Cool burns as soon as possible, usually by running under cold water, to ↓ pain and stop continuing thermal injury. Chemical burns from hydrofluoric acid (see ➲ Chemical burns, p. 405) are often extremely painful and need prolonged cooling in iced water. Pain from recent sprains and muscle injuries may be ↓ by cooling with ice-packs (or a pack of frozen peas) applied for 10–15min at a time, with towelling between the ice-pack and the skin.

Heat

Pain following sprains and strains of the neck, back, and limbs is often caused by muscle spasm. Symptomatic relief may be provided by heat from a hot bath, hot water bottle, or heat lamp.

Elevation

Many limb injuries produce considerable swelling, which causes pain and stiffness. Elevate the limb to ↓ swelling, which will help to relieve the pain and allow mobilization as soon as possible.

Dressings

Pain from minor burns and fingertip injuries often resolves after a suitable dressing is applied.

Local anaesthesia

Local anaesthesia (LA) provides excellent pain relief for fractured shaft of femur in the form of a femoral nerve or fascia iliaca compartment block (see ➲ Femoral nerve block p. 313; ➲ Shaft of femur fractures, pp. 486–7). Similarly, digital nerve and other blocks are useful for some finger and hand injuries (see ➲ Local anaesthetic nerve blocks, p. 302). Sometimes it can help to give analgesia in the form of LA before obtaining X-rays. Always check for a nerve injury (and document this) before injecting LA. Consider using a small bleb of LA SC before taking ABG.

Definitive treatment

Reducing a pulled elbow or trephining a subungual haematoma usually gives immediate relief of pain, so no analgesia is needed.

Psychological aspects of pain relief

Anxiety and distress accompany pain and worsen suffering. Psychological support is needed, as well as physical relief from pain. Patients are helped by caring staff who explain what is happening and provide support and re-assurance. The presence of family and/or a friend can help.

Analgesics: aspirin and paracetamol

Aspirin

Good for headaches, musculoskeletal pain, and dysmenorrhoea. It has anti-pyretic and mild anti-inflammatory actions. It interacts with some anticonvulsants and may exacerbate asthma and cause gastric irritation. Aspirin ↑ the risk of bleeding in patients on anticoagulants.

- Do not use aspirin in children <16y or during breastfeeding.
- Adult dose for analgesia is PO 300–900mg 4- to 6-hourly (max 4g daily).

Paracetamol ('acetaminophen' in the USA)

Paracetamol has similar analgesic and antipyretic actions to aspirin and causes less gastric irritation, but has no anti-inflammatory effects.

The therapeutic dose range of paracetamol in children and adults is 10–15mg/kg. Weigh and calculate the dose for adults and children who are small for age. In most patients, the dose can be based safely on age.

- Adult dose is 0.5–1g PO 4- to 6-hourly (max 4g in 24hr), but note some patients can get hepatotoxicity at normal doses—↓ dose if at risk (eg weight <50kg, chronic alcohol consumption, chronic malnutrition). IVI paracetamol is useful in certain circumstances—give 1g IVI over 15min in adults >50kg. ↓ dose to 15mg/kg if the adult weighs <50kg.
- For children aged <6y, use PO paracetamol infant suspension (120mg/5mL):
  - 1–2 months: 30–60mg every 8hr as required, max 60mg/kg/day.
  - 3–5 months: 60mg every 4–6hr, max four doses per day.
  - 6 months to 1y: 120mg every 4–6hr, max four doses per day.
  - 2–3y: 180mg every 4–6hr, max four doses per day.
  - 4–5y: 240mg every 4–6hr, max four doses per day.
- For children aged ≥6y, use paracetamol six plus suspension (250mg/5mL) every 4–6h, max four doses per day:
  - 6–7y: 240–250mg.
  - 8–9y: 360–375mg.
  - 10–11y: 480–500mg.
  - 12–15y: 480–750mg.
  - 16–17y: 0.5–1g.
- Paracetamol may be repeated 4- to 6-hourly. Adults and children aged ≥3 months may have a maximum of four doses in 24hr.
- Overdosage can cause liver and renal damage (see ➲ Paracetamol poisoning, pp. 198–201).

Compound analgesics (paracetamol + opioid)

Tablets containing paracetamol and low doses of opioids are widely used but have little benefit over paracetamol alone and cause more side effects, such as constipation and dizziness, particularly in the elderly. These compound preparations include:

- *Co-codamol 8/500* (codeine phosphate 8mg, paracetamol 500mg).
- *Co-dydramol* (dihydrocodeine tartrate 10mg, paracetamol 500mg).

Compound preparations of paracetamol and full doses of opioids, such as co-codamol 30/500 (codeine phosphate 30mg, paracetamol 500mg), are more potent but cause opioid side effects, including nausea, vomiting, constipation, dizziness, drowsiness, and respiratory depression.

Analgesics: NSAIDs

Non-steroidal anti-inflammatory drugs

NSAIDs are often used to treat musculoskeletal pain, with or without inflammation, although paracetamol is usually tried first. NSAIDs can cause gastric irritation, diarrhoea, GI bleeding, and perforation, with an ↑ risk at higher drug dosage and in patients aged >60y and those with a history of peptic ulcer. NSAIDs may exacerbate asthma and can precipitate AKI in patients with heart failure, cirrhosis, or renal insufficiency. Interactions occur with diuretics, anticoagulants, lithium, and other drugs (see *BNF*). Advise NSAIDs be taken after food to ↓ the risk of GI side effects. Avoid giving NSAIDs to patients who are already taking aspirin. Note there is evidence that NSAIDs impair healing after injury, so tend to be avoided by those involved in professional sport.

Many NSAIDs are available and all can cause serious adverse effects. Ibuprofen has the lowest incidence of side effects and may be bought without prescription. It is useful in children as an analgesic and an antipyretic.

- *Ibuprofen dosage in adults*: 200–400mg tds.
- *Doses for children* according to age are:
  - 1–2 months: 5mg/kg tds to qds.
  - 3–5 months: 50mg tds, max 30mg/kg/day.
  - 6–11 months: 50mg tds, max 30mg/kg/day.
  - 1–3y: 100mg tds, max 30mg/kg/day.
  - 4–6y: 150mg tds, max 30mg/kg/day.
  - 7–9y: 200mg tds, max 30mg/kg/day.
  - 10–11y: 300mg tds, max 30mg/kg/day.
  - 12–17y: 200–400mg tds.

Naproxen is more effective than ibuprofen but has fewer side effects than diclofenac:

- *Naproxen*: 500mg initially, then 250mg 6- to 8-hourly (max 1.25g daily).
- *Acute gout*: 750mg initially, then 250mg 8-hourly until pain resolves.

Diclofenac is similar in efficacy to naproxen but has more side effects:

- *Diclofenac* (PO or PR): 75–150mg daily in 2–3 divided doses.

Injectable NSAIDs

Some NSAIDs may be given by injection for musculoskeletal pain (eg for ureteric colic). The contraindications and side effects are the same as for oral treatment. IM injections are painful and can cause sterile abscesses, so PO or PR treatment is preferable.

- *Ketorolac* may be given IM or slowly IV (initial dose 10mg over at least 15s—see *BNF*). It is useful as an adjunct for manipulations under anaesthesia (MUAs).
- *Diclofenac* must be given by deep IM injection (not IV, which causes venous thrombosis). Dose: 75mg, repeated if necessary after 30min (max 150mg in 24hr).

Topical NSAIDs

NSAID gels or creams applied to painful areas provide some analgesia but are less effective than oral treatment. Systemic absorption can occur and cause adverse effects as for oral NSAIDs.

Analgesics: morphine

The standard analgesic for severe pain is morphine. It often causes nausea and vomiting in adults, so consider giving an antiemetic (cyclizine 50mg IV/IM or prochlorperazine 12.5mg IM) with it. Antiemetics are not usually necessary in children aged <10y.

Other side effects of opioids include drowsiness and constipation. Respiratory depression and hypotension may occur, especially with large doses. Pinpoint pupils can complicate neurological assessment. Naloxone (see ➲ Opioid poisoning, p. 196) reverses the effects of opioids.

IV morphine

In acute conditions, give morphine by slow IV injection, which provides rapid, but controlled, analgesia. The dose varies with the patient and the degree of pain. Titrate the dose depending on the response—2mg may be enough for a frail elderly person, but sometimes >20mg is needed in a young fit person with severe injuries. Dilute morphine with 0.9% saline to 1mg/mL (label the syringe clearly) and give it slowly IV (1–2mg/min in adults) in 1mg increments until pain is relieved. Give further analgesia if pain recurs. The dose of IV morphine in children is 100–200mcg/kg, given in increments, repeated as necessary. Patient-controlled analgesia using a computerized syringe pump is very good for post-operative analgesia, but rarely appropriate initially in the ED.

IM morphine

Provides slower and less controlled effects than IV analgesia—avoid its use, especially in shocked patients.

Oral morphine

Morphine may be given PO (eg as *Oramorph*® oral solution) but is not usually a first-line choice when a patient presents in pain to the ED.

Smooth muscle spasm due to opioids

In a (very) few patients, opioids such as morphine can cause severe pain due to smooth muscle spasm, especially spasm of the sphincter of Oddi. About 5–20min after morphine has been given, severe colicky abdominal pain develops. This may be typical of biliary colic but can mimic renal colic, intestinal perforation, or MI.

Pain from spasm of the sphincter of Oddi may be relieved by glucagon (1mg IV, repeated if necessary), although this is liable to cause vomiting. Naloxone (0.2mg IV, repeated if necessary) is also effective but may reverse the desired analgesia. GTN is another option.

Analgesics: Entonox® and ketamine

Entonox®

Entonox® is a mixture of 50% nitrous oxide (N_2O) and 50% O_2. It is stored as a compressed gas in blue cylinders with a blue and white shoulder. It is unsuitable for use at <–6°C, since the gases separate and a hypoxic mixture could be given. Entonox® diffuses more rapidly than nitrogen and so is *contraindicated* with the following: undrained pneumothorax (since it may produce a tension pneumothorax), after diving (↑ risk of decompression sickness), facial injury, base of skull fracture, intestinal obstruction, and ↓ conscious level.

Entonox® is controlled by a demand valve and inhaled through a mask or mouthpiece, often held by the patient. It gives rapid and effective analgesia and is widely used in prehospital care. In the ED, Entonox® is useful for initial analgesia, eg whilst splinting limb injuries, and for many minor procedures such as reduction of a dislocated patella or finger. Tell the patient to breathe deeply through the mask or mouthpiece, and warn that they may feel drowsy or drunk but that this will wear off within a few minutes.

Ketamine

This dissociative anaesthetic drug may be given IM or IV by experts and provides strong analgesia in sub-anaesthetic dosage. There is reluctance to use it in adult hospital practice, because it can cause hallucinations, but these are less of a problem in children. It is useful for sedating children for procedures such as minor wound suturing. Ketamine is useful in prehospital care, especially to help extrication or emergency amputation.

Airway-protective reflexes are maintained better with ketamine than with other induction agents, but airway obstruction and aspiration of gastric contents are still potential hazards. Respiratory depression is uncommon at normal dosage. Ketamine is a bronchodilator and may be used in asthmatics. It stimulates the cardiovascular system and often causes tachycardia and hypertension, so avoid it in severe hypertension. Hallucinations are less likely if a small dose of midazolam is given and the patient is not disturbed during recovery from anaesthesia.

Ketamine is available in *three strengths*: 10, 50, and 100mg/mL, which are easily confused. The IV dose for GA is 1–2mg/kg over 1min, which is effective after 2–7min and provides surgical anaesthesia for 5–10min. The IM dose for GA is 10mg/kg, which is effective after 4–15min and gives surgical anaesthesia for 12–25min. Further doses (10–20mg IV or 20–50mg IM) can be given if major limb movements or ↑ muscle tone prevent extrication of the patient.

For sedation of children undergoing suturing or other minor procedures, ketamine may be given IM (2.5mg/kg) or IV (1mg/kg over at least 1min). With this dose of ketamine, LA is needed for cleaning and suturing of wounds, but little physical restraint should be needed to allow the procedure to take place. Occasionally, a second dose of ketamine (1mg/kg IM or 0.5mg/kg IV) is required to achieve adequate sedation. Larger initial doses provide deeper sedation but are more likely to cause side effects (eg vomiting or agitation) during recovery. With low doses of ketamine, agitation is unlikely and there is no need to add midazolam.

Analgesics: other opioids

Codeine

This is a weak opioid which is used PO for moderate pain (30–60mg 4-hourly, max 240mg daily) and has side effects similar to those of morphine. Codeine may also be given IM (but not IV, because it can cause hypotension). Note that codeine is a pro-drug, so its efficacy is variable.

Dihydrocodeine

This is very similar to codeine. As with codeine, opioid dependency can occur with prolonged usage.

Tramadol

Stronger than codeine, tramadol inhibits reuptake of serotonin and noradrenaline, in addition to its opioid action. Its metabolism varies between individuals, and so its analgesic effects can be unpredictable. However, tramadol may be useful for the management of chronic pain in some patients, especially where NSAIDs are not an option. Start with 50mg PO bd, ↑ as necessary to 100mg PO qds.

Diamorphine

Otherwise known by the street name 'heroin', diamorphine has similar effects to morphine but is more soluble and so can be dissolved in a very small volume of diluent. Nasal diamorphine provides effective analgesia in children (see ➲ Nasal diamorphine for analgesia in children, p. 291).

Fentanyl

This short-acting opioid is particularly useful for patients undergoing brief procedures in the ED such as manipulation of fractures or dislocations. The dose of fentanyl is 0.5mcg/kg slow IV, repeated as required. The rapid onset (and offset) is an advantage, but depending upon the dose used, there is an ↑ risk of inducing apnoea when compared with morphine.

Pethidine

Providing rapid, but brief, analgesia, pethidine is less potent than morphine. It is associated with a number of problems and has fallen out of favour and routine use.

Penthrox®

Methoxyflurane (Penthrox®) is very useful for managing pain after trauma in adults, especially during manipulations of dislocations and fractures. It is easy to use and works quickly after inhalation. It does not usually require any specific additional monitoring. One or two 3mL doses may be given in 24h (eg for shoulder dislocation, one whilst getting X-rays, another whilst being relocated). Do not use it in patients with known renal impairment or liver disease or if there is a history of serious reaction to inhaled anaesthetics.

Analgesia for trauma

Multiple injuries

Entonox® may be useful for analgesia during transport and initial resuscitation but only allows administration of 50% O_2 and is contraindicated if there is an undrained pneumothorax. As soon as practicable, use other forms of analgesia, such as IV morphine (see ➲ Analgesics: morphine, p. 286) and/or nerve blocks (see ➲ Local anaesthetic nerve blocks, p. 302), and splintage of fractures to ↓ pain and blood loss.

Head injury

Relief of pain is particularly important in head-injured patients, since pain and restlessness ↑ ICP, which can exacerbate secondary brain injury. Aim to treat headache following a head injury with paracetamol, an NSAID, or codeine (which causes less central depression than stronger opioids such as morphine). If headache is severe or ↑, arrange a CT scan to look for an intracranial haematoma. Try to avoid strong opioids, because of concern about sedation and respiratory depression, but if pain is severe, give morphine in small IV increments—the effects can be reversed, if necessary, with naloxone. Femoral nerve block (or fascia iliaca compartment block) is particularly useful in a patient with a head injury and a fractured femur, since it ↓ the need for opioids.

Small children with minor head injuries often deny having headaches but look and feel much better if given paracetamol (see ➲ Analgesics: aspirin and paracetamol, p. 284). Give further doses, if necessary, over the following 12–24hr.

Chest injury

Chest injuries are often extremely painful. Good analgesia is essential to relieve distress, enable deep breaths to be taken, and ↓ risk of complications such as pneumonia and respiratory failure. Avoid Entonox® if a pneumothorax is a possibility, until this has been excluded or drained. Give high-concentration O_2, as necessary, and check SpO_2 and ABG. Give morphine in slow IV increments (see ➲ Analgesics: morphine, p. 286) and monitor for respiratory problems. Intercostal nerve blocks (see ➲ Intercostal nerve block, p. 303) provide good analgesia for fractured ribs but may cause a pneumothorax and so are only used in patients being admitted. In severe chest injuries, get anaesthetic or ICU help—thoracic epidural anaesthesia can sometimes avoid the need for IPPV. Before a thoracic epidural is performed, check X-rays/CT of the thoracic spine for fractures. Many patients who are admitted with chest injuries benefit from patient-controlled analgesia.

Analgesia in specific situations

Children

Injured children are distressed by pain and fear. Enlist parental support. Explanation and reassurance are important, but give analgesia as needed.

Start oral analgesia with paracetamol (see ➲ Analgesics: aspirin and paracetamol, p. 284), but if this is inadequate, add ibuprofen (see ➲ Analgesics: NSAIDs, p. 285), dihydrocodeine elixir, or morphine sulfate oral solution (eg Oramorph®):

- *Ibuprofen*—see ➲ Analgesics: NSAIDs, p. 285 for dose.
- *Dihydrocodeine elixir dose*: 0.5–1mg/kg PO 4- to 6-hourly.
- Children in severe pain may benefit from PO morphine
  - 1–2 months: 50–100mcg/kg.
  - 3–5 months: 100–150mcg/kg.
  - 6–11 months: 200mcg/kg.
  - 1–11y: 200–300mcg/kg.
  - 12–17y: 5–10mg.

Entonox® (see ➲ Analgesics: Entonox® and ketamine, p. 287) gives rapid analgesia without the need for an injection.

IV morphine is appropriate in severe injuries, but beware sedation.

Femoral nerve block (see ➲ Femoral nerve block, p. 313) provides good analgesia for femoral fractures and is usually well tolerated.

Digital nerve block with bupivacaine (see ➲ Digital nerve block, pp. 304–5) is useful for painful finger injuries, especially crush injuries. Consider before X-ray—when the child returns from X-ray, the finger may then be treated painlessly.

IM morphine could be used to provide analgesia for small burns or fractured arms, but PO morphine or nasal diamorphine are preferable, since IM injections are painful and unpleasant.

Nasal diamorphine is playing an ↑ role in the provision of pain relief in children (see Table 7.1).

Acute abdominal pain

It is cruel and unnecessary to withhold analgesia from patients with acute abdominal pain. Adequate analgesia allows the patient to give a clearer history and often facilitates examination and diagnosis—tenderness and rigidity become more localized, and masses more readily palpable. Good X-rays cannot be obtained if the patient is distressed and restless because of renal colic or a perforated ulcer.

Morphine by slow IV injection (see ➲ Analgesics: morphine, p. 286) is appropriate in severe pain, unless this is due to renal or biliary colic, in which an NSAID (see ➲ Analgesics: NSAIDs, p. 285) may be preferred. Morphine occasionally causes severe abdominal pain due to smooth muscle spasm of the sphincter of Oddi (see ➲ Smooth muscle spasm due to opioid analgesics, p. 286).

Toothache

Toothache or pain after dental extractions can often be eased by aspirin, an NSAID, or paracetamol. Do not give opioids such as codeine or dihydrocodeine, which may make the pain worse. Drainage of a dental abscess may be required to relieve toothache.

Nasal diamorphine for analgesia in children

In the UK, diamorphine is licensed for use IV, IM, SC, and PO. Nasal diamorphine is an effective and acceptable method of analgesia for children with limb fractures or small burns who do not need immediate venous access. It should be given as soon as possible, prior to X-rays.

Contraindications Age <1y (or weight <10kg), nasal obstruction or injury, basal skull fracture, opioid sensitivity.

Verbal consent for nasal diamorphine should be obtained from the child's parents (and the child, if appropriate). Follow local protocols and see https://bnfc.nice.org.uk/drug/diamorphine-hydrochloride.html

One method delivering nasal diamorphine is described as follows:

The dose of nasal diamorphine is 0.1mg/kg, given in a syringe in a volume of 0.2mL. The child is weighed. The appropriate concentration of solution for the weight of child is achieved by adding a suitable volume of 0.9% saline to a 10mg ampoule of diamorphine.

Table 7.1 Dosage of nasal diamorphine in children

Weight (kg)	Volume of saline (mL)	Dose of diamorphine (mg) in 0.2mL
10	2.0	1.0
15	1.3	1.5
20	1.0	2.0
25	0.8	2.5
30	0.7	2.9
35	0.6	3.3
40	0.5	4.0
50	0.4	5.0
60	0.3	6.7

A volume of 0.2mL of this solution is drawn up into a syringe and given in one or both nostrils, whilst the child's head is tilted backwards. Turn the head to each side, maintaining each position for several seconds. A small syringe can be used to drip the solution into the nose, but, if possible, use an aerosol device (eg MAD®), allowing for the dead space of the device (0.1mL for MAD®, so draw up 0.3mL). Record the time of administration. Monitor the conscious level for 20min. Respiratory depression is unlikely, but resuscitation facilities and naloxone must be available. Nasal diamorphine provides rapid analgesia which lasts up to 4hr.

Fentanyl may also be used nasally (initial dose 2mcg/kg) as an alternative to nasal diamorphine.

Local anaesthesia

Indications for local anaesthesia in the ED

LA is indicated in any situation in which it will provide satisfactory analgesia or safe and adequate conditions for operations or procedures. These include the following:

- *Insertion of venous cannulae* (0.1mL of 1% lidocaine SC 30s prior to cannulation ↓ the pain of cannulation without affecting the success rate).
- *Obtaining ABG*.
- *Cleaning, exploration, and suturing* of many wounds.
- *Analgesia for some fractures*, eg shaft of femur.
- *Minor operations/procedures*, eg manipulation of some fractures and dislocations, insertion of chest drain, drainage of paronychia, removal of corneal FB.

Contraindications to local anaesthetic

- *Refusal or poor patient co-operation*.
- *Allergy to LA*: severe allergic reactions to LA are rare, but anaphylaxis can occur. If allergy to LA is alleged, obtain full details of the circumstances and the drug involved and check with a senior before giving any LA. It may be possible to use a different drug. Some reactions are caused by the preservative in multi-dose vials, rather than the drug itself, so single-dose ampoules may not cause a problem. Some alleged 'allergies' are actually toxic effects due to overdosage, or faints due to fear and pain.
- *Infection at the proposed injection site*: injection into an inflamed area is painful and could spread infection. High tissue acidity from inflammation ↓ the effectiveness of LA drugs. Hyperaemia causes rapid removal of the drug, and so a short duration of action and an ↑ risk of toxicity. LA nerve block at a site away from the infected area can provide good anaesthesia (eg digital nerve block for paronychia or nerve blocks at the ankle for an abscess on the sole of the foot).
- *Bleeding disorder*: anticoagulant therapy and thrombocytopenia are contraindications for nerve blocks in which there is a risk of inadvertent arterial puncture (eg femoral nerve block and fascia iliaca block).

Special cautions (increased risk of toxicity)

- Small children.
- Elderly or debilitated.
- Heart block.
- Low cardiac output.
- Epilepsy.
- Myasthenia gravis.
- Hepatic impairment.
- Porphyria.
- Anti-arrhythmic or β-blocker therapy (risk of myocardial depression).
- Cimetidine therapy (inhibits metabolism of lidocaine).

Lidocaine (previously known as 'lignocaine')

Lidocaine is the LA used most often for local infiltration and nerve blocks. It is available in 0.5%, 1%, and 2% solutions, either 'plain' (without adrenaline) or with adrenaline 1:200,000. For routine use, the most suitable choice is 1% plain lidocaine.

- *Duration of action*: lidocaine starts to work within a few minutes—the effects last from 30 to 60min (for plain lidocaine) to 90min (lidocaine with adrenaline). The duration of action varies with the dosage and local circulation.
- *For plain lidocaine*: the maximum dose is 200mg (20mL of 1% solution) in a healthy adult or 3mg/kg in a child.
- *For lidocaine with adrenaline*: the maximum dose is 500mg (50mL of 1% solution) in a healthy adult or 7mg/kg in a child.

These are the maximum total doses for one or more injections of LA given together for local infiltration or nerve block (with care to avoid intravascular injection). Reduce the dose in debilitated or elderly patients, or if there is a particular risk of toxicity (see ➲ Local anaesthetic toxicity, p. 294).

Lidocaine can also be used for anaesthesia of the skin (with prilocaine in EMLA® cream—see ➲ Topical anaesthesia, p. 298), urethra, and cornea, and also as a spray for anaesthetizing mucous membranes in the mouth and throat.

Bupivacaine

Bupivacaine is particularly useful for nerve blocks since it has a long duration of action (3–8hr), although its onset of anaesthesia is slower than that of lidocaine. It may also be used for local infiltration, but not for Bier's block (see ➲ Bier's block, pp. 300–1). Bupivacaine is available in concentrations of 0.25% and 0.5%, with or without adrenaline—the usual choice is 0.5% bupivacaine without adrenaline. The maximum dose of bupivacaine (with or without adrenaline) for a fit adult is 150mg (30mL of 0.5% or 60mL of 0.25%) and for a child 2mg/kg.

Note: levobupivacaine is similar but has a longer duration of action.

Prilocaine

Prilocaine has a similar duration of action to lidocaine. It can be used for local infiltration or nerve blocks but is particularly useful for Bier's block (see ➲ Bier's block, pp. 300–1). High doses (usually >600mg) may cause methaemoglobinaemia. The maximum dose of prilocaine for a healthy adult is 400mg (40mL of 1% solution) and for a child 6mg/kg.

Tetracaine (amethocaine)

Tetracaine is used for topical LA of the cornea (see ➲ LA drops to aid examination, p. 551) and skin (see ➲ Topical anaesthesia, p. 298).

Proxymetacaine

Proxymetacaine is also used for topical LA of the cornea. It causes less initial stinging than tetracaine and so is particularly useful in children.

Local anaesthetic toxicity

Toxic effects

These result from overdosage of LA or inadvertent intravascular injection. The first symptoms and signs are usually neurological, with numbness of the mouth and tongue, slurring of speech, light-headedness, tinnitus, confusion, and drowsiness. Muscle twitching, convulsions, and coma can occur.

Cardiovascular toxicity may initially result in tachycardia and hypertension, but later there is hypotension with bradycardia and heart block. Ventricular arrhythmias and cardiac arrest occur occasionally, especially with bupivacaine.

Early signs of toxicity

These may be detected if the doctor maintains a conversation with the patient whilst injecting the LA. Toxic effects may start immediately if an intravascular injection is given. However, peak blood levels usually occur ~10–25min after injection—so if a relatively large dose has been given, do not leave the patient alone whilst anaesthesia develops.

Occasionally, patients initially agree to LA but become 'hysterical' or faint when an injection is given. In such circumstances, it may be difficult to distinguish immediately between the effects of anxiety and those of drug toxicity.

Management of LA toxicity

- Stop the procedure.
- Call for help.
- Clear and maintain the airway.
- Give 100% O_2 and ensure adequate lung ventilation.
- Obtain reliable IV access. If possible, take blood for U&E, FBC, and LFTs.
- Monitor ECG. Record pulse, BP, RR, and conscious level.
- If convulsions occur, ensure adequate oxygenation and give lorazepam (adult dose 2–4mg slowly IV; child 100mcg/kg, max 4mg) or diazepam (adult 5–10mg slowly IV; child 100mcg/kg).
- Treat hypotension by raising the foot of the trolley. If systolic BP remains <90mmHg in an adult, give IV fluids (eg 500mL of 0.9% saline). In a child, give 20mL/kg if systolic BP is <70mmHg.
- Bradycardia usually resolves without treatment. If bradycardia and hypotension persist, give atropine and consider IV lipid emulsion. Dobutamine, isoprenaline, or temporary pacing are potential options if bradycardia is associated with hypotension.
- In cardiac arrest due to LA toxicity, give lipid emulsion using Intralipid® 20% 1.5mL/kg IV over 1min (bolus of 100mL for a 70kg patient), then 15mL/kg/hr (500mL over 30min for a 70kg patient). Continue CPR. If circulation is still inadequate, repeat IV bolus of Intralipid® twice at 5min intervals, then IVI 30mL/kg/hr (500mL over 15min). The maximum total dose of 20% lipid emulsion is 12mL/kg. Note that propofol is not an alternative to lipid emulsion.

(See ➲ Lipid emulsion (Intralipid®) therapy for drug toxicity, p. 195 and https://anaesthetists.org/Home/Resources-publications/Guidelines/Management-of-severe-local-anaesthetic-toxicity)

Adrenaline (epinephrine) in LA

Most LAs cause vasodilatation, so adrenaline is sometimes added as a vasoconstrictor. This ↓ blood loss, ↑ duration of anaesthesia, and ↓ toxicity by delaying absorption of the LA. Lidocaine with adrenaline is often useful in scalp wounds, in which bleeding can be profuse, but the bleeding point is not visible.

Bupivacaine with adrenaline is used for intercostal nerve block to ↓ the risk of toxicity from rapid absorption in a relatively vascular area.

Lidocaine with adrenaline can be used in some situations (see below for contraindications) if a relatively large volume of LA is needed, since the maximum dose for a healthy adult is 500mg (50mL of 1% solution), compared to 200mg (20mL of 1%) for plain lidocaine. Other possibilities in such circumstances include 0.5% lidocaine, prilocaine (max dose 40mL of 1% solution), or GA.

The maximum concentration of adrenaline in LA is 1 in 200,000, except for dental anaesthesia in which 1 in 80,000 may be used. The maximum total dose of adrenaline in a healthy adult is 500mcg.

Contraindications and cautions

Never use adrenaline for injections in the nose, ears, or penis, nor in Bier's block (see ➲ Bier's block, pp. 300–1). Avoid adrenaline for injections in or near flap lacerations, since vasoconstriction could cause ischaemic necrosis. Adrenaline is traditionally regarded as dangerous in digital nerve blocks of fingers and toes, because of the risk of ischaemia, but some hand surgeons have used LA with adrenaline uneventfully to ↓ bleeding and avoid the need for a finger tourniquet. However, use plain LA (without adrenaline) routinely in fingers and toes to avoid concerns about ischaemia.

Avoid adrenaline in

- IHD.
- Hypertension.
- Peripheral vascular disease.
- Thyrotoxicosis.
- Phaeochromocytoma.
- Patients on β-blockers.

The *BNF* states that LA with adrenaline appears to be safe in patients on tricyclic antidepressants.

Storage

Keep ampoules and vials of LA with adrenaline in a locked cupboard, separate from those without adrenaline, so that they are only available by special request and are not used inadvertently or inappropriately.

General principles of local anaesthesia

Obtain a brief medical history and record drug treatment and allergies. Think about possible contraindications and cautions for LA (see ➲ Local anaesthesia, pp. 292–3). Obtain expert advice if there is any query or concern.

Consent for local anaesthesia

Explain to the patient what is planned. Verbal consent is adequate for most LA procedures in the ED.

Written consent is advised

- If there is a significant risk of a toxic reaction or complication, including procedures needing large doses of LA.
- For Bier's block (see ➲ Bier's block, pp. 300–1).
- For intercostal nerve block (risk of pneumothorax).

Safety

Ensure that resuscitation equipment and drugs for toxic reactions are readily available. Monitoring and IV access are not needed for routine simple LA but are essential if there is a risk of complications or toxicity. Calculate the maximum dose of LA that could be used (see ➲ Local anaesthesia, pp. 292–3) and think how much might be needed. Before drawing up any LA, check the drug label carefully, especially if adrenaline is contraindicated.

Giving local anaesthetic

- Lie the patient down in a comfortable position, with the site of injection accessible and supported. Some patients faint if LA is injected whilst they are sitting up.
- Warm the LA to body T° prior to use.
- Wash hands, use gloves, and clean the skin.
- Use a fine needle, if possible. Before inserting the needle, warn the patient and hold the relevant part firmly to prevent movement.
- Aspirate and check for blood in the syringe before injecting any LA. If the needle moves, aspirate again.
- Inject LA slowly to ↓ pain. Do not use force if there is resistance to injection.
- Maintain a conversation with the patient, to allay anxieties and also to detect any early signs of toxicity (see ➲ Local anaesthetic toxicity, p. 294).

Further details of techniques and precautions are listed in:

- ➲ Topical anaesthesia, p. 298.
- ➲ Local infiltration anaesthesia and ➲ Field block, p. 299.
- ➲ Haematoma block, p. 299.
- ➲ Bier's block, pp. 300–1.
- ➲ Local anaesthetic nerve blocks, p. 302; ➲ Digital nerve block, pp. 304–5; ➲ Median and ulnar nerve blocks, pp. 306–7; ➲ Radial nerve block at the wrist, p. 308 ➲ Nerve blocks of forehead and ear, pp. 310–11; ➲ Dental anaesthesia, p. 309; ➲ Intercostal nerve block, pp. 303; ➲ Femoral nerve block, p. 313; ➲ Nerve blocks at the ankle, pp. 314–15.

Recording the local anaesthetic

Write clearly in the notes to record the time and site of injection and the type and quantity of LA given.

Local anaesthesia in children

The general principles are the same as for adults. LA is very useful in children but requires experienced staff. Many children tolerate LA without any problem, but in some, sedation with midazolam (see ➲ Sedation in children, p. 319) or ketamine (see ➲ Ketamine, p. 287) can be helpful.

Weigh the child, if possible, and calculate the maximum dose of LA (see ➲ Lidocaine (previously known as 'lignocaine'), p. 293). In an average-size child, a simple initial estimate of the maximum dose of 1% plain lidocaine is 1mL/y of age (ie 3mL for a 3y old child). If a larger volume may be needed, consider using 0.5% solution or lidocaine with adrenaline (see ➲ Adrenaline (or epinephrine) in local anaesthesia, p. 295), or possibly GA instead.

Prepare everything before bringing the child into the room—rattling equipment and drawing up LA within sight of a child causes unnecessary anxiety. Most parents prefer to stay with their child during the procedure and this is usually helpful. Position the child and parent comfortably. Explain simply and honestly what is going to happen. Have adequate help to keep the child still. Use a small needle, if possible, and inject slowly to minimize pain from the injection.

Topical anaesthesia

LA applied directly to mucous membranes of the mouth, throat, or urethra will diffuse through and block sensory nerve endings. Development of anaesthesia may take several minutes, and the duration is relatively short because of the good blood supply. Overdosage is relatively easy because most topical preparations contain high concentrations of lidocaine (2% in lidocaine gel, 5% in ointment, and 4% or 10% in lidocaine spray).

Lidocaine gel has been used to allow cleaning of gravel burns, but this is not advisable—absorption of lidocaine can easily cause toxicity and the degree of anaesthesia is rarely satisfactory. Scrubbing is often necessary to remove embedded gravel, so proper anaesthesia is essential. Field block may be adequate for a small area, but GA is often necessary for cleaning large or multiple gravel burns, in order to avoid tattooing.

Topical anaesthesia

Lidocaine with prilocaine (eg EMLA®) cream

Lidocaine 2.5% with prilocaine 2.5% cream (eg EMLA®—'eutectic mixture of local anaesthetics') can usefully ↓ pain of an injection or cannulation. It must only be applied to intact skin (not wounds) and the onset of anaesthesia is slow, usually ~1hr. Apply a thick layer of cream to the skin and cover it with an occlusive dressing, which must be left undisturbed for 1hr.

Tetracaine (amethocaine) gel (Ametop®)

This is similar to EMLA® but acts more quickly (~30–45min) and causes vasodilatation, which aids venous cannulation. Do not use it in wounds because of the risk of rapid absorption and toxicity.

Other topical LA agents

Topical agents such as TAC (tetracaine, adrenaline, and cocaine) or LET (lidocaine, epinephrine, and tetracaine) are sometimes used to provide anaesthesia for wound repair. These preparations can provide effective anaesthesia, but toxic effects may occur from excessive absorption (especially of cocaine).

Ethyl chloride

Ethyl chloride is a clear fluid which boils at 12.5°C. Spraying the liquid on the skin causes rapid cooling and freezing of the surface. In the past, ethyl chloride was used for incision of paronychias and small abscesses, but it rarely provides adequate anaesthesia and is not recommended. Ethyl chloride is highly inflammable and is a GA, so it must always be handled with care.

Local anaesthetic administration

Local infiltration anaesthesia

Local infiltration is the technique used most often in the ED. The LA injected SC in the immediate area of the wound acts within 1–2min. Anaesthesia lasts 30–60min with plain lidocaine or ~90min with lidocaine and adrenaline.

In clean wounds, consider ↓ the pain of injection by inserting the needle through the cut surface of the wound. Do not do this in dirty or old wounds, because of the risk of spreading infection. Less pain is produced by injecting slowly through a thin needle, injecting in a fan-shaped area from a single injection site, and inserting the needle in an area already numbed by an earlier injection. Rapid injection of LA, especially in scalp wounds, can cause spraying of the solution from the tip of the needle or from separation of the needle from the syringe. Slow injection and the use of goggles will ↓ the risk of transmission of infection.

Field block

This involves infiltration of LA SC around the operative field. Sometimes it is only necessary to block one side of the area, depending on the direction of the nerve supply. Field block can be useful for ragged and dirty wounds and for cleaning gravel abrasions. Check the maximum safe dose before starting a field block. If relatively large volumes of anaesthetic might be needed, consider using 0.5% lidocaine or lidocaine with adrenaline (see ➲ Adrenaline (or epinephrine) in local anaesthesia, p. 295).

Haematoma block

A Colles' fracture (see ➲ Colles' fracture, pp. 454–5) can be manipulated after infiltration of LA into the fracture haematoma and around the ulnar styloid. This may provide less effective anaesthesia than Bier's block (see ➲ Bier's block, pp. 300–1) and risk a poorer reduction. It also technically converts a closed fracture into an open one, and so there is a theoretical risk of infection, but in practice, this is rarely a consideration if an aseptic technique is employed.

Contraindications and warnings

- Fractures >24hr old (since organization of the haematoma prevents spread of the LA).
- Infection of the skin over the fracture.
- Methaemoglobinaemia (avoid prilocaine).

Drug and dosage 15mL of 1% plain prilocaine. Lidocaine can be used, but it has a lower margin of safety. Never use solutions containing adrenaline.

Technique Use a 20mL syringe and 0.6 × 25mm needle, with full asepsis. Insert the needle into the fracture haematoma and aspirate blood to confirm this—it is usually easiest to do this by angling the needle slightly and approaching the fracture from the dorsum of the wrist, proximal to the fracture. Inject slowly to ↓ pain and the risk of high blood levels and toxicity. Anaesthesia develops in ~5min and lasts 30–60min. Sometimes anaesthesia is inadequate, so an alternative anaesthetic is needed.

Bier's block

Bier's block (IVRA) is often used to provide anaesthesia for reduction of Colles' fractures or for minor surgery below the elbow. Bier's block uses a large dose of LA, and so there is a risk of a toxic reaction, although this is minimized by correct technique. Undertake a preoperative assessment and checklist, including recording of BP and weight. Obtain written consent for the operation. Ensure that there are at least two trained staff present throughout the procedure, including a practitioner who is competent to deal with severe toxic reactions.

Contraindications

- Allergy to LA.
- Severe hypertension (>200mmHg systolic) or obesity (cuff unreliable).
- Severe peripheral vascular disease.
- Infection or lymphoedema in the affected arm.
- Raynaud's syndrome or scleroderma.
- Sickle-cell disease or trait.
- Methaemoglobinaemia.
- Children aged <7y (older children may also not be suitable for Bier's block, depending upon the child).
- Unco-operative or confused patient.
- Procedures needed in both arms.
- Surgery that may last >30min.
- Surgery that may need the tourniquet to be released.

Proceed with caution in patients who have epilepsy because of the risk of a fit from LA toxicity.

Drug and dose

The most suitable drug for Bier's block is prilocaine, from a single-dose vial without preservative. Never use solutions with adrenaline. Do not use lidocaine or bupivacaine, which are more likely than prilocaine to cause toxic effects. The ideal concentration of prilocaine is 0.5%. If only 1% prilocaine is available, dilute it with an equal volume of 0.9% saline to make 0.5% prilocaine.

The dose of prilocaine is 3mg/kg, which is 42mL of 0.5% prilocaine for a 70kg adult, or 30mL of 0.5% prilocaine for a 50kg patient.

Equipment

- A special tourniquet apparatus is required, including a double cuff with a fail-safe mechanism option to ensure the proximal cuff cannot be deflated until the distal cuff is inflated.
- Check the tourniquet apparatus and cuff regularly.
- Ordinary BP cuffs and sphygmomanometers are not reliable enough and should not be used for Bier's blocks.
- Check that resuscitation equipment and drugs are available (including Intralipid®).
- Ensure that the patient is on a tipping trolley.
- Monitor the ECG, BP, and SpO_2 throughout.

Technique for Bier's block

- Insert a small IV cannula in the dorsum of the hand on the side of the operation (ready for injection of prilocaine) and another IV cannula in the opposite arm (for emergency use, if needed).
- Check the radial pulse. Place the double tourniquet high on the upper arm over padding, but do not inflate it yet.
- Elevate the arm for 3min, whilst pressing over the brachial artery, to try to exsanguinate the limb. (Do not use an Esmarch bandage for this purpose, because of pain.)
- Whilst the arm is elevated, inflate the proximal cuff tourniquet to 300mmHg, or at least 100mmHg above the systolic BP. Lower the arm onto a pillow, and check that the tourniquet is not leaking.
- Record the tourniquet time. Observe the tourniquet pressure constantly during the procedure.
- Slowly inject the correct volume of 0.5% plain prilocaine into the isolated limb, which will become mottled. If the operation is on the hand, squeeze the forearm during injection to direct the LA peripherally. Test for anaesthesia after 5min. If anaesthesia is inadequate, inject 10–15mL of 0.9% saline to flush prilocaine into the arm. Occasionally, no adequate anaesthesia is achieved and GA or IV sedation is needed instead.
- Complete the manipulation or operation. Before applying a POP back slab, remove the cannula from the injured arm.
- Keep the proximal tourniquet cuff inflated for at least 20min and a maximum of 45min. *Note*: if after 20min, there is severe pain due to the cuff and/or a second manipulation is required, use the fail-safe option and inflate the distal cuff over the now anaesthetized skin, then deflate the proximal cuff.
- Obtain a check X-ray whilst the proximal tourniquet cuff is still inflated (in case remanipulation is required).
- If the check X-ray is satisfactory, deflate the tourniquet slowly and record the time. Maintain a conversation with the patient and watch carefully for any sign of toxicity. If any toxic effects occur, re-inflate the tourniquet and give any necessary treatment (see ➔ Local anaesthetic toxicity, p. 294).
- After release of the tourniquet, the arm becomes warm and flushed. Sensation returns after a few minutes.
- Observe the patient carefully for at least 30min after a Bier's block, in case of delayed toxicity. Check the circulation of the limb before the patient is discharged home. Reactive swelling can occur—elevate the limb in a sling and give POP instructions.

(See the RCEM best practice guideline, available at https://www.rcem.ac.uk)

Local anaesthetic nerve blocks

LA nerve blocks are very useful to enable minor procedures and to provide analgesia.

Equipment for nerve blocks

Ordinary injection needles can be used for most local blocks in the ED. Anaesthetists sometimes use special pencil-point or short bevel needles when blocking large nerve trunks and plexuses.

General procedure for nerve blocks

- Follow the general principles of LA (see ➲ Local anaesthesia, pp. 292–3).
- Review the relevant anatomy for the block. Determine the site of injection by feeling for local structures such as arteries or tendons.
- When performing a nerve block, hold the needle with the bevel in the line of the nerve (rather than across it), to reduce the risk of cutting nerve fibres.
- Ask the patient about tingling in the area supplied by the nerve. Do not try to elicit paraesthesiae. If paraesthesiae occurs, withdraw the needle 2–3mm before injecting.
- Wait for the nerve block to work, but do not leave the patient alone during this time. Estimate when a nerve block should be effective and do not test sensation before then. Small nerves may be blocked in 5min, but large nerves may take up to 40min.

Failed nerve block

If a nerve block does not work, consider waiting longer or giving another injection. Before giving any more LA, review the relevant anatomy; consider using USS guidance, and check that the maximum safe dose of the drug will not be exceeded. Entonox® can be helpful as a supplement to LA for some procedures such as reduction of dislocations. Alternatively, sedation (see ➲ Approach to sedation, pp. 316–17) may be useful, or occasionally GA instead.

Ultrasound guidance for nerve blocks

USS guidance can help in identifying nerves and other structures and allows visualization of the needle position and the spread of LA. Precise injection of LA adjacent to a nerve gives a faster onset and a longer duration of anaesthesia, with a smaller volume of LA, less pain, and a ↓ risk of complications. USS is unnecessary for some nerve blocks, eg digital nerves and supraorbital nerve block. USS allows nerve blockade away from identifying structures (eg medial nerve block in the forearm).

Successful use of USS for LA requires appropriate equipment, knowledge of the relevant anatomy, and training in USS techniques.

Intercostal nerve block

Intercostal nerve blocks (see Fig. 7.1) can give useful analgesia for patients with rib fractures who are admitted to hospital. Inserting a block is not routine but requires training and experience. These blocks must not be used in outpatients and should not be performed bilaterally because of the risk of pneumothorax. Patients with obesity or severe obstructive airways disease have ↑ risk of complications. Alternative procedures used in the ICU are interpleural analgesia and thoracic epidurals, but these are not appropriate initially in the ED.

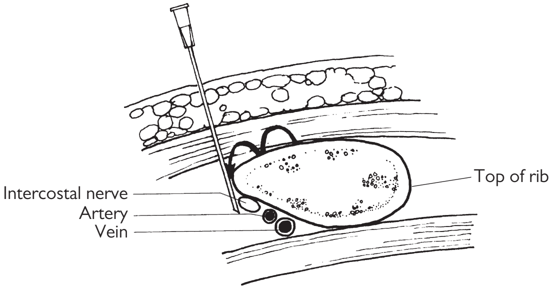

Fig. 7.1 Intercostal nerve block (note that the neurovascular bundle runs below the rib).
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Digital nerve block

Digital nerve block (see Fig. 7.2) is used frequently for simple procedures on the fingers and toes. (The term 'ring block' is often used but is incorrect since it implies that LA is injected in a ring around the finger, which is unnecessary and might cause ischaemia due to vascular compression.)

A dorsal nerve and a palmar digital nerve run along each side of the finger and thumb. Similarly, there are dorsal and plantar nerves in the toes.

Plain lidocaine (1%) is often used, but bupivacaine (0.5% plain) is preferable because it is less painful on injection and gives prolonged anaesthesia and analgesia. Traditional advice is never to use adrenaline or any other vasoconstrictor. In an adult, use 1–2mL of LA on each side of the finger, thumb, or big toe. Use smaller volumes in the other toes or in children.

Technique

- Use a 0.6 × 25 mm (23G) needle [0.5 × 16 mm (25G) in small children].
- Insert the needle from the dorsum on the lateral side of the base of the digit, angled slightly inwards towards the midline of the digit, until the needle can be felt under the skin on the flexor aspect.
- Aspirate to check the needle is not in a blood vessel.
- Slowly inject 0.5–1mL. Continue injecting as the needle is withdrawn.
- Repeat on the medial side of the digit.
- If anaesthesia is needed for the nail bed of the great toe, give an additional injection of LA SC across the dorsum of the base of the proximal phalanx, to block the dorsal digital nerves and their branches. This is also required for anaesthesia of the dorsum of the digit proximal to the middle phalanx.

Anaesthesia develops after ~5min. Autonomic nerve fibres are blocked, as well as sensory nerve fibres, so when the block works, the skin feels dry and warm. Occasionally, anaesthesia remains inadequate and another injection is needed. The maximum volume for a finger, thumb, or big toe is 5mL. Use less in the other toes or in children.

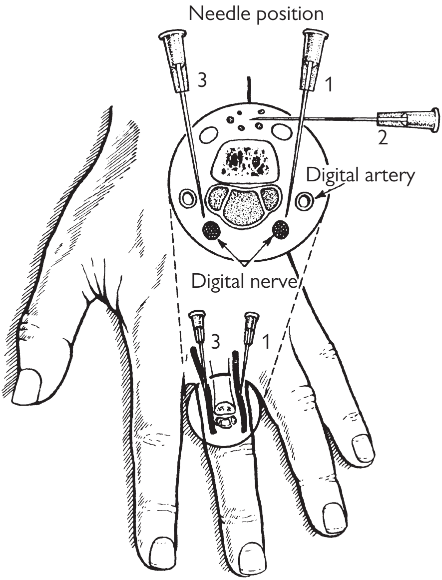
Single injection digital nerve block

Anaesthesia of the distal phalanx and distal interphalangeal joint can be achieved by a single SC injection on the volar aspect of the base of the finger. Pinch the soft tissues just distal to the proximal skin crease. Insert a 25G needle just beneath the skin at the midpoint of the skin crease, and inject 2–3mL of 0.5% bupivacaine. Massage the LA into the soft tissues.

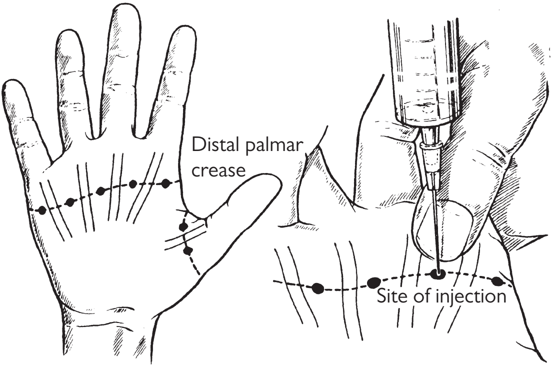
Digital nerve block at the metacarpal level

Digital nerves can be blocked where they run in the interspaces between the metacarpals. Insert a thin needle in the palm through the distal palmar crease, between the flexor tendons of adjacent fingers. Injection of 3–4mL of 1% plain lidocaine will block the adjacent sides of these two fingers. Anaesthesia develops after 5–10min. Alternatively, a dorsal approach can be used—this is often preferred because it is less painful, but there is an ↑ risk of inadvertent venepuncture and the digital nerves are further from the dorsal surface, so a deep injection is needed.

Digital nerve block



Digital nerve block at the base of the finger



Digital nerve block at the metacarpal level

Fig. 7.2 Digital nerve block.

Median and ulnar nerve blocks

The median nerve supplies sensation to the radial half of the palm, the thumb, the index and middle finger, and the radial side of the ring finger. The ulnar nerve supplies the ulnar side of the hand, the little finger, and the ulnar side of the ring finger. The radial nerve supplies the dorsum of the radial side of the hand. The different nerve distributions overlap. In some people, the radial side of the ring finger and the ulnar side of the middle finger are supplied by the ulnar, rather than the median, nerve. LA block of one or more nerves at the wrist provides good anaesthesia for minor surgery on the hand and fingers (see Fig. 7.3).

Median nerve block

At the wrist, the median nerve lies under the flexor retinaculum on the anterior aspect of the wrist, under or immediately radial to the tendon of the palmaris longus and 5–10mm medial to the tendon of the flexor carpi radialis. Just proximal to the flexor retinaculum, the median nerve gives off the palmar cutaneous branch, which travels superficially to supply the skin of the thenar eminence and the central palm. Carpal tunnel syndrome is a contraindication to median nerve block.

Technique

- Use a 0.6mm (23G) needle and ~5–10mL of 1% lidocaine.
- Ask the patient to flex the wrist slightly and bend the thumb to touch the little finger, in order to identify the palmaris longus.
- Insert the needle vertically at the proximal wrist skin crease, between the palmaris longus and the flexor carpi radialis, angled slightly towards the palmaris longus, to a depth of 1cm. If paraesthesiae occurs, withdraw the needle by 2–3mm.
- Inject ~5mL of LA slowly.
- Block the palmar cutaneous branch by injecting another 1–2mL SC, whilst withdrawing the needle.
- Some people do not have a palmaris longus tendon—in this case, identify the flexor carpi radialis and insert the needle on its ulnar side.
- USS enables blockade of the median nerve in the forearm.

Ulnar nerve block

In the distal forearm, the ulnar nerve divides into a palmar branch (which travels with the ulnar artery to supply the hypothenar eminence and the palm) and a dorsal branch (which passes under the flexor carpi ulnaris to supply the ulnar side of the dorsum of the hand).

Technique

- Use a 0.6mm (23G) needle and 5–10mL of 1% lidocaine. Avoid adrenaline in peripheral vascular disease.
- Check the radial pulse before blocking the ulnar nerve.
- Feel the ulnar artery and flexor carpi ulnaris tendon, and insert the needle between them at the level of the ulnar styloid process.
- Aspirate and look for blood in the syringe. Withdraw the needle 2–3mm if paraesthesiae occurs.
- Inject 5mL of LA.
- Block the dorsal branch of the ulnar nerve by infiltrating SC 3–5mL of LA from the flexor carpi ulnaris around the ulnar border of the wrist.

Nerve blocks at the wrist

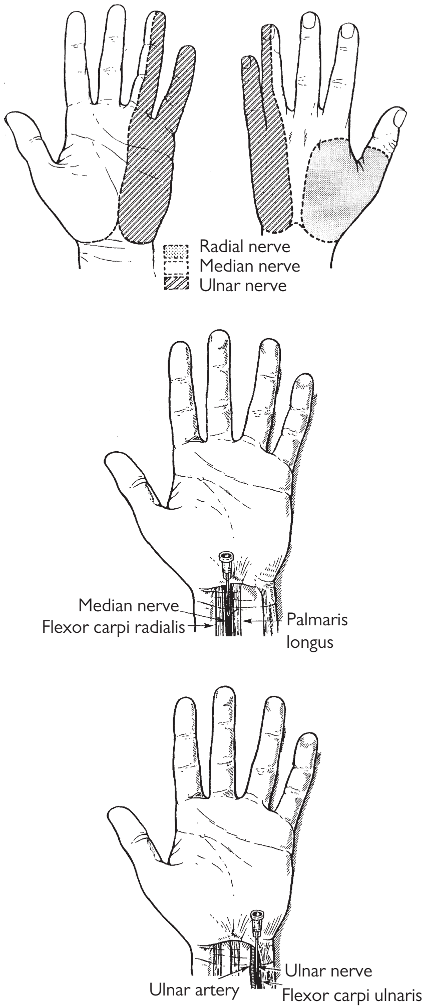


Fig. 7.3 Nerve blocks at the wrist.

Radial nerve block at the wrist

Radial nerve block

In the distal part of the forearm, the radial nerve passes under the tendon of the brachioradialis and lies subcutaneously on the dorsum of the radial side of the wrist where it separates into several branches and supplies the radial side of the dorsum of the hand.

Technique

- Use a 0.6mm (23G) needle and 5mL of 1% lidocaine, with or without adrenaline.
- Infiltrate LA SC around the radial side and the dorsum of the wrist from the tendon of the flexor carpi radialis to the radio-ulnar joint. Beware of inadvertent IV injection.

Radial nerve block (see Fig. 7.4) involves an infiltration technique and often has a more rapid onset and a shorter duration of action than median and ulnar nerve blocks. In combined blocks, experts may use lidocaine with adrenaline, in order to prolong the anaesthesia and ↓ the risk of lidocaine toxicity.

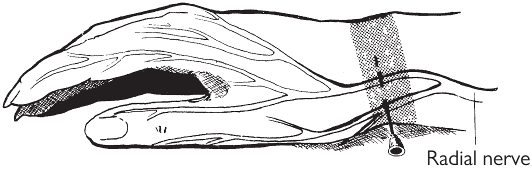


Fig. 7.4 Radial nerve block at the wrist.

Other nerve blocks in the arm

Nerve blocks at the elbow The median, ulnar, and radial nerves can be blocked at the level of the elbow, but this is rarely necessary. The onset of anaesthesia is slower than with blocks at the wrist.

Brachial plexus blocks These should only be used by doctors with anaesthetic training. Brachial plexus blocks can provide good anaesthesia for operations on the arm, but the onset of anaesthesia is often slow (30–45min) and there is a risk of LA toxicity because of the large dose required. The axillary approach can be used in patients who are being discharged later, but if the supraclavicular approach is used, admission to hospital is necessary, because of the risk of a pneumothorax. USS guidance helps to allow accurate positioning of the injection, which improves the effectiveness of the block and ↓ the risk of complications.

Dental anaesthesia

Intraoral injections of LA are used frequently for dental procedures but can also be extremely useful for cleaning and repair of wounds of the lips, cheeks, and chin. Some basic training/experience in dental techniques is helpful. Give dental LA with dental syringes and cartridges of LA. An appropriate drug for most purposes is lidocaine 2% with adrenaline 1 in 80,000. Some dental syringes do not allow aspiration prior to injection. Disposable dental syringes are preferable to reusable syringes, to ↓ the risk of needlestick injury from re-sheathing of needles.

Infra-orbital nerve block

The infra-orbital nerve supplies the skin and mucous membrane of the cheek and upper lip, and also the lower eyelid and the side of the nose. The nerve emerges from the infra-orbital foramen, which is 0.5cm below the infra-orbital margin and vertically below the pupil when the eyes are looking forward. The nerve can be blocked at the infra-orbital foramen by injection through the skin, but the intraoral approach is preferable, because it is less unpleasant for the patient. Insert the needle into the buccogingival fold between the first and second premolars, and direct it up towards the infra-orbital foramen.

Mental nerve block

The mental nerve supplies sensation to the lower lip and chin. It emerges from the mental foramen, which is palpable on the mandible on a line between the first and second premolar teeth. The nerve can be blocked at the mental foramen with 1–2mL of LA, using either an intra- or extra-oral approach. Avoid injecting into the mental canal, since this may damage the nerve. If the wound to be repaired extends across the midline, bilateral mental nerve blocks will be needed.

The nerves to a single lower incisor may be blocked by submucous infiltration of LA in the buccal sulcus adjacent to the tooth.

Nerve blocks of forehead and ear

Nerve blocks of the forehead

Many wounds of the forehead and frontal region of the scalp can be explored and repaired conveniently under LA block of the supraorbital and supratrochlear nerves (see Fig. 7.5).

The supraorbital nerve divides into medial and lateral branches, and leaves the orbit through two holes or notches in the superior orbital margin, ~2.5cm from the midline. The branches of the supraorbital nerve supply sensation to most of the forehead and the frontal region of the scalp.

The supratrochlear nerve emerges from the upper medial corner of the orbit and supplies sensation to the medial part of the forehead.

Technique

- Use 5–10mL of 1% lidocaine, with or without adrenaline.
- Insert the needle in the midline between the eyebrows and direct it laterally.
- Inject LA SC from the point of insertion along the upper margin of the eyebrow.
- If the wound extends into the lateral part of the forehead, SC infiltration of LA may be needed lateral to the eyebrow, to block the zygomaticotemporal and auriculotemporal nerves.

Possible complications

- Injury to the eye can occur if the patient moves during the injection.
- It is possible to block the supraorbital nerve at the supraorbital foramen, but this is not advisable since inadvertent injection into the orbit may cause temporary blindness if the LA reaches the optic nerve.

Nerve blocks of the ear

The auricle (pinna) of the ear is supplied by branches of the greater auricular nerve (inferiorly), the lesser occipital nerve (posteriorly), and the auriculotemporal nerve (anteriorly/superiorly). These nerves can be blocked by SC infiltration of up to 10mL of 1% plain lidocaine in the appropriate area or in a ring around the ear (see Fig. 7.5).

To block the *greater auricular nerve*, infiltrate 1cm below the earlobe from the posterior border of the sternomastoid muscle to the angle of the mandible.

Block the *lesser occipital nerve* by infiltration just behind the ear.

When blocking the *auriculotemporal nerve* by infiltration just anterior to the external auditory meatus, aspirate carefully to avoid inadvertent injection into the superficial temporal artery.

Nerve blocks: the forehead and ear

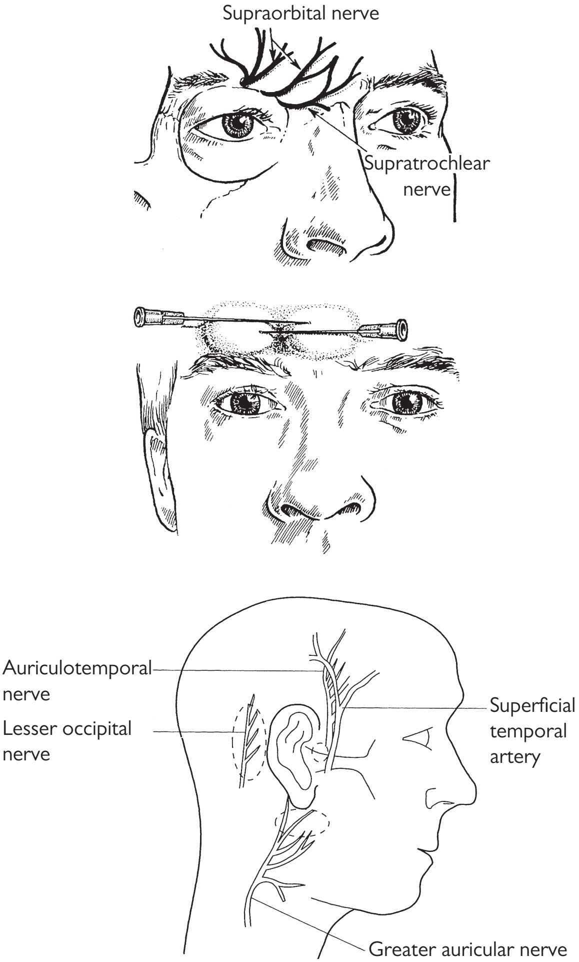


Fig. 7.5 Nerve blocks of the forehead and ear.

Fascia iliaca compartment block

Anatomy

The femoral nerve passes under the inguinal ligament, lateral to the femoral artery. The femoral nerve supplies the hip and knee joints, the skin of the medial and anterior thigh, and the quadriceps, sartorius, and pectineus muscles in the anterior compartment of the thigh. The lateral femoral cutaneous nerve passes under the inguinal ligament near the anterior superior iliac spine, to supply sensation to the lateral aspect of the thigh.

Background

The principal advantage of a fascia iliaca compartment block over a femoral nerve block is that it can be performed 'blind' (ie without USS guidance), with minimal risk of inadvertent puncture of neurovascular structures. It has been advocated for use with hip and/or femoral shaft fractures. The block works by LA spreading throughout the compartment, rather than targeting a specific individual nerve, so a relatively large volume of (diluted) LA is required. It can be reasonably expected to block the femoral and lateral femoral cutaneous nerves.

Contraindications

- Allergy to LA.
- Infection and/or inflammation over the injection site.
- Previous femoral bypass surgery or near a graft site.
- Anticoagulation.

Technique

- Explain the procedure and gain consent from the patient.
- Prepare the equipment, including relevant specialized long needles and LA:
  - Use 30mL of 0.25% levobupivacaine in adults weighing ≤50kg.
  - Use 40mL of 0.25% levobupivacaine in adults weighing >50kg.
- Clean the skin and identify the anterior superior iliac spine and pubic tubercle on the side of the fracture, and place a finger on each of these, then draw an imaginary line between them and divide this line up into thirds, thereby identifying the junction of the lateral third and medial two-thirds—the injection site is 1cm below (caudal to) this point. The femoral pulse is well medial to this.
- Direct the needle in the sagittal plane, and having pierced the skin, advance through two distinct palpable 'pops' (penetration through first the fascia lata and then the fascia iliaca). Advance a further 1–2mm, then attempt to aspirate, and if no blood is aspirated, inject LA slowly—if there is resistance, stop and withdraw slightly, then try again. Stop if there is pain or paraesthesiae on injection. Attempt to aspirate after every 5mL of injection.
- At the end of the procedure, withdraw the needle and apply a small amount of pressure to the injection site.
- Following the procedure, continue regular observations (pulse, BP, RR, SpO_2) every 5min for at least 30min—as pain improves, the possible effect on the RR of any IV opioids which have been given may be accentuated.

Femoral nerve block

This provides good analgesia within a few minutes for pain from a fractured neck or shaft of femur. It may be used in children, as well as in adults.

Technique (without using ultrasound)

(See Fig. 7.6.)

- Use a mixture of lidocaine and bupivacaine to give both rapid-onset and prolonged anaesthesia. In an adult, give 5mL of 1% lidocaine and 5mL of 0.5% bupivacaine. In a child, use 0.1mL/kg of 1% lidocaine and 0.1mL/kg of 0.5% bupivacaine. Check the maximum dose carefully, especially in children or if bilateral femoral nerve blocks are needed.
- Use a 0.8 × 40mm (21G) needle in adults, and a 0.6 × 25mm (23G needle in children.
- Blocking the right femoral nerve is easiest to perform by standing on the patient's left side (and vice versa).
- Using your non-dominant hand, palpate the femoral artery just below the inguinal ligament.
- Clean the skin.
- Insert the needle perpendicular to the skin and 1cm lateral to the artery to a depth of ~3cm. If paraesthesiae occurs, withdraw the needle 2–3mm.
- Aspirate and check for blood.
- Inject LA whilst moving the needle up and down and fanning out laterally to ~3cm from the artery. (The distances quoted refer to adults.)
- If the femoral artery is punctured, compress it for 5–10min. If no bleeding is apparent, continue with the femoral nerve block.

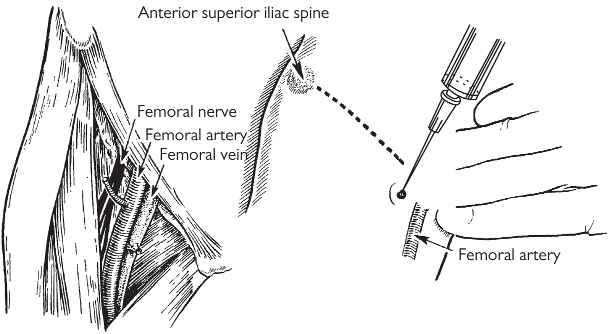


Fig. 7.6 Femoral nerve block.

Ultrasound-guided technique

The 'blind' technique for femoral nerve block has a high success rate and usually provides rapid and effective analgesia. However, USS (see ➔ Local anaesthetic nerve blocks, p. 302) is very helpful to delineate the anatomy of the femoral nerve (which can vary between patients) and to allow precise positioning of the injection adjacent to the nerve.

Nerve blocks at the ankle

Indications

- Cleaning, exploration, and suturing of wounds of the foot.
- Removal of FBs, drainage of small abscesses on the sole of the foot.
- Analgesia for crush injuries of the forefoot.
- LA blocks at the ankle are particularly useful for anaesthetizing the sole of the foot where local infiltration is very painful and unsatisfactory.

Anatomy

Sensation in the ankle and foot is supplied by five main nerves:

- The saphenous nerve (medial side of the ankle).
- The superficial peroneal nerve (front of the ankle and dorsum of the foot).
- The deep peroneal nerve (lateral side of the big toe and medial side of the second toe).
- The sural nerve (heel and lateral side of the hind foot).
- The tibial nerve (which forms the medial and lateral plantar nerves, supplying the anterior half of the sole).

There are individual variations and significant overlap between the areas supplied by different nerves, especially on the sole of the foot. It is often necessary to block more than one nerve (see Fig. 7.7).

For each of these blocks, use a 0.6mm (23G) needle and 5mL of 1% lidocaine (with or without adrenaline) or 0.5% bupivacaine. Check the maximum dose (see ➔ Local anaesthesia, pp. 292–3), especially for multiple blocks. USS can help to allow accurate injection of LA, so smaller amounts are needed.

Do not use adrenaline in patients with peripheral vascular disease.

Saphenous nerve

Infiltrate LA SC around the great saphenous vein, anterior to and just above the medial malleolus. Aspirate carefully because of the risk of IV injection.

Superficial peroneal nerve

Infiltrate LA SC above the ankle joint from the anterior border of the tibia to the lateral malleolus.

Deep peroneal nerve

Insert the needle above the ankle joint between the tendons of the tibialis anterior and the extensor hallucis longus. Inject 5mL of LA.

Sural nerve

Lie the patient prone. Insert the needle lateral to the Achilles tendon, and infiltrate subcutaneously to the lateral malleolus.

Tibial nerve

Lie the patient prone. Palpate the posterior tibial artery. Insert the needle medial to the Achilles tendon and level with the upper border of the medial malleolus, so the needle tip is just lateral to the artery. Withdraw slightly if paraesthesiae occurs. Aspirate. Inject 5–10mL of LA.

Nerve blocks at the ankle

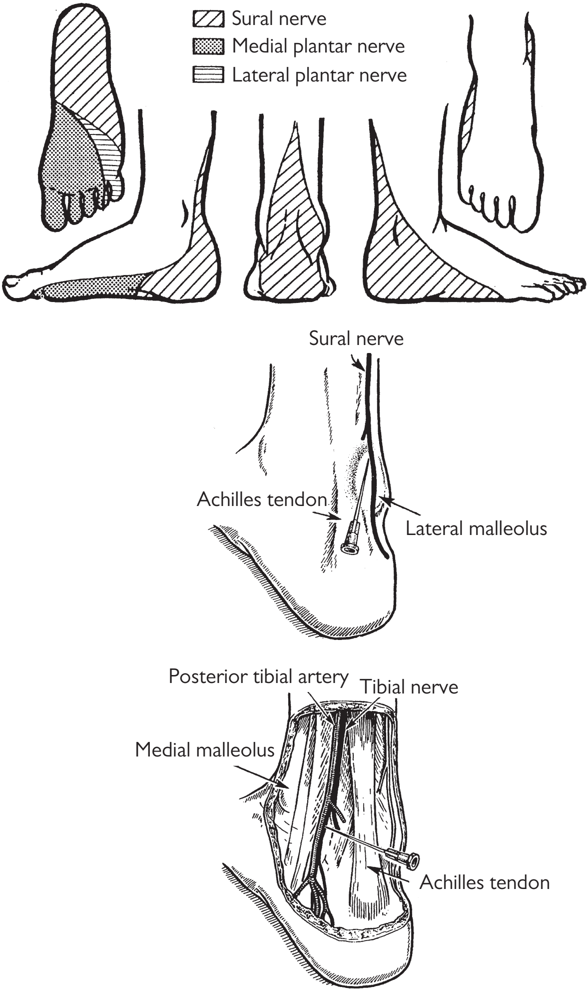


Fig. 7.7 Nerve blocks at the ankle.

Approach to sedation

Sedation is extremely important in everyday ED work to help patients tolerate painful and distressing procedures such as reduction of dislocations.

Definitions

Sedation is a continuum ranging from being fully conscious through to unresponsiveness. The American Society of Anesthesiologists (ASA) has developed a classification, outlined in Table 7.2. For most purposes, the aim of sedation in the ED is to achieve 'minimal' or 'moderate' sedation using this scheme. Separate from this classification is 'dissociative sedation' using ketamine, in which the patient has a trance-like cataleptic state with significant analgesia and amnesia, but with relatively preserved airway reflexes, breathing, and circulation.

Table 7.2 ASA classification of depth of sedation

Minimal sedation (anxiolysis)	Normal response to voice. Airway, breathing, and circulation unaffected
Moderate sedation/ analgesia ('conscious sedation')	Purposeful response (not reflex withdrawal) to voice or touch. Airway maintained, breathing adequate, and circulation usually maintained
Deep sedation/ analgesia	Purposeful response to repeated or painful stimulation. Airway may need protection and ventilation may need support. Circulation usually maintained
General anaesthesia (GA)	Unrousable, even by painful stimulus. Airway often requires intervention; ventilation is frequently inadequate, and cardiovascular function may be impaired

Indications

Sedation is usually indicated in the ED to enable brief painful procedures or interventions to occur. Sedation is most commonly used in the ED for emergency reduction of dislocations and/or fractures and cardioversion for potentially life-threatening arrhythmias, but it is also sometimes used for less urgent conditions (eg the exploration/cleaning/closure of wounds).

When appropriate, sedation may be used with an analgesic or LA. Similarly, do not use sedation when it would be more appropriate to use GA.

Consent and documentation

Explain and discuss the procedure and associated risks with the patient, and record this within the notes. Complete a standard pro forma for each patient who has sedation. In addition to recording observations and drugs given as part of the procedure, ensure that pre- and post-sedation checks are all recorded.

Risk assessment

Sedation carries many of the same risks and complications as those of GA. The principal concerns are obstructed airway, aspiration of gastric contents, respiratory depression, and ↓ cardiac output. Assess the risks before committing to provide sedation. Ideally, patients should be fasted before IV sedation. Ask about and record pre-existing medical conditions, drug therapy, allergies, and time of last food and drink. Record vital signs: pulse, BP, RR, and SpO_2. Establish the ASA physical status classification (see ➲ General anaesthesia in the ED, pp. 320–1).

Airway problems

Clues to possible difficulties managing the airway during sedation include: older, obese patients with a beard, a short neck, or a small mouth opening, history of sleep apnoea, previous airway problems during anaesthesia, and rheumatoid arthritis.

Aspiration of gastric contents

Vomiting or regurgitation and aspiration of gastric contents is a particular risk in patients who are fasted for <4hr, especially for deeper sedation. Delaying procedures may not help as gastric emptying can be delayed in patients who have just been injured and/or given opioid drugs. Fasting is not needed for sedation using N_2O/O_2 mixtures alone or for minimal or moderate sedation where verbal contact is maintained. For procedures requiring deeper sedation where there is a concern about the lack of fasting time, consider whether more experienced staff and/or GA may be needed instead. Discuss the risk of aspiration vs the benefits of performing the procedure under sedation when obtaining consent.

Respiratory and cardiac complications

Patients at ↑ risk of respiratory or cardiac complications include the elderly, those with obesity, and those with pre-existing heart/lung disease and/or ASA ≥3.

Staff

Ensure that sedation is only given by appropriately trained staff. The number and training of staff required will vary according to the depth of sedation. RCEM recommendations for minimum staffing for moderate sedation/analgesia ('conscious sedation') are one physician to provide sedation and one physician or nurse as operator and one nurse.

Some sedatives cause amnesia and transient confusion—a chaperone may avoid difficulties if there is any allegation of impropriety.

Equipment

Use a trolley which can be tilted head-down. Ensure suction, resuscitation equipment, and reversal drugs are immediately available.

Monitoring during IV sedation

Ensure sedated patients have a venous cannula and receive O_2, pulse oximetry monitoring, and capnography (most accurately using nasal prongs with an end-tidal CO_2 outlet). Monitor the ECG. Continue monitoring observations every 5min for at least 30min after the last drug was given.

Drugs for IV sedation

Sedative drugs may be given PO, IM, IV, or by inhalation. All IV sedative drugs will produce anaesthesia if given in excessive dosage. Aim to use the minimum dose that will give adequate sedation and allow the procedure to be completed satisfactorily. Note that patients with renal or hepatic disease may require ↓ drug dosage.

- Midazolam is the most suitable benzodiazepine. It has a plasma half-life of ~2hr in young adults (longer in the elderly or obese) and metabolites are relatively inactive. In fit adults, the initial dose of midazolam is 2mg IV over 1min. If sedation is inadequate after 2min, give incremental doses of 0.5–1mg. When fully sedated, the patient will be drowsy, with slurred speech, but will obey commands. A typical dose is 2.5–5mg. Elderly patients are more susceptible to benzodiazepines—give smaller doses. Give 0.5–1mg as an initial dose—the total dose needed is usually 1–3mg.
- Diazepam is not suitable for IV sedation of patients for planned later discharge, since it has a prolonged action and an active metabolite with a plasma half-life of ~3–5 days.
- Opioids such as fentanyl (dose 0.5mcg/kg—see ➲ Analgesics: other opioids, p. 288) may be used IV combined with midazolam, but there may be a synergistic effect with an ↑ risk of respiratory depression. Give the opioid first, followed by careful titration of midazolam.
- Other drugs: propofol (see ➲ General anaesthetic drugs, p. 326–7) can give excellent sedation for short procedures, with rapid recovery, but its use requires anaesthetic training. Ketamine (see ➲ Ketamine, p. 287) may be given IV or IM, but it requires special training.

Antagonists

Ensure that the specific antagonists flumazenil (for benzodiazepines) and naloxone (for opioids) are available immediately, although they should be needed very rarely. If respiratory depression occurs, standard techniques to maintain the airway and breathing are more important than giving antagonists. Flumazenil and naloxone have shorter durations of action than the drugs they antagonize, so continue careful observation if either drug is used.

Recovery and discharge after sedation

If IV sedation is used, monitor carefully until recovery is complete. Minimum criteria for discharging a patient are:

- Stable vital signs.
- Ability to walk without support.
- Toleration of oral fluids and minimal nausea.
- Adequate analgesia.
- Adequate supervision at home by a responsible adult.

Instruct the patient (both verbally and in writing) not to drive, operate machinery, make any important decisions, or drink alcohol for 24hr. Arrange appropriate follow-up. Ensure the adult accompanying the patient knows who to contact if there is any problem.

Sedation in children

Many children (and their parents and staff) are distressed by procedures such as suturing of minor wounds under LA. Sedation is helpful to prevent distress and allows procedures to take place with minimal physical restraint. A suitable environment within the ED is required in order to enable sedation of children—this includes a quiet child-friendly area with O_2, suction, and monitoring and resuscitation equipment available, together with a quiet recovery area.

Sedation may be given by PO or nasal routes, IM, or IV. Paediatric IV sedation requires anaesthetic experience because of the narrow therapeutic margin between sedation and anaesthesia.

Inhalational sedation and analgesia with N_2O (Entonox®—see ➲ Analgesics: Entonox® and ketamine, p. 287) are rapidly reversible and relatively risk-free, and can be used, when appropriate, in adults and some children.

Ketamine in children

Ketamine given IM in a dose of 2–2.5mg/kg is often used for paediatric sedation in the ED by staff with appropriate training (see ➲ Analgesics: Entonox® and ketamine, p. 287). An alternative is 1mg/kg IV over 1–2min. These doses of ketamine do not provide full anaesthesia, and so local anaesthesia is still required for cleaning and suturing of wounds. Three members of staff are needed: one doctor to manage sedation and the airway, one clinician to perform the procedure, and a nurse to support the patient/family and assist with regular observations (every 5min) for at least 30min after giving sedation.

Adverse effects

- Vomiting occurs in up to 10% of children, usually during recovery.
- Agitation is unusual but responds to small doses of midazolam.
- Laryngospasm can occur occasionally following administration of ketamine, but this small risk is reduced by using low doses of IM ketamine.

Recovery and discharge

Children have usually recovered within 1–2hr. They can be safely discharged once able to walk, talk, and interact normally. Provide the parents with advice (including a written advice sheet) on what to do following discharge—in particular, advise them that their child should not eat or drink for 2hr after discharge because of the risk of vomiting.

Other drugs

Oral midazolam is used by some specialists. Oral sedation with *promethazine* is not advisable, since it is often ineffective.

General anaesthesia in the ED

GA may be needed in the ED for many different conditions:

- Minor surgery (eg drainage of abscesses, manipulation of fractures).
- Cardioversion.
- Airway problems (eg facial trauma, burns, epiglottitis).
- Respiratory failure (eg asthma, COPD, pulmonary oedema, chest injuries).
- To protect the airway and control ventilation after head injuries and to keep the patient immobile for a CT scan.
- To protect the airway and maintain ventilation in status epilepticus unresponsive to standard drug therapy.
- Immediate major surgery (eg thoracotomy or laparotomy for trauma, ruptured ectopic pregnancy, or aortic aneurysm). If at all possible, take the patient to the operating theatre before anaesthesia, as the loss of sympathetic tone after the onset of anaesthesia can cause catastrophic hypotension in a hypovolaemic patient. In extreme emergencies, it may be necessary to operate in the ED.

GA in the ED tends to be stressful for the anaesthetist and potentially hazardous for the patient, who is usually unprepared for anaesthesia, with a full stomach and an ↑ risk of aspiration. GA should only be given by doctors with anaesthetic training, but other staff should know what is required, so they can help when necessary.

Preoperative assessment

This is essential for safe anaesthesia. If time allows, assess the patient before contacting the anaesthetist to arrange anaesthesia. However, if emergency anaesthesia is needed, call the anaesthetist immediately, so that he/she can come and assess the patient, and get senior help if necessary. For a checklist of questions to ask before GA, see ➔ Checklist for preoperative assessment in the ED, p. 321.

Fitness for GA The ASA classification of preoperative fitness is widely used by anaesthetists:

1. Healthy patient with no systemic disease.
2. Patient with a mild to moderate disease which does not limit their activity in any way (eg treated hypertension, mild diabetes, smoker).
3. Patient with a severe systemic disturbance from any cause which limits activity (eg IHD with ↓ exercise tolerance, severe COPD).
4. Patient with a severe systemic disease which is a constant threat to life (eg severe chronic bronchitis, advanced liver disease).
5. Moribund patient who is unlikely to survive 24hr with or without treatment.

The risk of complications from GA correlates well with the ASA group. Only patients in ASA groups 1 and 2 should be given an elective anaesthetic by a junior anaesthetist in the ED. Children aged <7y should not usually have GA in the ED, except in an emergency.

Preoperative investigations

No investigation is needed, unless preoperative assessment reveals a problem. Measure Hb in any patient who appears anaemic. Ask about sickle-cell disease in any patient of Afro-Caribbean, Cypriot, or Indian origin. Measure U&E in patients on diuretics, and blood glucose in patients with diabetes. ECG and CXR are not needed, unless clinically indicated. Perform a pregnancy test if pregnancy is possible.

Checklist for preoperative assessment in the ED

- Age.
- Weight.
- Time of last drink.
- Time of last food.
- Drugs.
- Drugs given in the ED.
- Time of last analgesia.
- Allergies.
- Sickle-cell risk?
- Infection risk?
- Family history of GA problems?
- Airway problem?
- Dentures/crowns/loose teeth?
- Chest disease?
- Smoker?
- Cardiac disease?
- BP.
- GI problem?
- Other illness?
- Possibility of pregnancy?
- Previous GA (problems?)?
- Consent form signed?
- Is the patient expected to go home after recovery from anaesthesia?
- Is there a responsible adult who can look after the patient at home?

Preparation for GA

Ideally, the patient should have nothing to drink for 4hr and no food for 6hr before anaesthesia. Explain why this is necessary. Fasting does not guarantee an empty stomach. Trauma, pregnancy, and opioids delay gastric emptying.

If the patient is in pain, give analgesia and an antiemetic. Discuss with the anaesthetist any other drug treatment that is required. Patients with a hiatus hernia or gastro-oesophageal reflux need antacid prophylaxis (eg ranitidine 50mg IV and an antacid).

Explain the proposed operation and anaesthesia to the patient (and relatives, if appropriate) and ensure valid consent is obtained. The patient must be clearly labelled with a wristband. Remove contact lenses, false teeth, and dental plates.

Recovery and discharge after anaesthesia

When the operation has finished, place the patient in the recovery position and ensure continuous observation by trained staff until recovery is complete. The anaesthetist should stay with the patient until consciousness is regained and the airway is controlled. Monitoring and resuscitation equipment and drugs must be available. The minimum criteria for discharging a patient are the same as those following sedation (see ➔ Recovery and discharge after sedation, p. 318).

Importantly, tell the patient (both verbally and in writing) not to drive, operate machinery, make any important decisions, or drink alcohol for 24hr. Arrange appropriate follow-up and make sure that the adult accompanying the patient knows who to contact if there is a problem.

Emergency anaesthesia and rapid sequence induction

Emergency anaesthesia and intubation are often needed to protect the airway and provide adequate ventilation in a patient with a head injury or multiple trauma. There is a high risk of aspiration of gastric contents into the lungs, so use a cuffed ET tube (uncuffed in infants). In a patient with a gag reflex, any attempt to intubate without anaesthesia may cause vomiting and aspiration. Anaesthesia before intubation is essential in head-injured patients to minimize the ↑ in ICP.

Rapid sequence induction

RSI involves administration of a sedative or an induction agent virtually simultaneously with a neuromuscular-blocking agent to allow rapid tracheal intubation.

►► *RSI should only be performed by staff who have had specific training and experience in the techniques and the drugs used, and the recognition and management of possible problems.* However, it is useful if ED staff who have not had such training understand the principles of RSI, so that they can assist as needed.

- Call for senior ED/anaesthetic/ICU help.
- Check all drugs and equipment using a standardized checklist including: suction, bag–valve–mask (or water circuit and T piece), laryngoscope (and spare with large blade), bougie, appropriate-sized tracheal tubes (× 2) with cuffs checked, then deflated, syringe, connector to attach tracheal tube to bag/ventilator, in-line end-tidal CO_2 monitoring, and tube holder/tie. Ensure that an appropriately sized supraglottic device [i-Gel or laryngeal mask airway (LMA)] and equipment for a surgical airway are immediately available.
- Check that the trolley can be tilted head-down easily.
- Check monitoring equipment (ECG, BP, pulse oximeter, end-tidal CO_2 monitor).
- Explain the procedure to the patient, if possible.
- Assess the risks and any conditions which might cause problems with intubation (eg trauma to the face or neck, ↓ mouth opening, receding chin). Identify and always verbalize a backup plan for failed intubation prior to commencing the procedure (see ➲ Difficult intubation, pp. 324–5) and communicate this to the team. The Difficult Airway Society has produced some useful guidelines on this (https://www.das.uk.com).
- Establish monitoring (ECG and pulse oximetry) and secure IV access.
- Protect the cervical spine in all trauma patients—an assistant should provide in-line immobilization during intubation. In other patients, use a pillow and position the head and neck to aid intubation.
- If possible, pre-oxygenate for 3min with 100% O_2 via a tight-fitting mask, with the patient breathing spontaneously. If breathing is inadequate, ventilate for 2min on 100% O_2 with a bag and mask.
- Ask an assistant to apply cricoid pressure whilst the patient is pre-oxygenated by pressing firmly downwards with the thumb and index finger on the cricoid cartilage. Note that although evidence for cricoid pressure is lacking, it is still widely used.
- Administer the appropriate drugs.

Standard drugs for RSI

A balanced RSI requires an induction drug in an appropriate dose and a neuromuscular-paralysing drug to facilitate intubation. A widely used combination is fentanyl (3mcg/kg), followed by ketamine (2mg/kg), with immediate administration of a muscle relaxant, typically rocuronium (1mg/kg).

Pre-induction opioid

The use of a pre-induction dose of opioid to ↓ sympathetic response to laryngoscopy benefits haemodynamically stable patients and those with ↑ ICP.

Ketamine

Note that ketamine is useful in trauma RSI as it helps maintain haemodynamic stability. ↑ ICP is not a contraindication to ketamine at induction as cerebral perfusion is augmented and pre-treatment with opioid will offset the sympathetic response. However, the sympathomimetic effects of ketamine can result in tachycardia and hypertension, which may be harmful in some patients with cardiac disease—these effects can be mitigated with pre-induction fentanyl.

Rocuronium

The standard drug for neuromuscular blockade is rocuronium, which is reliable, lasts longer (hence less unwanted 'wake-up'), and has fewer contraindications than suxamethonium.

Intubation technique

- Maintain the cricoid continuously until the airway is secure.
- Keep the face mask tightly applied until the anaesthetic and relaxant are effective.
- Then intubate and inflate the cuff quickly.
- Try to confirm tracheal placement of the tube—ideally it will have been seen passing through the cords, but this may not always be possible in an emergency intubation.
- Check air entry in both sides of the chest.
- Check end-tidal CO_2 (but this may be misleading if oesophageal intubation occurs in a patient who has recently consumed antacids or fizzy drinks). If CO_2 is not detected, oesophageal intubation has occurred.
- Release cricoid pressure when the ET tube is correctly positioned, the cuff has been inflated, and ventilation is satisfactory.
- Secure the tracheal tube.
- Continue observation and monitoring.

Difficult intubation

Difficulties with intubation may result from problems with the equipment, the patient, and the circumstances of intubation, and from a lack of experience or skill.

Equipment

Ensure proper working equipment is available where intubation may be needed: pillow, suction, laryngoscope (and spare) with interchangeable blades, ET tubes of different diameters (cut to suitable lengths, but with uncut tubes available), syringe and clamp for cuff, connectors, flexible stylet, gum-elastic bougie, lubricating jelly, Magill's forceps, and tape for securing ET tube. A face mask and a ventilating bag and oral/nasal airways must be immediately available. LMAs and cricothyroidotomy equipment must be accessible. Fibre-optic/video laryngoscopes are proving to be increasingly useful.

The patient

Patients may be difficult to intubate because of facial deformity or swelling, protruding teeth, ↓ mouth opening from trismus or trauma, ↓ neck movement or instability of the cervical spine, epiglottitis or laryngeal problems, tracheal narrowing or deviation, and blood, vomit, or FB in the airway.

Circumstances and skills

Intubation is much easier in the controlled environment of an operating theatre than in an emergency in the ED or in prehospital care. Skilled help is vital—in-line immobilization of the neck, cricoid pressure, and assistance with equipment and cuff inflation are needed. Practice intubating manikins regularly.

Practical points

Before attempting intubation, oxygenate by bag-and-mask ventilation. Take a deep breath as you start intubation—if the patient is not intubated successfully when you have to breathe again, remove the ET tube and laryngoscope, and ventilate with O_2 for 1–2min using a bag and mask before another attempt. Consider adjusting the patient's position, using a different size of laryngoscope blade or ET tube or a stylet or bougie. Cricoid pressure can be changed to laryngeal manipulation by pushing the larynx backwards into view. The BURP (Backwards, Upwards, Rightwards Pressure) manoeuvre on the thyroid cartilage may be useful in a difficult intubation.

Oesophageal intubation

Fatal if unrecognized. The best way of confirming tracheal intubation is to see the ET tube pass between the vocal cords. Inadvertent oesophageal intubation can produce misleadingly normal chest movements and breath sounds. End-tidal CO_2 measurement helps to confirm tracheal intubation, but it can be misleadingly ↑ in patients who have taken antacids or fizzy drinks. If in doubt, remove the ET tube and ventilate with a bag and mask.

Difficult intubation guidelines

Persistent unsuccessful attempts at intubation cause hypoxia and an ↑ risk of aspiration and damage to the teeth and other structures. Get senior help early. (See Fig. 7.8 and the Difficult Airway Society guidelines available at https://www.das.uk.com)

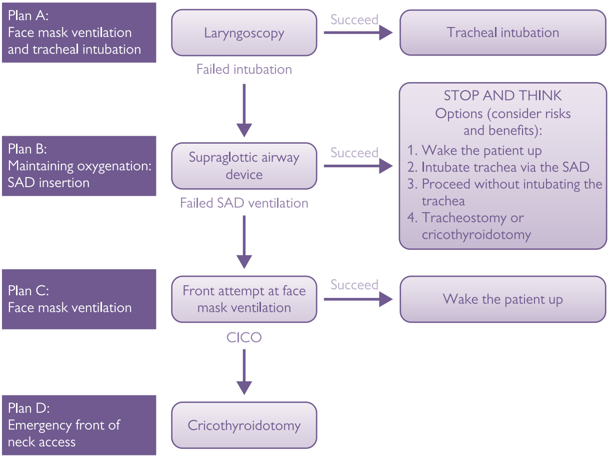


Fig. 7.8 Overview of the Difficult Airway Society's difficult airway guidelines. CICO, Cannot Intubate Cannot Oxygenate; SAD, supraglottic airway device.

Reproduced from Frerk, C. *et al*. (2015). Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults, BJA: *British Journal of Anaesthesia*, Volume 115, Issue 6, December 2015, Pages 827–848, https://doi.org/10.1093/bja/aev371

Laryngospasm

Laryngospasm occurs when the laryngeal muscles contract and occlude the airway, preventing ventilation and causing hypoxia.

Causes

- Stimulation of the patient during light anaesthesia.
- Airway irritation by secretions, vomit, blood, or oropharyngeal airway.
- Extubation of a lightly anaesthetized patient.

Treatment

- Give 100% O_2 and get expert help.
- Clear the airway of secretions, using gentle suction.
- Gently ventilate the patient using a bag and mask, with gentle application of PEEP. Over-inflation is liable to fill the stomach and cause regurgitation.
- Monitor the ECG for bradycardia or arrhythmias.

In severe laryngospasm, an experienced anaesthetist may consider deepening anaesthesia or giving a muscle relaxant to allow intubation or ventilation with a bag and mask.

General anaesthetic drugs

► *GA should only be given after anaesthetic training.*

IV induction agents are used for induction of anaesthesia, as the sole drug for short procedures (eg cardioversion), for treatment of status epilepticus unresponsive to other anticonvulsants (see ➲ Seizures and status epilepticus, pp. 156–7), for total IV anaesthesia, and for sedation of a ventilated patient. They are particularly hazardous in patients with upper airway obstruction or severe hypovolaemia. Thiopental, etomidate, and many other drugs are unsafe in acute porphyria (see ➲ Porphyria, p. 173 and *BNF*).

Propofol

This is particularly useful in day-case surgery and for manipulation of fractures and dislocations, because recovery is rapid. Injection causes a burning sensation, which may be painful. Hypotension is common and severe bradycardia may occur. Induction dose is 1.5–2.5mg/kg. Propofol has profound vasodilatory effects which can result in haemodynamic instability, but consider it for those patients with a purely neurological indication for RSI (particularly if there is coexisting hypertension or seizures).

Ketamine

This is used in prehospital care and increasingly in hospital care as well (see ➲ Ketamine, p. 287). It may be useful for RSI in hypotensive patients and in acute asthma. Induction dose is 1–2mg/kg IV.

Etomidate

This causes less hypotension than propofol or thiopental (and so may be useful in patients who are already hypotensive), and recovery is rapid. However, the injection is painful and uncontrolled muscle movements and adrenocortical suppression may occur—avoid it in patients who have, or are at risk of developing, sepsis. Induction dose is up to 0.3mg/kg.

Thiopental (thiopentone)

This is a barbiturate drug. Thiopental sodium solution is unstable and has to be prepared from powder to form a 2.5% solution (25mg/mL). Care is needed with injections because extravasation causes irritation and arterial injection is particularly dangerous. Hypotension may occur, especially with overdosage. The induction dose in a fit adult is up to 4mg/kg (child: 2–7mg/kg).

Muscle relaxants

Rocuronium is a muscle relaxant that is now considered the standard drug to allow intubation, especially in RSI of anaesthesia (see ➲ Emergency anaesthesia and rapid sequence induction, pp. 322–3). The muscle relaxant effects of rocuronium last for much longer than those of suxamethonium (typically ~45min).

Atracurium and vecuronium are non-depolarizing muscle relaxants, which act for ~20–30min. They cause fewer adverse effects than older relaxants (eg pancuronium). Paralysis from these drugs can be reversed with neostigmine, which is given with atropine or glycopyrronium to prevent bradycardia.

Suxamethonium is a short-acting depolarizing muscle relaxant, which is now used much less frequently. In a dose of 1mg/kg, it causes muscle fasciculation, followed rapidly by flaccid paralysis. It is contraindicated in hyperkalaemia and also in burns, paraplegia, or crush injuries where dangerous hyperkalaemia may develop if suxamethonium is used 5–120 days after injury. Suxamethonium causes ↑ ICP and ↑ intra-ocular pressure. Usual duration of action is ~5min, but prolonged paralysis occurs in patients with abnormal pseudo-cholinesterase enzymes.

Inhalational anaesthetics

These can be used for analgesia (especially Entonox®), induction of anaesthesia (particularly in upper airway obstruction, when IV induction of anaesthesia is hazardous), and maintenance of anaesthesia.

N_2O is widely used for analgesia as Entonox®, a 50:50 mixture with O_2 (see ➲ Analgesics: Entonox® and ketamine, p. 287). It is also used frequently in GA in a concentration of 50–70% in O_2, in combination with other inhaled or IV anaesthetics. N_2O is contraindicated in certain circumstances (eg undrained pneumothorax—see ➲ Analgesics: Entonox® and ketamine, p. 287).

Methoxyflurane (Penthrox®) is an inhalational agent used as an analgesic in trauma by senior/suitably trained clinicians.

Halothane, enflurane, isoflurane, and sevoflurane are inhalational anaesthetic agents that are given using specially calibrated vaporizers in O_2 or a mixture of N_2O and O_2. Sevoflurane is particularly useful for gas induction of anaesthesia in upper airway obstruction and can play a role in ongoing bronchospasm in life-threatening asthma. Halothane is also effective for gas induction but is now rarely used because of the risk of hepatotoxicity, especially after repeated use. Halothane sensitizes the heart to catecholamines, so adrenaline must not be used with halothane. Inhalational anaesthetic drugs can cause malignant hyperpyrexia (see ➲ Heat illness, pp. 274–5) in susceptible patients.

Chapter 8

Major trauma

Major trauma: treatment principles

Suspect major trauma in:

- High-speed road collisions, vehicle ejection, rollover, and prolonged extrication.
- Death of another individual in the same collision.
- Pedestrians thrown up or run over by a vehicle.
- Falls of >2m.

Airway control

Use basic manoeuvres (suction, chin lift, oropharyngeal airway) to open the airway and apply O_2 by face mask. Avoid head tilting or moving the neck if there is possible neck injury. If the airway remains obstructed despite these measures, consider advanced manoeuvres (see ➲ Airway obstruction: surgical airway, p. 336).

Oxygen

Provide O_2 as required. Treat patients who are apnoeic or hypoventilating with bag-and-mask ventilation prior to tracheal intubation and IPPV.

Cervical spine control

This is an early priority in a patient who presents with possible spine injury (eg neck pain, loss of consciousness). There are concerns about routine use of collars (eg ↑ ICP), so consider the need for adhesive tape and sandbags, but bear in mind that these may cause problems (eg patients who are vomiting or unco-operative patients who have drunk alcohol).

IV fluids

Insert two large cannulae into forearm or antecubital fossa veins. If initial attempts fail, consider intra-osseous (IO) access. Avoid inserting lines into the lower limbs in suspected pelvic trauma. Treat hypovolaemia from blood loss with IV blood and blood products, rather than large amounts of crystalloid. Consider starting the Massive Haemorrhage Protocol (see ➲ Massive blood transfusion, p. 182).

Tranexamic acid

In suspected major haemorrhage (and within 3hr of injury), give tranexamic acid 1g IV over 10min (if not already given by paramedics prehospital). Follow this with an infusion of tranexamic acid 1g IVI over 8hr.

Analgesia

Give morphine IV (diluted in saline to 1mg/mL), titrated in small increments according to response. Provide an antiemetic (eg cyclizine 50mg IV) at the same time. Consider other forms of analgesia (eg regional nerve blocks, immobilization, splintage of fractures). *Note*: ketamine in low dose is increasingly being used to manage pain (especially prehospital) and where there is a concern about opioids and hypotension.

Tetanus

Ensure tetanus prophylaxis in all patients (see ➲ Tetanus prophylaxis, p. 424).

Antibiotics

Give prophylactic IV antibiotics for compound fractures and penetrating wounds of the head, chest, or abdomen. Antibiotic choice follows local policy—a broad-spectrum antibiotic (eg cefuroxime) is useful.

Approach to trauma resuscitation

Advanced Trauma Life Support (ATLS®)

The ATLS® concept was introduced by the American College of Surgeons in an attempt to improve the immediate treatment of patients with serious injury. The ATLS® (and now the European Trauma Course) approach enables standardization of trauma resuscitation. Treatment of all patients with major trauma passes through the same phases:

- Primary survey.
- Resuscitation phase.
- Secondary survey.
- Definitive care phase.

A key feature of ATLS® is frequent re-evaluation of the patient's problems and the response to treatment. Any deterioration necessitates a return to evaluate the 'ABC' (airway, breathing, and circulation).

Treatment is particularly designed to prevent trauma-induced coagulopathy, acidosis, and hypothermia—the so-called 'triad of death'.

Primary survey

On initial reception of a seriously injured patient, identify and address life-threatening problems as rapidly as possible. Adopt a 'cABCDE' approach, quickly evaluating and treating:

- c—catastrophic haemorrhage control (pressure on external bleeding).
- A—airway maintenance, with cervical spine control.
- B—breathing and ventilation.
- C—circulation and haemorrhage control.
- D—disability (rapid assessment of neurological status).
- E—exposure (the patient is completely undressed to allow full examination).

With optimal staffing and direction, instead of considering each aspect sequentially ('A' to 'E'), aim for the team to address them simultaneously.

Resuscitation phase

During this period, treatment continues for the problems identified during the primary survey. Further practical procedures (eg insertion of oro-/NG tube, chest drain, and urinary catheter) are performed. Occasionally, immediate surgery (damage control surgery) is required for haemorrhage control before the secondary survey.

Secondary survey

A head-to-toe examination to identify other injuries should be accompanied by relevant imaging and other investigations. Monitor closely—any deterioration requires a repeat assessment. Adopting a high index of suspicion is essential to avoid missing occult injuries.

Definitive care phase

The early management of all injuries is addressed, including fracture stabilization and emergency operative intervention.

Investigations in major trauma

Select specific investigations according to the presentation, but most patients with major trauma require: group and save/cross-match, FBC, U&E, CT and/or X-rays, and VBG (including lactate and glucose levels).

SpO_2

Attach a pulse oximeter on ED arrival, then monitor continuously.

Blood tests

Check U&E, FBC, and glucose. If there is any possibility of significant haemorrhage, request a group and save or cross-match. Request a baseline clotting screen in patients with major haemorrhage or those at special risk (eg alcoholics or those on anticoagulants). Request FFP and platelets early for patients with major haemorrhage. Thromboelastography (TEG) and rotational thromboelastometry (ROTEM) may have a role in identifying trauma-induced coagulopathy.

X-rays

The traditional approach of obtaining cervical spine, chest, and pelvis X-rays for blunt trauma has been largely replaced by CT.

Urinalysis

Test the urine for blood if there is suspicion of abdominal injury. Microscopic haematuria is a potential marker of intra-abdominal injury.

Arterial blood gas

ABG provides useful information about the degree of hypoxia, hypoventilation, and acidosis. In critically ill patients (especially those requiring ventilatory support or those destined for neurosurgery/ICU), repeat as necessary and consider inserting an intra-arterial line to continuously monitor BP.

Electrocardiogram

Monitor all patients; record an ECG if >50y or significant chest trauma.

Computed tomography scan

CT is the standard way to evaluate head, neck and truncal injuries—often in the form of a 'pan-scan' if there is injury to more than one body region. Co-location of the scanner within the ED helps issues of transfer and monitoring whilst scanning. Do not transfer patients with haemodynamic instability out of ED to a CT scanner.

USS (FAST) and diagnostic peritoneal lavage

Focussed assessment with sonography for trauma (FAST) (see ➔ Focussed assessment with sonography for trauma (FAST) scan, p. 355) is an USS technique to identify free fluid (or gas) in the peritoneal, pleural, or pericardial cavities. It can be performed by a trained ED doctor, surgeon, or radiologist. Local policy and expertise will determine individual ED practice. Diagnostic peritoneal lavage (DPL) is rarely used now in developed countries, given the availability of FAST and CT. DPL still plays an important role if FAST and CT are not available.

Other investigations

Angiography is indicated in certain specific circumstances (major pelvic fracture, aortic injury). Occasionally, other tests requiring specialist expertise (eg echocardiography) may prove to be useful.

Trauma scoring

Trauma scoring is often used in research on the epidemiology and management of trauma. A basic understanding of the accepted system of trauma scoring may be of benefit to those treating injured patients.

Injury Severity Score

The Injury Severity Score (ISS) is widely used to retrospectively score the anatomical injuries of an individual patient. The score is obtained by first scoring each individual injury using the Abbreviated Injury Scale (AIS), which attributes a score between 1 and 6 to each individual injury, as follows:

AIS 1 = minor injury
AIS 2 = moderate injury
AIS 3 = serious injury
AIS 4 = severe injury
AIS 5 = critical injury
AIS 6 = inevitably fatal injury

To calculate the ISS from an array of AIS scores for a patient, the three highest AIS scores in different body regions are squared, then added together. The ISS considers the body to comprise six regions: head/neck; face; chest; abdomen; extremities; and external (skin). Possible ISS scores range from 1 to 75. Any patient with an AIS = 6 is automatically given an ISS of 75. (See https://www.aast.org/Library/TraumaTools/InjuryScoringScales.aspx)

For example, see Table 8.1.

Table 8.1 Example of scores of a patient after blunt trauma

Injuries	AIS (body region)
Closed linear temporal skull fracture	AIS = 2 (head/neck)
Major aortic arch rupture at its root	AIS = 5 (chest)
Bilateral pulmonary contusions	AIS = 4 (chest)
Massive splenic rupture with hilar disruption	AIS = 5 (abdomen)
Multiple widespread superficial abrasions	AIS = 1 (external)

ISS = $(5)^2 + (5)^2 + (2)^2 = 54$. The ISS is non-linear, and some scores (eg 15) are impossible. One accepted definition of 'major trauma' is an ISS of >15.

The Revised Trauma Score

The Revised Trauma Score (RTS) is used to assess the physiological disturbance of a trauma patient. The score is calculated from the RR, systolic BP, and GCS. Each of these parameters are assigned a code (value) to which a weighting factor is applied. The three resultant scores are then added together to give the RTS. The RTS ranges from 0 (worst possible) to 7.84 (best).

TRISS methodology

Combining the ISS with the RTS and adding a weighting factor according to the age of the patient, it is possible to calculate a 'probability of survival' (Ps) for each patient, based upon the national norm. Patients who survive with Ps of <0.5 are regarded as 'unexpected survivors', and patients who die with Ps of >0.5 as 'unexpected deaths'. By analysing the results of treating a large number of patients, the TRISS methodology may be used to compare 'performances' (eg of one hospital against the national norm).

Airway obstruction: basic measures

Severely injured patients die rapidly unless oxygenated blood reaches the brain and other vital organs. Clear, maintain, and protect the airway; ensure that ventilation is adequate, and give O_2 as required. The most urgent priority is to clear an obstructed airway, but avoid causing or exacerbating any neck injury—instruct someone to hold the head and neck in a neutral position until the neck is satisfactorily immobilized.

When treating any seriously injured patient, always ensure that O_2, suction, and airway equipment are readily available. Get senior ED ICU/anaesthetic help early if a patient with a serious airway problem arrives or is expected.

Causes of airway obstruction

- Coma from any cause can result in airway obstruction and loss of protective airway reflexes.
- Blood or vomit may block the airway.
- The airway may be disrupted by trauma of the face or larynx, or may be occluded by a haematoma or by oedema following burns.

Assessment of airway obstruction

Talk to the patient and assess—a lucid reply shows the airway is patent, the patient is breathing, and some blood is reaching the brain. Do not move the neck until it has been checked and cleared of injury (see ➔ Major trauma: treatment principles, p. 330).

Look and listen to check how the patient is breathing. Complete airway obstruction in someone who is still trying to breathe results in paradoxical movements of the chest and abdomen, but no breath sounds. Gurgling, snoring, and stridor are signs of partial obstruction.

Management of airway obstruction

- Look in the mouth and pharynx for FBs, blood, and vomit. The tip of a laryngoscope may be useful as an illuminated tongue depressor.
- Remove any FB with Magill's forceps, and suck out any liquid with a large rigid suction catheter. See if the patient responds and has a gag reflex, but beware of precipitating coughing or vomiting.
- If vomiting occurs, tilt the trolley head down and suck out any vomit.
- Lift the chin and use the jaw thrust manoeuvre (see ➔ Jaw thrust manoeuvre, p. 335) to open the airway, but do not flex or extend the neck.
- After any airway intervention, look, listen, and feel to reassess airway patency and efficacy of breathing.
- If the gag reflex is absent or poor, insert an *oropharyngeal airway* (see ➔ Insertion of oropharyngeal airway, p. 335). This helps to hold the tongue forward but can cause vomiting or coughing if there is a gag reflex. If the gag reflex is present or the patient's jaws are clenched, consider a *nasopharyngeal airway* (evidence of severe facial or head injury is a relative contraindication).
- If the airway is now patent and the patient is breathing, give high-concentration O_2 (15L/min via a non-rebreathing reservoir mask).
- If the airway is patent, but breathing inadequate, ventilate with an O_2 bag-and-mask device and prepare for tracheal intubation. Aim for one person to hold the mask on the face with both hands to ensure a good seal, whilst a second person squeezes the ventilation bag.

Insertion of oropharyngeal airway

- Select the appropriate size of the airway.
- Hold an airway against the patient's face. Select the size based on the vertical distance between the incisors and the angle of the mandible. A large adult usually needs a size 4 airway; most men require a size 3, and some women need a size 2. An incorrectly sized airway may make the obstruction worse, rather than better.
- Open the patient's mouth and use a rigid suction catheter with high-power suction to suck out any fluid or blood from the oropharynx.
- Insert the oropharyngeal airway 'upside down' for 4–5cm (halfway), then rotate it 180° and insert it until the flange is at the teeth.
- In children, use a laryngoscope as a tongue depressor and insert the airway the 'correct way up' to avoid trauma to the palate.
- Recheck the airway and breathing and give high-flow O_2.
- Ventilate the patient if breathing is inadequate.

Insertion of nasopharyngeal airway

- Select an appropriate airway, usually a 7.0mm for adult ♂ and a 6.0mm for adult ♀.
- Lubricate the airway and insert the tip of it into one nostril, then direct it posteriorly.
- The airway should slide easily into the nose until the flange abuts the nostril and the tip is just visible in the pharynx. Never force a nasopharyngeal airway into the nostril—any bleeding produced will markedly aggravate the airway problem.
- Recheck the airway and breathing, and give high-flow O_2.

Jaw thrust manoeuvre

The aim of this is to open the upper airway with minimum movement of the cervical spine. Place the forefingers of both hands immediately behind the angles of the mandible and push the mandible anteriorly. This will lift the tongue anteriorly and thus away from the posterior pharyngeal wall.

Tracheal intubation in trauma

An injured patient with no gag reflex needs intubation to maintain the airway and protect it against blood and vomit. Intubation may also be needed because of: apnoea (after initial ventilation with a bag–valve–mask), respiratory inadequacy, to prevent potential obstruction from facial burns, or to allow manipulation of ventilation in patients with ↑ ICP. Intubation in such circumstances requires emergency anaesthesia—suitable expertise, appropriate equipment, and assistance are essential (see ➔ Emergency anaesthesia and rapid sequence induction, pp. 322–3). An assistant holds the head to prevent neck movement during intubation, whilst another assistant provides cricoid pressure (as per local protocols).

Confirm correct tracheal tube placement by:

- Seeing the tube pass through the cords.
- Observing symmetrical chest movement.
- Listening over both axillae for symmetrical breath sounds.
- Confirming placement with end-tidal CO_2 monitoring.

If airway obstruction is complete, the obstruction cannot be relieved, and intubation is impossible, an urgent surgical airway is needed (see ➔ Airway obstruction: surgical airway, p. 336).

Airway obstruction: surgical airway

A *surgical airway* is needed if the airway is obstructed by trauma, oedema, or infection and the trachea cannot be intubated. Emergency tracheostomy is not indicated in this situation because it is too time-consuming to perform and the necessary expertise may not be available.

Surgical cricothyroidotomy

This technique (see Fig. 8.1) is not appropriate in children aged <12y.

- Feel the thyroid and cricoid cartilages and the cricothyroid membrane between them. If right-handed, stand on the patient's left.
- Clean the area and give LA (if the patient is conscious and time allows).
- Hold the thyroid cartilage with the non-dominant hand, and make a transverse incision through the skin and the cricothyroid membrane, then turn the blade through 90° with the sharp edge caudally. If unable to palpate the cricothyroid membrane, make a ~9cm vertical incision, then bluntly dissect with the fingers to the larynx.
- Slide a bougie alongside the blade into the trachea; remove the scapel, and railroad a lubricated 6.0mm cuffed tracheal tube into the trachea.
- Remove the bougie tube; inflate the cuff, and connect the tube to a catheter mount and ventilation bag.
- Confirm correct placement with end-tidal CO_2 monitoring.
- Ventilate the patient with O_2 and secure the tracheal tube.
- Examine the chest and check for adequacy of ventilation.

Needle cricothyroidotomy

This is a rapid temporizing measure whilst preparation is made for a definitive airway (eg surgical cricothyroidotomy). Jet insufflation via a cannula placed through the cricothyroid membrane can provide up to 45min of oxygenation of a patient with partial airway obstruction (see Fig. 8.2).

- Use a large IV cannula-over-needle (adults: 12 or 14G; children: 16 or 18G) attached to a syringe. If right-handed, stand on the patient's left.
- Palpate the cricothyroid membrane between the thyroid and cricoid cartilages. Hold the cricoid cartilage firmly with the left hand.
- Pass the needle and cannula at a 45° angle to the skin in the midline through the lower half of the cricothyroid membrane into the trachea.
- Aspirate whilst advancing the needle. Aspiration of air confirms entry into the trachea. Withdraw the needle whilst advancing the cannula down into position in the trachea.
- Connect the cannula via a Y connector or O_2 tubing with a side hole to wall O_2 at 15L/min (in a child, the rate should initially be set in L/min at the child's age in years, ↑ if necessary until capable of causing chest movement). Hold the cannula firmly in position. Occlude the side hole or the end of the Y connector with the thumb for 1 in 5s to give intermittent insufflation of O_2.

Spontaneous breathing through the small airway of a cannula is very difficult, but the patient should be able to exhale partially in the 4s between jets of O_2. However, CO_2 retention occurs and limits the time that jet insufflation can be tolerated. Proceed immediately to a definitive airway (call a senior ENT or maxillofacial surgeon).

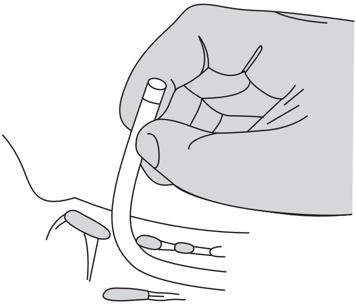


Fig. 8.1 Surgical cricothyroidotomy.

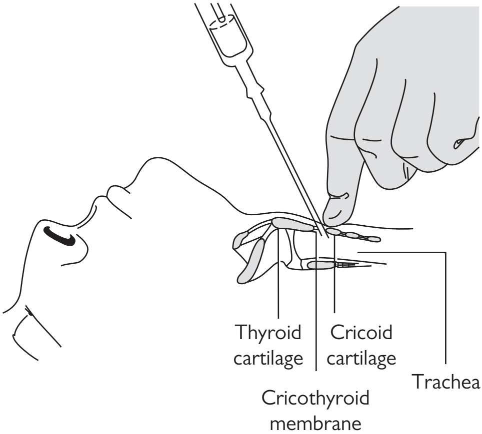


Fig. 8.2 Needle cricothyroidotomy.

Tension pneumothorax

Tension pneumothorax is a life-threatening emergency and requires prompt recognition and treatment. It occurs when gas progressively enters the pleural space but is unable to leave. ↑ pressure causes complete lung collapse on the affected side and ultimately pushes the mediastinum to the other side. Movement of the mediastinum leads to kinking of the great vessels, thereby ↓ venous return and cardiac output. Additional compromise results from compression of the lung on the other side, particularly in patients undergoing IPPV. The process leading to tension pneumothorax may occur very rapidly, culminating in cardiac arrest within minutes.

Causes

Tension pneumothorax is seen most frequently following trauma, but it may also occur iatrogenically after attempted insertion of a central venous line (see ➲ Central venous access, pp. 58–9). A small (perhaps unsuspected) simple pneumothorax is particularly likely to become a tension pneumothorax when IPPV is commenced.

Features

- Dyspnoea, tachypnoea, and acute respiratory distress.
- Absent breath sounds on the affected side.
- Hyper-resonance over the affected lung (difficult to demonstrate in a noisy environment).
- Distended neck veins (unless hypovolaemic), tachycardia, hypotension, and ultimately loss of consciousness.
- Trachea deviated away from the affected side (rarely clinically apparent).
- ↑ airway pressure in a patient receiving IPPV.

Diagnosis

This is *essentially clinical*—do not waste time obtaining X-rays.

Treatment

Apply high-flow O_2, then perform urgent decompression. Options are:

- If skills allow, perform finger thoracostomy decompression in the axilla in the fifth intercostal space, just anterior to the mid-axillary line, then follow this with a chest drain.
- Alternatively, immediately decompress by inserting an IV cannula (16G or larger) into the second intercostal space in the mid-clavicular line, just above the third rib (to avoid the neurovascular bundle; see Fig. 8.3). Withdraw the needle and listen for a hiss of gas. Tape the cannula to the chest wall, then insert an axillary chest drain on the affected side immediately (see ➲ Chest drain insertion, p. 346). Remove the cannula and apply an adhesive film dressing.

After decompression, check the patient and obtain a CXR.

Note: the risk of causing a pneumothorax by needle decompression in a patient who did not have one is ~10%. If the patient is very muscular or obese, consider using a longer cannula than normal (eg central venous line) to ensure that the pleural cavity is reached.

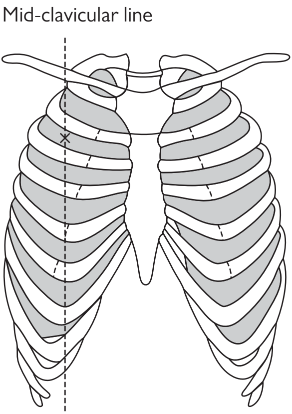


Fig. 8.3 Site for needle decompression of right tension pneumothorax.

Tension pneumothorax seen on X-ray or CT

Traditional teaching implies that tension pneumothorax is easy to diagnose on clinical grounds, and whilst this can be true, there are occasions when the diagnosis is less obvious—some of the signs are relatively subtle in a busy resuscitation room. Also, sometimes patients deteriorate whilst undergoing imaging, such that tension pneumothorax is first identified on a CXR or a CT scan. Once identified, decompress, according to the findings on the CXR or CT scan. Take particular care to ensure that the correct side is decompressed—there have been occasions when attention has been focussed on the wrong side (particularly with a pneumothorax seen on CT scan).

Rib fractures

Isolated rib fracture

A history of trauma with subsequent musculoskeletal pain suggests rib fracture. The diagnosis is confirmed by localized chest wall tenderness—the diagnosis of a single rib fracture is a clinical one. Check for features of pneumothorax (dyspnoea, ↓ air entry—see ➲ Traumatic pneumothorax, p. 344), secondary pneumonia, or multiple rib fractures, and if any is present, obtain a CXR.

Treat an uncomplicated isolated rib fracture with oral analgesia (eg co-codamol ± NSAID). Warn the patient that the rib may remain painful for ≥3 weeks and to seek medical advice if additional symptoms develop.

Multiple rib fractures

Observe the chest wall carefully for a flail segment, and look for clinical evidence of pneumothorax or, in late presentations, pneumonia.

Check SpO_2 and ABG, and obtain a CXR. Note that up to 50% of rib fractures may not be apparent on CXR—adopt a low threshold for CT scan which may reveal the full extent of the chest injury.

Treat flail segment and pneumothorax as described in ➲ Flail segment, p. 342 and ➲ Traumatic pneumothorax, p. 344. Treat patients with uncomplicated multiple rib fractures according to the presence of other injuries and pre-existing medical problems as follows:

- In patients with other injuries requiring IPPV, discuss the potential need for chest drains with the ICU team (↑ risk of pneumothorax).
- Patients with pre-existing pulmonary disease and limited respiratory reserve require admission for analgesia and physiotherapy.
- Patients with chest infection often require admission for analgesia, monitoring, antibiotics, and physiotherapy, depending upon the past medical history and clinical and radiological findings.

Chest wall injury pathways

Recognition of the morbidity and mortality associated with chest wall injury (especially in the elderly) has resulted in widespread adoption of chest wall injury pathways. These include a plan for management based on a scoring system—an example is shown in Table 8.2.

Table 8.2 Chest wall injury score

Age	+1 for each 10y aged >10y
Ribs	+3 for each fracture
Chronic lung disease	+5 if present
Anticoagulant or antiplatelet use	+4 (low-dose aspirin does not count)
SpO_2	+2 for each 5% ↓ below 95%

Scores can help to guide management:

- >10—requires admission.
- >20—refer to ICU/critical care.
- >30—consider referral to a regional major trauma centre.

Sternal fracture

Background

Fracture of the sternum frequently occurs during road traffic collisions, either due to impact against the steering wheel or seat belt. The injury may be associated with myocardial contusion, great vessel injury, and spinal injury.

Features

Anterior chest pain with localized tenderness over the sternum may be accompanied by bruising and/or swelling.

Investigations

- Place on a cardiac monitor.
- Record an ECG to exclude arrhythmias, MI (see ➔ ST segment elevation MI, pp. 74–5), or myocardial contusion (look for ST changes, particularly elevation). Consider further investigation with echocardiography.
- Check cardiac-specific enzymes (troponins) if there are ECG changes.
- Request CXR and lateral sternal X-ray—the latter will demonstrate the fracture (which is usually transverse), and the former associated injuries (see Fig. 8.4).

Treatment

Provide analgesia and O_2, as required. Admit patients who have evidence of myocardial contusion or significant injuries elsewhere. Only consider discharging those patients who have an isolated sternal fracture, with a normal ECG, no associated injuries, and normal pre-existing cardiopulmonary function. Ensure that patients who are discharged receive oral analgesia (eg co-codamol ± NSAID) and GP follow-up, together with advice on when to seek urgent medical review if complications ensue.

Note: rarely, forced flexion of the chest causes a displaced sternal fracture, with wedge fractures of the upper thoracic vertebrae. Check the spine carefully; ask about pain, and look for kyphosis and tenderness (which may not be apparent). Lateral thoracic X-rays often fail to show injuries to the upper thoracic vertebrae, so if injury is suspected at this site, consider requesting a CT scan.

Fig. 8.4 Fracture of the sternum in a 90y old man.

Flail segment

Fracture of ≥3 ribs in two places allows part of the chest wall to move independently. This flail segment usually indicates significant injury to the underlying lung (typically pulmonary contusions). Large flail segments occur laterally when several ribs on one side fracture anteriorly and posteriorly. Similarly, an anterior flail segment is produced by bilateral fractures of all ribs anteriorly—in this case, the free portion comprises the sternum, the costal cartilages, and the medial parts of the fractured ribs (see Fig. 8.5).

Presentation

The flail segment causes pain and moves paradoxically, compared with the rest of the chest wall, limiting the effectiveness of respiration. The diagnosis is a clinical one, but it can be difficult to make. Look tangentially at the chest for areas which move paradoxically (ie inward during inspiration and outward during expiration). There may be associated features of respiratory distress (cyanosis, tachypnoea). Check for pneumothorax or haemothorax (see ➲ Traumatic pneumothorax, p. 344).

Investigations

Assess for respiratory compromise clinically, together with some tests:

- SpO_2 on pulse oximetry.
- ABG—the combination of hypoxia and respiratory acidosis (↑ pCO_2, ↑ H^+) indicates severe respiratory compromise.
- CT is more useful than CXR in demonstrating fractures and other injuries (eg pulmonary contusions, pneumothorax, haemothorax).

Treatment

- Provide high-flow O_2, and treat associated life-threatening problems.
- Contact the ICU/anaesthesia team, and carefully consider the need for immediate or urgent tracheal intubation with IPPV.
- Carefully observe and monitor in an HDU or ICU.
- Prescribe regular oral analgesia. Selected patients may benefit from patient-controlled analgesia, an epidural, or regional anaesthesia.

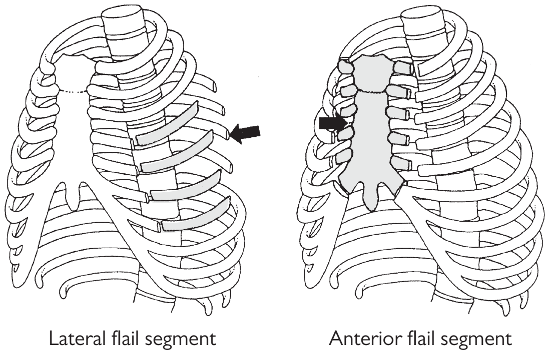


Fig. 8.5 Lateral (left) and anterior (right) flail segments.

Ruptured diaphragm

Left-sided ruptures predominate (75%).

Major diaphragmatic rupture

Usually with associated herniation of abdominal contents into the chest, this is a severe injury resulting from a significant traumatic insult (often massive abdominal crushing). Depending upon the extent of the injuries, the patient may present hypoxic, with hypovolaemic shock and respiratory compromise. Note that a ruptured diaphragm may have some clinical features similar to those of a tension pneumothorax. Call a surgeon and an anaesthetist, as the patient will require urgent intubation and IPPV.

Minor diaphragmatic rupture

Less dramatic herniation may present in a more subtle fashion and result from a penetrating injury. The diagnosis is difficult to identify on CT scanning and is frequently missed initially. However, it is important because:

- It is often associated with injury to both abdominal and thoracic contents.
- There are possible late complications (eg bowel herniation/obstruction).
- It does not heal spontaneously.

Suspect a ruptured diaphragm from the mechanism of injury and an abnormal or a high hemidiaphragm contour on erect CXR. Look for stomach or bowel loops in the chest—the gastric tube may be seen coiled in the intra-thoracic stomach. If a ruptured diaphragm is suspected, resuscitate and refer to a surgeon.

Oesophageal rupture

Traumatic (non-iatrogenic) rupture of the oesophagus is uncommon but may follow a blunt or penetrating injury. Suspect it if the patient complains of chest and back/neck pain in the presence of a normal ECG. Check for surgical emphysema in the neck. Imaging (CXR or CT) may demonstrate pneumomediastinum (a layer of gas around the heart/mediastinum), a left-sided pleural effusion, or pneumothorax. Provide O_2 and IV analgesia, and start IV antibiotics (eg cefuroxime 1.5g). Resuscitate; treat other injuries, and refer to a cardiothoracic surgeon.

Boerhaave's syndrome

'Spontaneous' rupture of the oesophagus is associated with overindulgence and vomiting. Patients are classically middle-aged and present with severe chest pain, signs of shock, and subcutaneous emphysema. CXR or (better) CT will confirm the diagnosis. If suspected, treat as outlined above for traumatic oesophageal rupture.

Traumatic pneumothorax

Background

Pneumothorax frequently results from a blunt injury, with associated rib fractures, or from a penetrating injury (knife stabbing or gunshot wound). It may also be iatrogenic, secondary to attempted insertion of a central venous line.

Clinical features

Patients are likely to complain of symptoms relating to the associated injuries (eg rib fractures—see ➲ Rib fractures, p. 340). The degree of breathlessness resulting from a pneumothorax depends largely upon its size. Other features may be present, including surgical emphysema, cyanosis, and ↓ air entry over the affected lung. Severe dyspnoea and distended neck veins/hypotension suggest tension pneumothorax (see ➲ Tension pneumothorax, pp. 338–9). SpO_2 and ABG may reveal hypoxia.

CXR demonstrates the pneumothorax. Both inspiratory and expiratory X-rays are not required. Wherever possible, obtain an erect CXR. X-rays taken with the patient lying supine may not show a free lung edge, despite a considerable pneumothorax, because in this position, air tends to lie anteriorly in the pleural space (see Fig. 8.7). If there is no definite pneumothorax visible on a supine CXR, features which are suggestive of a pneumothorax are:

- Hyperinflation of the affected hemithorax, with a depressed hemidiaphragm.
- Double contour of a hemidiaphragm.
- Basal hyperlucency of the affected lung.
- Visualization of apical pericardial fat tags.

A *CT scan* obtained to assess other injuries will easily demonstrate a pneumothorax. Not infrequently, small pneumothoraces that are not apparent on a CXR are clearly apparent on CT.

Point-of-care USS is also good at identifying pneumothoraces.

Treatment

Tension pneumothorax is an emergency requiring immediate needle decompression (see ➲ Tension pneumothorax, pp. 338–9) or thoracostomy. Provide O_2 and drain significant traumatic pneumothoraces using a chest drain and an open technique, as described in ➲ Chest drain insertion, p. 346.

There is ↑ experience with initially managing some patients who have an isolated chest injury and small traumatic pneumothoraces in a conservative fashion, using close observation and no chest drain. Patients who have multiple injuries and/or other injuries (particularly those requiring GA and IPPV) certainly require chest drain insertion in the ED.

Haemothorax

Blood may collect in the pleural cavity, in association with a pneumothorax (haemopneumothorax) or without (haemothorax). A large amount of bleeding into the pleural space sufficient to produce hypovolaemic shock is termed *massive haemothorax*.

Clinical features

The clinical presentation is similar to that seen in traumatic pneumothorax, except that there may be dullness to percussion over the affected lung and, with massive haemothorax, evidence of hypovolaemia.

CXR Blood from a haemothorax collects under the affected lung, showing up as ↑ shadowing on a supine X-ray, with no visible fluid level. It may be very difficult to distinguish a haemothorax from pulmonary contusions on a supine X-ray, but a haemothorax may produce blurring of the hemidiaphragm contour or of the costophrenic angles.

CT scan Will easily define a haemothorax and associated injuries (see Fig. 8.8).

Treatment

Give O_2 and insert two large venous cannulae (sending blood for cross-matching). If hypovolaemic, give blood before inserting a large (≥32FG) chest drain. Although it is common practice to try to direct the chest drain towards the diaphragm, this seldom makes a difference in practice—it is more important to use a chest tube of sufficient calibre in order to minimize blockages due to blood clots.

Chest drain insertion

Use the 'open' technique, as described below. Explain the procedure; obtain consent, and confirm that the patient has venous access, is breathing O_2, and is fully monitored. Ensure that all equipment is ready and a good light and assistance are available. Give adequate IV opioid analgesia to conscious patients, as this procedure can be painful.

- Abduct the ipsilateral arm fully.
- Don a sterile gown and gloves, plus goggles/face shield.
- Clean the skin with antiseptic and cover with sterile drapes.
- Identify the fifth intercostal space just anterior to the mid-axillary line (count down and across from the angle of Louis at the level of the second rib) (see Fig. 8.6, top).
- Generously infiltrate LA (1% lidocaine ± adrenaline) under the skin and down to the periosteum at the upper edge of the sixth rib.
- Prepare the chest drain; remove and discard the trocar (in adults, use size 28–32FG; in children, use the largest size that will comfortably pass between the ribs).
- Make a 2–3cm skin incision in the line of the ribs (see Fig. 8.6).
- Use blunt dissection with artery forceps to open the tissues down to the pleural space, just above the sixth rib.
- Puncture the pleura with the artery forceps.
- Taking care to avoid a finger injury from rib fractures, insert a gloved index finger into the pleural cavity to ensure there are no adhesions and that you are within the thoracic cavity (see Fig. 8.6).
- Insert the chest drain, ensuring that all drainage holes are inside the chest (typically ~15–20cm in adults).
- Connect the drain to an underwater seal and look for 'swinging'.
- Suture the drain securely in place (eg with heavy silk), and cover with an adhesive film dressing and adhesive tape (see Fig. 8.6). Whilst securing it, get an assistant to hold the drain, so that it does not inadvertently fall out. It is useful to insert two untied sutures at the site of exit of the chest drain, so that these can be later tied to close the exit site when the drain is removed.
- Check the underwater seal is 'swinging' in the tube with respiration.
- Listen for air entry and check the patient.
- Obtain a CXR to confirm placement—if the tube has been inserted too far (eg so that it is touching the mediastinum), pull it back slightly and re-suture and secure in place.
- Afterwards, keep the water seal drainage bottle below the level of the patient. Avoid clamping the tube.

Referral to a thoracic surgeon If the chest drain initially yields >1500mL of blood or subsequently drains >200mL/hr for 2hr, refer urgently to a thoracic surgeon for a possible urgent thoracotomy.

Ruptured bronchus Persistent, continuing bubbling of gas through the underwater drain may reflect a major rupture of the tracheobronchial tree, especially if the lung fails to re-expand. Bronchial rupture may also present with haemoptysis or tension pneumothorax. Involve a thoracic surgeon at an early stage.

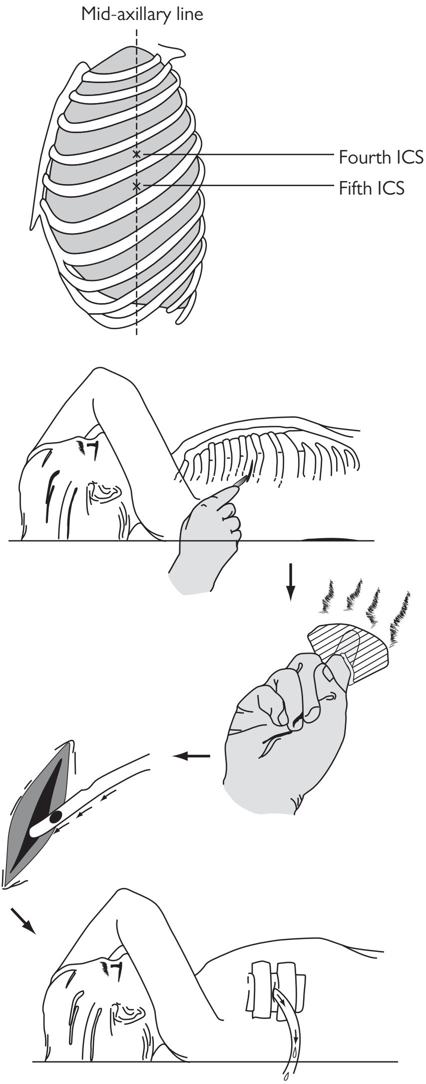


Fig. 8.6 Chest drain insertion.

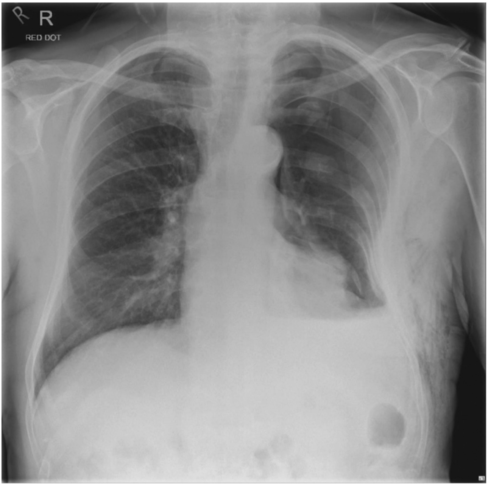


Fig. 8.7 CXR in a patient with blunt chest trauma.

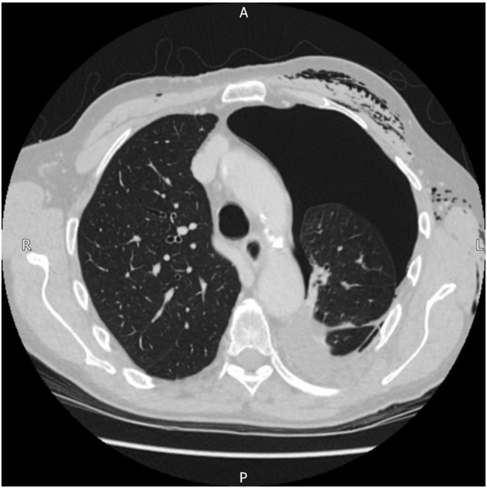


Fig. 8.8 CT in the same patient shown in Fig. 8.7—blunt chest trauma, comprising rib fractures, subcutaneous emphysema, a left pneumothorax, and a small haemothorax.

Pulmonary contusions and aspiration

Pulmonary contusions

High-energy transfer during blunt injury (eg road traffic collisions or high falls) often causes pulmonary contusions. Suspect these in all patients with flail segments (see ➲ Flail segment, p. 342).

Clinical features

Pulmonary contusions produce V/Q mismatch, which may lead to hypoxia and respiratory distress, and ↑ the likelihood of ARDS.

Radiological appearances

Pulmonary contusions may be visible on initial CXR as patchy opacification. However, initial radiological appearances are non-specific and may be confused with those seen after pulmonary aspiration or haemothorax (see ➲ Haemothorax, p. 345). X-ray changes resulting from pulmonary contusions tend to be progressive and become more prominent with time.

Management

Provide high-flow O_2, and check ABG to help assess the need for GA, tracheal intubation, and IPPV. Involve ICU specialists early.

Pulmonary aspiration

Inhalation of vomit and other foreign material may add considerably to the damage resulting from the initial injury (see ➲ Pulmonary aspiration, p. 116–17).

Common associations

- Inhalation of vomit after head injury with ↓ conscious level and impaired protective laryngeal reflexes—gastric contents are particularly irritant to the respiratory tract.
- Inhalation of blood and teeth after facial trauma.
- Inhalation of water and foreign matter in near drowning (see ➲ Drowing and near drowning, pp. 268–9).

Presentation

Suspect pulmonary aspiration from the history, associated respiratory signs, and the X-ray appearance. The CXR may show diffuse opacification affecting one or both lungs—the distribution depends upon the position at the time of aspiration.

Management

- Check SpO_2 and ABG, and obtain a CXR.
- Provide high-flow O_2 as required.
- Treat other injuries.
- Consider the need for GA, tracheal intubation, and IPPV. Bronchoscopy may be needed to remove large FBs from within the bronchial tree.
- Even if there is no urgent requirement for IPPV, remember that the respiratory problem is likely to worsen (with the development of infection/ARDS), so involve the ICU team early.
- Do not give routine antibiotics, unless there is a specific indication, such as immersion in sewage or in rat-infested water with the risk of developing leptospirosis (see ➲ Leptospirosis (Weil's disease), p. 249).

Approach to penetrating chest injury

Initial assessment and resuscitation

Do not be misled by seemingly innocuous wounds. The size of the external wound has no correlation with the potential for internal injury. Give O_2 if SpO_2 is low. Gain venous access (send blood for cross-matching or group and save) and resuscitate according to an evaluation of ABCDE. Remove the patient's clothes and log roll to check for wounds to the back and perineum. Particularly in gunshot injuries, perform an early check for evidence of spinal cord injury. Remember that a penetrating chest injury often involves the abdomen (and vice versa). During the initial assessment, aim to exclude or identify and treat:

- Tension pneumothorax (see ➲ Tension pneumothorax, pp. 338–9).
- Sucking chest wound (see ➲ Thoracotomy for cardiac arrest, p. 353).
- Cardiac tamponade (see ➲ Thoracotomy for cardiac arrest, p. 353).
- Massive haemothorax (see ➲ Traumatic pneumothorax, p. 344 and ➲ Haemothorax, p. 345).

Further management depends partially upon the haemodynamic status.

Haemodynamically stable patient

Many patients present without overt evidence of significant injury:

- Provide O_2 and secure venous access, and send blood for group and save.
- Monitor SpO_2, pulse, BP, and RR.
- Administer minimal or no IV fluids.
- Perform a FAST scan, if possible (see ➲ Focussed assessment with sonography for trauma (FAST) scan, p. 355).
- Obtain a CT chest and abdomen or a CXR (ideally PA erect).
- Record an ECG.
- Provide IV analgesia as required (see ➲ Major trauma: treatment principles, p. 330).
- Consider tetanus status and the need for prophylactic antibiotics (eg cefuroxime 1.5g IV—according to local policy).
- Cover the chest wound with a sterile dressing.
- Drain any pneumothorax with a chest drain (having decompressed any tension pneumothorax—see ➲ Tension pneumothorax, p. 338–9). *Do not* insert the drain through the wound (this ↑ the risk of infection).
- Refer all patients for admission, observation, formal wound cleaning, exploration, and closure. If the patient remains stable overnight, with no clinical or radiological abnormalities, they may be safely discharged with arrangements for review.
- Document the size, position, and other features of the chest wound, remembering the potential medicolegal significance (see ➲ The approach to wounds, p. 410).

The unstable patient

Haemodynamic instability may be due to tension pneumothorax, massive haemothorax, sucking chest wound, or cardiac tamponade. Treat each of these, as outlined in ➲ Thoracotomy for cardiac arrest, p. 353, involving a senior surgeon at an early stage.

Indications for thoracotomy

Thoracotomy in theatre will be required for significant haemorrhage, which typically means:

- >1.5L of free blood obtained by initial chest drainage, or
- >200mL of blood draining per hour via a chest drain.

Open chest injury

An open wound between the pleural cavity and the outside may cause respiratory insufficiency. When the chest expands on inspiration, there is less resistance to air movement through the open chest wound than down the tracheobronchial tree. Air flow into the lungs is reduced, and the lung collapses as air enters the pleural space and produces a pneumothorax. Hypoxia develops rapidly.

Features

Look for respiratory distress, tachypnoea, and cyanosis.

Management

- Provide high-flow O_2.
- Ideally, cover with a one-way adhesive chest seal. If not available, it is traditional to occlude with a dressing on three sides (although the evidence for this is lacking), or alternatively cover with an occlusive dressing and insert an immediate chest drain. If signs of deterioration occur, consider a possible tension pneumothorax, in which case remove the dressing.
- Insert a chest drain (not through the wound) to drain the pneumothorax.
- Provide further resuscitation as necessary.
- Call a thoracic surgeon to arrange formal wound closure.

Traumatic cardiac arrest

Background

Cardiac arrest following trauma generally carries a poor prognosis, although there is a chance of recovery (especially following penetrating trauma), depending upon the exact situation. First, try to determine whether the cardiac arrest is likely to be due to the injurious event itself or to an underlying medical condition which subsequently has resulted in injuries.

Action if cardiac arrest is likely due to the injury

If there is a high index of suspicion of a traumatic aetiology to the arrest, consider the possible likely reversible causes (usually associated with PEA). These are:

- Hypoxia: secure the airway with a tracheal tube and ventilate with O_2.
- Hypovolaemia: give blood and plasma (eg 4U of O-negative packed red cells stat—warmed via a blood warmer).
- Tension pneumothorax: perform immediate bilateral finger thoracostomies.
- Cardiac tamponade: if the above fail and/or fluid is suspected or seen on eFAST, perform a clam shell thoracotomy. Pericardiocentesis is often unsuccessful due to clots which have formed in the pericardial sac and which cannot be aspirated.

Do not perform chest compressions, as these are not likely to improve outcome, given the underlying aetiology. Remember also that sometimes peripheral pulses cannot be felt in very low output states. In the presence of some injuries, such as multiple displaced rib fractures, chest compressions carry the risk of causing further injury.

Similarly, avoid adrenaline as there is no evidence of a benefit for it in traumatic cardiac arrest.

Return of spontaneous circulation after traumatic arrest

If there is ROSC, continue resuscitation and employ appropriate imaging (eg abdominal USS, CXR, pelvic X-ray, CT) to establish the exact nature of the underlying injuries and to guide management such as damage control surgery and interventional radiology.

Thoracotomy for cardiac arrest

Indications for resuscitative thoracotomy

Emergency thoracotomy can be performed in order to relieve cardiac tamponade, perform haemostasis of lung injury, compress the thoracic aorta if there is massive haemorrhage below the diaphragm, and perform internal cardiac massage.

Consider thoracotomy in the ED if there is refractory hypotension despite vigorous resuscitation or failure to regain output despite treatment of hypoxia, blood replacement, and bilateral thoracostomies. It is generally stated that thoracotomy can be considered after penetrating trauma with <15min of CPR and after blunt trauma with <10min of CPR.

Procedure

- Summon expert help (ED consultant; cardiothoracic, general, or trauma surgeon; anaesthetist) and proceed immediately. Do not wait.
- Whilst the thoracotomy tray is being opened, don gloves, a face shield, and an apron; ensure that the patient is being ventilated with O_2 via a tracheal tube. Continue rapid IV blood via multiple lines, and obtain blood for transfusion.
- Perform bilateral thoracostomies.
- Connect the thoracostomies with an incision using a scalpel.
- Join the thoracostomies by cutting through the intercostal muscles using strong scissors (eg Tuff Cut®), then cut horizontally through the sternum using scissors or a Gigli saw.
- Open the chest with rib spreaders or ask a member of staff to pull the chest open.
- Open the pericardium with scissors (cut vertically and take care to avoid the left phrenic nerve).
- Remove any tamponade.
- Manage myocardial wounds by finger pressure or with a Foley catheter or a non-absorbable suture (eg interrupted 4/0 Prolene sutures, using Teflon or pericardial buttresses if necessary). Once sutures are in place, stop internal cardiac massage and check the cardiac rhythm and output. If the heart is fibrillating, defibrillate using internal defibrillation paddles, by placing a paddle over each side of the heart. Start with 5J energy initially, ↑ as necessary to a maximum of 50J. Use an external defibrillator if no internal paddles are available.
- Consider controlling massive pulmonary haemorrhage by collapsing the lung (eg using an incontinence pad).
- If massive bleeding below the diaphragm is suspected, compress the aorta using a fist.
- If internal cardiac compression is required, provide this using a bimanual technique, by compressing the heart between two flat hands, with the fingers placed over the defects.
- Once a pulse has been restored, ensure that hypovolaemia is corrected. Give cefuroxime 1.5g IV; insert an arterial line and a urinary catheter, and recheck U&E, glucose, FBC, and clotting.
- The surgical team will direct further surgical management.

Aortic injury

The vast majority of aortic injuries (~90%) are sustained during high-energy blunt trauma (eg road traffic collisions, high falls). Only a small proportion of these patients reach hospital with signs of life. The usual site of rupture is just distal to the origin of the left subclavian artery, possibly caused by differential shearing forces between the mobile arch and the fixed descending thoracic aorta. An alternative proposed mechanism is that during rapid deceleration, the first rib and clavicle swing down and directly 'nip' the aorta (the 'osseous pinch' theory). The injury is relatively unusual in children, who are perhaps protected by having more elastic tissues.

Features

Patients who reach hospital alive are most likely to have a partial or a contained rupture, with a haematoma confined by the aortic adventitia. They may complain of chest and back pain, and there may be a harsh systolic murmur, absent or ↓ pulses (with differential BP between the arms and legs), and evidence of hypovolaemic shock—features of other significant non-aortic injuries may predominate.

Diagnosis

The diagnosis of aortic injury can be difficult—adopt a high index of suspicion. If there is suspicion of an aortic injury, obtain a CT scan. CXR features can be quite subtle.

CXR features suggesting aortic injury

- Widened mediastinum (>8cm on PA film).
- Abnormal aortic arch contour.
- Deviation of the trachea to the right side.
- Deviation of an orogastric/NG tube to the right side (such that it lies to the right of the T4 spinous process).
- Depression of the left main bronchus >40° below the horizontal.
- Left pleural cap or fractured first/second ribs are often quoted but are of little diagnostic value.
- The CXR may be normal!

Management

Resuscitate and treat other injuries. Aortic injuries are associated with other severe chest injuries, eg flail segments, pulmonary contusions. As a minimum, provide O_2, insert two IV cannulae, start IV fluids, provide analgesia, and monitor vital signs and SpO_2. Check U&E, glucose, FBC, clotting, ABG, and cross-match. Insert a urinary catheter and an arterial line.

Involve a cardiothoracic surgeon or a vascular surgeon with expertise in aortic injury. Refer urgently for specialist investigation (CT and/or aortography). Involve an anaesthetist/ICU. Control BP (avoid over-infusion of IV fluids; use GTN IVI to maintain systolic BP (~90mmHg) prior to treatment. This may involve open surgical repair or an endovascular stent graft.

Focussed assessment with sonography for trauma (FAST) scan

This is used in the ED resuscitation room to assess the chest and abdomen of acutely injured patients, especially those with shock. Do not perform FAST scanning before immediate CT or to determine the need for CT.

This can be performed by a trained ED doctor, surgeon, or radiologist.

Advantages

- Can be done in the ED.
- Quick: takes 2–3min.
- Non-invasive.
- Repeatable if concerns persist or the patient's condition changes.

Disadvantages

- Operator-dependent.
- Does not define the injured organ, but only the presence of blood or fluid in the abdomen or pericardium.

Ideally performed with a portable or hand-held USS scanner.
Looks at four areas for the presence of free fluid only:

- Hepatorenal recess (Morrison's pouch).
- Splenorenal recess.
- Pelvis (pouch of Douglas).
- Pericardium.

The scan is usually done in that order, as the hepatorenal recess is the first to fill with fluid in the supine position and is most easily identified.

If the indication for FAST scanning is to identify cardiac tamponade, the first view should be the pericardial view.

Free fluid appears as a black echo-free area:

- Between the liver and the right kidney.
- Between the spleen and the left kidney.
- Behind the bladder in the pelvis.
- Around the heart in the pericardium.

A positive FAST scan

- One which identifies any free fluid in the abdomen or in the pericardium.
- Visible free fluid in the abdomen implies a minimum volume of ~500mL.

The finding of blood in the pericardium after trauma is an indication for an emergency thoracotomy, ideally in the operating theatre; however, perform this in the ED if the patient arrests.

Note that FAST scanning is very sensitive at detecting a pneumothorax. FAST scanning requires training prior to use on trauma patients; there is a significant false-negative rate in inexperienced hands.

Blunt abdominal trauma

Blunt injury to the abdomen may be isolated or associated with injuries elsewhere. Evaluation of the abdomen may be particularly difficult in the latter situation. The mechanisms of injury responsible are diverse and include road traffic collisions, crushing injuries, high falls, and direct blows (eg kicks and punches). Remember that a lower chest injury may be associated with splenic or liver injuries.

Examination

- *Assess* for hypovolaemia. Check pulse, BP, and capillary refill.
- *Look* for bruising (eg 'lap belt' imprint). (Measurements of the abdominal girth are unhelpful and unreliable as a means of assessing intra-abdominal haemorrhage.)
- *Feel* for tenderness and evidence of peritonism. Listening for bowel sounds is not helpful—their presence or absence is not discriminatory.
- *Check* for femoral pulses.
- *Log roll* to check for loin tenderness and back injury, but do not allow this to delay CT—defer until after the scan.
- *Examine the perineum* and consider a *rectal examination*, checking perineal sensation, anal tone, rectal integrity/blood, and in the ♂, the position of the prostate. A high-riding, 'boggy' or impalpable prostate may indicate urethral injury (see ➲ Urethral trauma, p. 360).

Investigations

The choice of investigation depends upon individual circumstances, local policy, facilities, and expertise. Patients who are haemodynamically unstable or who have peritonism need immediate referral/laparotomy.

Perform urinalysis in all patients. A positive urinalysis is a marker for an intra-abdominal solid organ injury, not just a renal tract injury. Insert a urinary catheter in patients who present with haemodynamic disturbance or who are critically ill (unless there is evidence of urethral injury—see ➲ Urethral trauma, p. 360). Perform a pregnancy test in all women of child-bearing age.

Serum amylase does not discriminate between those with significant intra-abdominal injury and those without: it is unhelpful in the early stages of trauma resuscitation.

Plain abdominal X-ray is traditional, but rarely useful.

FAST (USS) provides a rapid, repeatable, non-invasive bedside test. It is operator-dependent. Haemoperitoneum is identified by scanning the hepatorenal and splenorenal recesses and the pelvis. The pericardium can also be scanned to look for tamponade (see ➲ Focussed assessment with sonography for trauma (FAST) scan, p. 355).

CT scans are extensively used to evaluate abdominal injuries, as well as identify injuries in other regions (eg retroperitoneum, brain, chest). The major advantage of CT is the ability to diagnose the injured organ(s) within the abdomen and to quantify injuries (minor laceration of the liver or spleen vs multiple deep lacerations with significant haemoperitoneum) (see Fig. 8.9). CT can help to guide management, particularly interventional radiology.

Initial stabilization

(See ➲ Major trauma: treatment principles, p. 330.)

- Provide O_2.
- Treat airway and breathing problems.
- Insert two wide-bore (>16G) IV lines.
- Send blood for U&E, glucose, FBC, clotting screen, and cross-matching.
- Give blood as required, according to initial evidence of hypovolaemia and response to treatment.
- Provide IV analgesia as necessary (contrary to popular opinion, this does not compromise clinical abdominal evaluation).
- Consider the need for an orogastric/NG tube and a urinary catheter.
- Involve a surgeon at an early stage.
- Inform the senior surgeon, duty anaesthetist, and theatre staff if an urgent laparotomy is needed.

Further evaluation and treatment

Once resuscitation is under way, tailor treatment according to the clinical situation.

Haemodynamically unstable Refer urgently to a senior surgeon for laparotomy. Inform the operating theatre and the duty anaesthetist immediately. There may be no need (or time) to attempt to define the intra-abdominal injury. Encourage damage control surgery to be urgently considered in unstable, acidotic, or cold patients.

Clinical peritonism Resuscitate as above; provide IV antibiotics (eg cefuroxime 1.5g) and refer urgently to a surgeon for laparotomy.

Haemodynamically stable, no peritonism Refer to a surgeon for further investigation and observation. FAST (USS) and abdominal CT scans are very useful in further assessment of these patients. Depending on local policy, others may be appropriately managed with regular observations and clinical re-examination.

Possible abdominal injury in the multiply injured These patients provide a diagnostic challenge—tailor investigations and management to individual circumstances. FAST (USS) is a rapid, simple, and useful tool to help to identify significant intra-abdominal haemorrhage in the multiply injured patient. CT has superior diagnostic accuracy, but it takes time and requires IV contrast and usually an internal transfer within the hospital. If the patient is haemodynamically stable, aim to perform a 'pan-scan' CT as soon as possible. The pan-scan CT will typically include the head, neck, chest, abdomen, pelvis, spine, and femoral shafts. The decision of whether or when to perform a CT scan on haemodynamically unstable patients needs to be taken by senior members of the trauma resuscitation team and will be shaped partly by expertise, resources, and transfer time to the CT scanner.

Abdominal trauma in pregnancy Involve a senior obstetrician and a gynaecologist at an early stage. USS can demonstrate fetal viability and look for signs of abruption and uterine rupture. Remember to check the rhesus/antibody status (see ➲ Trauma in pregnancy, pp. 612–13).

Penetrating abdominal trauma

Most penetrating abdominal injuries are caused by knives or guns. The size of the external wound bears little relationship to the severity of intra-abdominal injuries. These injuries have medicolegal implications (see ➲ Interpersonal violence—medicolegal implications, p. 411).

Initial approach

On receiving the patient, provide O_2; secure venous access, and resuscitate according to an initial assessment of ABCDE.

Obtain complete exposure at an early stage in order to check for additional wounds to the chest, back, loins, buttocks, and perineum.

Evaluation of abdominal injury

Unless the patient presents with hypovolaemic shock, it may be difficult to decide the extent and severity of the abdominal injury on clinical grounds. In addition to standard monitoring and palpation of the abdomen, perform a digital rectal examination, and (especially in gunshot injuries) check carefully for spinal cord/cauda equina injury (see ➲ Approach to possible spinal injury, pp. 388–9).

Investigations

Urinalysis Check the urine for blood.

Blood Check BMG, U&E, glucose, FBC, clotting, and group and save/cross-match.

CT scan Obtain a CT scan if the haemodynamic status of the patient allows. X-rays are much less useful—a CXR can show free gas under the diaphragm, and a supine abdominal X-ray can identify bullet fragments, etc.

FAST (USS) FAST scanning will rapidly identify the presence of free intra-abdominal fluid (see ➲ Focussed assessment with sonography for trauma (FAST) scan, p. 355).

Management

- Give O_2: insert two IV cannulae, and send blood as outlined previously.
- In the unstable patient, give blood as necessary, but avoid excessive IV fluids—aggressive infusion worsens outcome. A systolic BP of ~90mmHg in a conscious patient is enough until the start of surgery.
- Provide IV analgesia (eg titrated increments of morphine) as required.
- Give IV antibiotics (eg cefuroxime 1.5g + metronidazole 500mg).
- Consider the need for tetanus prophylaxis (see ➲ Tetanus prophylaxis, p. 424).
- Cover the wound with a sterile dressing. Never probe or explore the wound in the ED to try and define the depth and possible peritoneal penetration. Involve the surgeon early to decide further management.
- Patients who are haemodynamically unstable, have gunshot wounds, or have obvious protruding bowel contents require urgent resuscitation and laparotomy at an early stage. Cover protruding omentum or bowel with saline soaked sterile swabs, but do not push it back into the abdomen.

Renal trauma

Most renal injuries result from direct blunt abdominal trauma, the kidney being crushed against the paravertebral muscles or between the twelfth rib and the spine. Indirect trauma (eg a fall from a height) can tear the major blood vessels at the renal pedicle or rupture the ureter at the pelviureteric junction. Penetrating injuries are relatively rare. Many patients with renal trauma also have other important injuries, which may obscure the diagnosis of the renal injury.

Children are particularly prone to renal injuries. Trauma may uncover congenital abnormalities, hydronephrosis, or occasionally incidental tumours.

Clinical features

Most patients provide a history of a blow to the loin or flank and have loin pain followed by haematuria (which may be delayed). The loin is tender and there may be visible bruising or abrasions. Worsening renal pain may indicate progressive renal ischaemia. Perinephric bleeding can cause loin swelling and a palpable mass. Haematuria *may be absent* in severe injuries in which there are renal vascular tears, thrombosis, or even complete ureteric avulsion.

Investigations

Look for, and record, visible haematuria and test for microscopic haematuria. Get venous access, and send blood for FBC, U&E, glucose, clotting screen, and group and save.

- *CT*: urgent abdominal CT is needed if there is frank haematuria or if the patient was shocked (but is now stable) and has frank or microscopic haematuria. The surgical team should be involved before a CT scan is arranged. Patients should be haemodynamically stable for transfer to CT scanning. Intravenous urography (IVU) is unnecessary if contrast-enhanced CT is planned or has been done.
- *FAST (USS)*: this shows renal morphology and confirms the presence of two kidneys, but it does not demonstrate function. It may reveal intraperitoneal blood.
- *Selective angiography*: this is occasionally helpful.

Stable patients with isolated microscopic haematuria do not necessarily need urgent IVU or CT but require review and appropriate follow-up (eg repeat urinalysis at the GP in a few days' time).

Management

Most *blunt renal injuries* settle with bed rest and analgesia. Give prophylactic antibiotics after consulting the surgical team and according to local policy. Repeat and record pulse, BP, and T°.

Patients with *penetrating renal injuries* and *severe blunt renal trauma* need urgent expert urological assessment ± emergency surgery—the warm ischaemic time of a kidney is only ~2hr. Resuscitate with blood and give IV analgesia and antibiotics.

Bladder injury

The bladder most often ruptures into the peritoneal cavity, as a result of a direct blow to the lower abdomen. These injuries often occur in individuals with distended bladders. Bone fragments from a fractured pelvis may also penetrate the bladder (see ➲ Pelvic fractures, pp. 480–1).

Clinical features

Lower abdominal tenderness ± peritonism may be associated with haematuria or an inability to pass urine. Look for perineal bruising, and check for fresh blood at the external urethral meatus. Perform a rectal examination to check for the position of the prostate and the integrity of the rectum.

Investigations and management

CT will identify significant bladder injuries and any associated pelvic fractures. If there is no sign of urethral injury, pass a catheter to check for haematuria. Refer to the urology team. A cystogram will demonstrate extravasation from a bladder injury. Refer patients with intraperitoneal rupture for laparotomy and repair. Extraperitoneal ruptures may heal with catheter drainage and antibiotics.

Urethral trauma

Posterior urethral tears are often associated with pelvic fractures. Urethral injury may also result (in the absence of fracture) from blows to the perineum (especially falling astride).

Look for perineal bruising and blood at the external urethral meatus, and perform a rectal examination (an abnormally high-riding prostate or an inability to palpate the prostate imply urethral injury).

If urethral injury is suspected, do not attempt urethral catheterization, but refer urgently to the urology team. Some urologists advocate a single gentle attempt at urethral catheterization. Other options are to perform a retrograde urethrogram to assess the extent of the urethral injury or to undertake suprapubic catheterization and subsequent imaging.

Penile injuries

(See ➲ Penile problems and prostatitis, p. 543.)

Scrotal and testicular trauma

Scrotal injuries

Wounds involving the scrotal skin may need to be sutured (preferably with absorbable sutures)—most heal rapidly. Refer for investigation if there is complete scrotal penetration with the attendant risk of damage to the testis, epididymis, or vas deferens. If the testis is visible through the wound, refer for surgical exploration and repair in theatre.

Testicular injuries

Blunt injury to the scrotum/testis may result in a scrotal haematoma or testicular haematoma or rupture. All of these are very painful—provide good analgesia. Further management depends upon the exact diagnosis. USS will help to distinguish between a haematoma and testicular rupture. Involve the urology team—haematomas may respond to conservative measures, but testicular rupture requires urgent surgical exploration and repair.

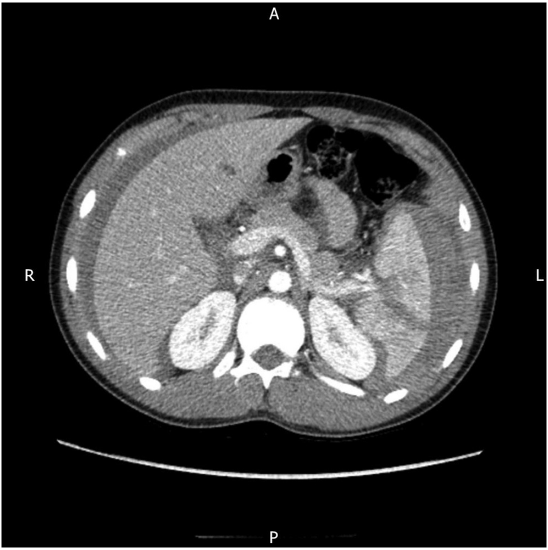


Fig. 8.9 CT in blunt abdominal trauma showing splenic rupture with a large amount of free fluid in the peritoneal cavity.

Head injury: introduction

The size of the problem

Many patients with serious or fatal trauma have suffered a head injury. Additionally, minor head injuries are a frequent reason for attendance at an ED. Blunt injury is far more common than penetrating injury.

Common causes of head injury

- Road traffic collisions of all types.
- Falls.
- Assaults.
- Sporting and leisure injuries.
- Workplace injuries.

Pathophysiology

Brain injury may be primary or secondary.

Primary injury Occurs at the time of the head injury. This takes the form of axonal shearing and disruption, with associated areas of haemorrhage. This primary damage may be widespread ('diffuse axonal injury') or localized (eg 'contre-coup' frontal contusions in a fall hitting the occiput).

Secondary injury Occurs later, due to various problems that commonly co-exist. Many of these are preventable or treatable and should thus be the focus during resuscitation:

- Hypoxia.
- Hypovolaemia and cerebral hypoperfusion.
- Intracranial haematoma with localized pressure effects and ↑ ICP.
- Other causes of ↑ ICP, including cerebral oedema and hypercapnia.
- Epileptic fits.
- Infection.

The role of intracranial pressure

Once the skull sutures have fused, the cranium is a closed box. Thus, a small ↑ in volume (eg from swelling or haematoma) results in a large ↑ in ICP (see Fig. 8.10). As ICP ↑, cerebral perfusion pressure ↓, since:

$$\text{Cerebral perfusion pressure} = \text{Mean arterial pressure} - \text{ICP}$$

Once cerebral perfusion pressure falls <70mmHg, significant secondary brain injury may occur. Control of ICP and BP (including avoiding wild swings in BP) is an important treatment goal, especially as the normal cerebrovascular autoregulatory mechanisms are impaired after head injury. Cerebral arterioles remain sensitive to pCO_2, however, with an ↑ pCO_2 resulting in marked arterial vasodilatation and unwanted ↑ ICP. Controlling pCO_2 to within normal levels is therefore important.

↑ ICP produces a diminishing conscious level and causes herniation of the temporal lobe through the tentorial hiatus, compressing the oculomotor nerve, resulting in ipsilateral pupillary dilatation. This may progress to contralateral hemiparesis and brainstem compression, with cardiorespiratory arrest. ↑ ICP leads to a reflex ↑ in systemic arterial BP, together with bradycardia—this combination is the *Cushing response*.

Indications for referral to hospital

Any one of the following criteria indicates the need for hospital assessment:

- Impaired conscious level at any time.
- Amnesia for the incident or subsequent events.
- Neurological symptoms (vomiting, severe and persistent headache, seizures).
- Clinical evidence of a skull fracture (CSF leak, peri-orbital haematoma).
- Significant extracranial injuries.
- Worrying mechanism (high-energy, possible NAI), possible penetrating injury).
- Continuing uncertainty about the diagnosis after the first assessment.
- Medical comorbidity (anticoagulant use, alcohol abuse).
- Adverse social factors (eg alone at home).

The following are highly recommended:

- The SIGN guideline on head injury is accessible at https://www.sign.ac.uk
- The NICE clinical guidelines on head injury updated in 2019 are accessible at https://www.nice.org.uk

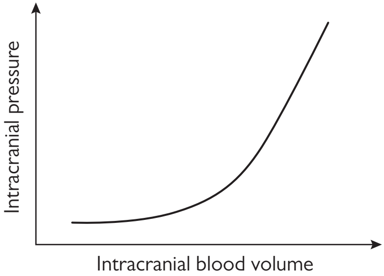


Fig. 8.10 ICP according to intracranial blood volume.

Head injury: triage and monitoring

Triage

Every ED requires a system for the rapid initial assessment of head-injured patients. The exact system will depend upon local policy, expertise, and facilities. It must enable patients with significant injuries to receive immediate resuscitation and ensure urgent treatment of those patients liable to complications. Experienced nursing staff can quickly identify those patients in need of urgent attention, based upon:

- The mechanism of injury.
- The history from the ambulance crew.
- An assessment of vital signs.
- The conscious level according to the GCS (see ➔ Glasgow coma Score (adults), p. 369).
- Limb power.
- Pupil responses.
- BMG.

For patients who are *haemodynamically stable, alert, and orientated*, with no neurological deficit and an apparently minor head injury, it is appropriate to proceed to obtaining a full history, as outlined in ➔ Head injury: history, pp. 366–7.

For patients with *multiple injuries and/or a serious head injury*, there will be no time initially to obtain a full history. Instead, proceed rapidly to initial assessment and resuscitation. During the first few seconds, it is useful to obtain an impression of the severity of the head injury. One simple method (AVPU) classifies patients according to their response to stimulation:

- *A*lert.
- Responsive to *V*oice.
- Responsive only to *P*ain.
- *U*nresponsive.

If a patient is unresponsive or responds only to pain, call for senior ED help and an ICU specialist or anaesthetist, since expert airway care (RSI, tracheal intubation, and IPPV) will be needed.

Monitoring

Ensure that every head-injured patient receives regular neurological observations. These should include measurements of the GCS, pupil response, limb power, pulse, BP, and RR on a standard chart, such as the one shown in Fig. 8.11. This monitoring is critical if complications such as intracranial haematomas, fits, and hypovolaemia from other injuries are to be detected and treated at an early stage. Any deterioration in GCS is an emergency—re-examine the patient and correct identifiable problems promptly, whilst obtaining urgent senior help.

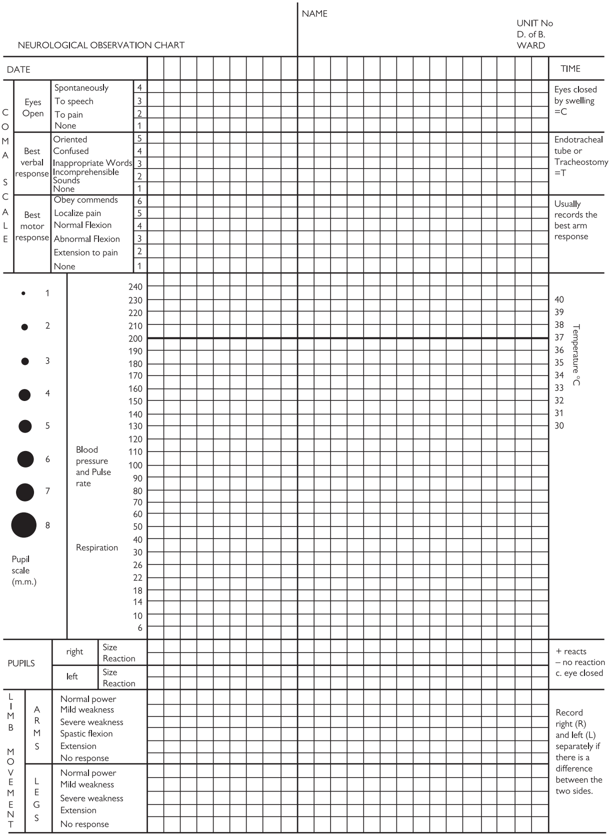


Fig. 8.11 An example of a neurological observation chart.

Head injury: history

It may be impossible to obtain a complete history of what happened from the patient, particularly if there was loss of consciousness and/or amnesia. Patients may incorrectly assume that they were rendered unconscious as a result of an injury if they cannot recall what happened. Use all available sources of information, including friends and family, other witnesses, and the ambulance crew.

Cover the following areas:

Mechanism of injury

Eliciting the exact mechanism of injury will provide an impression of the nature of the forces involved and the risk of subsequent complications. Consider the possibility that the head injury may have been preceded and caused by another medical problem (eg arrhythmia, epilepsy, MI, diabetes).

Time of injury

Although this information is useful, it may be difficult to establish exactly on occasions.

Loss of consciousness/amnesia

A period of unconsciousness implies a head injury of at least moderate severity. It can be difficult to establish exactly how long unconsciousness lasted, particularly if there is associated amnesia. Document the length of amnesia (both before and after injury), but remember that the full extent of the amnesia may not become apparent until much later. Thirty minutes of amnesia for events before the injury is one of the criteria for obtaining a CT scan in adults (see ➲ Head injury: imaging, p. 370).

Subsequent symptoms

Some symptoms are relatively common after head injury (eg headache and vomiting)—many patients will complain of these without being directly asked. There are a number of other symptoms, however, which the patient may not mention unless specifically asked. Enquire about the following symptoms:

- Headache.
- Nausea and vomiting.
- Limb weakness.
- Paraesthesiae.
- Diplopia.
- Rhinorrhoea.
- Otorrhoea.

Past medical history

Document pre-existing illnesses and symptoms, particularly those that may have caused the head injury (eg cardiac arrhythmias, epilepsy, diabetes) or might make the consequences more severe (eg bleeding tendency, low platelets).

Drug history

Ask particularly about recent alcohol and other drug ingestion and whether or not the patient is taking anticoagulant drugs (eg warfarin, rivaroxaban). This is very important, since patients with bleeding disorders and/or on anticoagulants have a much higher risk of intracranial problems after head injury and often require CT and hospital admission (see ➲ Minor head injury, pp. 374–5). Evidence is emerging that some antiplatelet drugs (eg clopidogrel) may also add extra risk of intracranial haemorrhage after a head injury—although not currently part of the standard criteria for obtaining a CT scan after head injury, adopt a lower threshold for requesting a CT brain scan in patients on clopidogrel (see ➲ Head injury: imaging, p. 370).

Social history

Before contemplating discharge of any head-injured patient, establish if there is a responsible adult at home or if there is someone else with whom the patient could go and stay overnight.

Tetanus status

If there are any wounds, consider the need for tetanus prophylaxis (see ➲ Tetanus prophylaxis, p. 424).

Head injury: examination

Resuscitate according to problems identified in the primary survey. Follow an initial brief neurological examination (GCS, pupil reactions, limb weakness) with a definitive complete examination as follows.

Cervical spine injury

Consider this possibility in all cases (see ➲ Major trauma: treatment principles, p. 330).

Glasgow coma score

Determining the conscious level is a crucial part of the neurological examination. The adult score ranges from 3 to 15 and is calculated as shown in Table 8.3. Repeated GCS recordings underpin monitoring the head-injured patient. A fall in GCS indicates a potentially serious deterioration and mandates a search for correctable conditions.

Vital signs

Record pulse, BP, and RR.

BMG

This is essential in all patients with altered conscious level.

Alcohol

Record if the patient smells of alcoholic drinks, but never assume ↓ GCS is due to alcohol.

Eye signs

Document the pupil size (in mm) and reaction to light. Unilateral pupillary dilatation may reflect orbital injury or oculomotor nerve compression due to ↑ ICP (see ➲ The role of intracranial pressure, p. 362). A unilateral small pupil may indicate carotid artery dissection (Horner's syndrome). Check the range of eye movements and for diplopia or nystagmus. If there is any suspicion of eye injury, measure VA (see ➲ Approach to eye problems, pp. 550–1). In infants, check for retinal haemorrhages (see ➲ Head injuries, p. 760). Note that papilloedema is a late sign of ↑ ICP.

Scalp, face, and head

Examine the cranial nerves, and search for abnormal cerebellar signs (nystagmus, hypotonia, intention tremor, dysdiadochokinesia). Carefully record scalp, ear, or facial injury (see ➲ Maxillofacial injuries: introduction, pp. 378–9).

The limbs

Check limb tone, power, sensation, and reflexes. Abnormalities (eg hemiparesis) may result from the primary brain insult or spinal injury or be a consequence of a developing intracranial haematoma requiring urgent intervention. A stroke can cause a fall resulting in a head injury.

Other injuries

The presence of a head injury can render the identification of non-cranial injuries difficult. Intra-abdominal injuries often coexist with serious head injuries and are difficult to detect: have a low threshold for FAST ± CT. In particular, relatively minor non-life-threatening orthopaedic injuries (eg finger dislocations, wrist fractures) are easily missed. Ensure full examination, including palpation of all limbs, for possible injury.

Signs of base of skull fracture

This is often a clinical diagnosis. One or more of the following may be seen:

- Bilateral orbital bruising confined to the orbital margin ('panda eyes').
- Subconjunctival haemorrhage (no posterior margin of bleeding seen).
- Haemotympanum or bleeding from the auditory meatus.
- CSF otorrhoea or rhinorrhoea (± anosmia). Fluid mixtures containing relatively similar quantities of blood and CSF will separate into a 'double ring' when dropped onto blotting paper.
- Battle's sign: bruising over the mastoid process without local direct trauma follows a petrous temporal bone fracture but takes several days to appear.

Glasgow coma score (adults)

The GCS assesses the level of consciousness by scoring three aspects of the patient's response and adding up the scores to reach a final score.

Table 8.3 Glasgow coma score

Eye response	Open spontaneously	4
	Open to verbal command	3
	Open to pressure	2
	No response	1
Verbal response	Talking and orientated	5
	Confused/disorientated	4
	Inappropriate words	3
	Incomprehensible sounds	2
	No response	1
Motor response	Obeys commands	6
	Localizes pain	5
	Flexion/withdrawal	4
	Abnormal flexion	3
	Extension	2
	No response	1
Total (GCS) score		Range 3–15

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Notes

- Record the GCS in shorthand, showing its component parts [eg GCS 10/15 (E3, V2, M5) means that the patient opens their eyes to verbal commands, speaks incomprehensible sounds, localizes a painful stimulus]. Similarly, when communicating with other health professionals, describe the total score (GCS) and list its components.
- Unconsciousness is generally taken to mean no eye response and GCS ≤8.
- 'Abnormal flexion' implies decorticate rigidity, and 'abnormal extension' implies decerebrate rigidity.
- The GCS is difficult to apply to small children but may be modified, as outlined on ➲ Glasgow coma score (children), p. 737.

Head injury: imaging

Use of X-rays has been replaced by CT scanning. In the UK, the SIGN guidelines on early management of head injury (https://www.sign.ac.uk) were updated in 2009. In England and Wales, NICE guidance was published in 2014 and updated in 2017, and is available at https://www.nice.org.uk

Role of CT scanning

CT scanning is used to identify and define brain injury, especially intracranial haematomas amenable to surgical treatment. Ensure adequate resuscitation before transferring for CT scanning. In many cases, this will include RSI, tracheal intubation, and IPPV. Always arrange for appropriately trained staff to accompany the patient to the CT scanner. When clinical features point strongly to an intracranial haematoma (eg emergence of focal signs or a deteriorating GCS), discuss promptly with a neurosurgeon the benefits of transferring the patient to a centre that has both CT scanning facilities and an emergency neurosurgical service.

Indications for CT scan

Request CT scan for any of the following (https://www.nice.org.uk):

- GCS <13/15 on initial assessment in the ED.
- GCS <15/15 at 2hr post-injury.
- Suspected open or depressed skull fracture.
- Any sign of basal skull fracture.
- Post-traumatic seizure.
- Focal neurological deficit.
- >1 episode of vomiting (except in children <12y where clinical judgement is required).
- Amnesia for >30min of events before impact*.
- Loss of consciousness and/or amnesia, combined with one of: age >65y, coagulopathy (including clotting disorder, anticoagulant drug treatment), or dangerous mechanism* (eg pedestrian hit by car, fall >1m or five steps).

Most requests will be urgent (scan performed and interpreted within an hour), except for the two indications marked with an asterisk (*), which, if isolated, may allow a CT scan to be obtained less urgently (within 8hr), depending upon locally agreed policy.

Interpretation of CT scan

CT scans must be assessed by someone with appropriate expertise.

- Skull fractures are usually obvious, as is the degree of depression of fragments.
- Intracranial haematomas may cause a midline shift and take several forms. Extradural haematomas (Intracranial haematoma, p. 373) appear as high-density (white), lens-shaped lesions (see Fig. 8.12). Subdurals conform more to the surface of the brain (Intracranial haematoma, p. 373) (see Fig. 8.13). Extradural and subdural haematomas can coexist.
- Cerebral contusions appear as patches of low or mixed attenuation.
- Cerebral swelling may take some time to develop, causing the ventricles to appear smaller than normal.

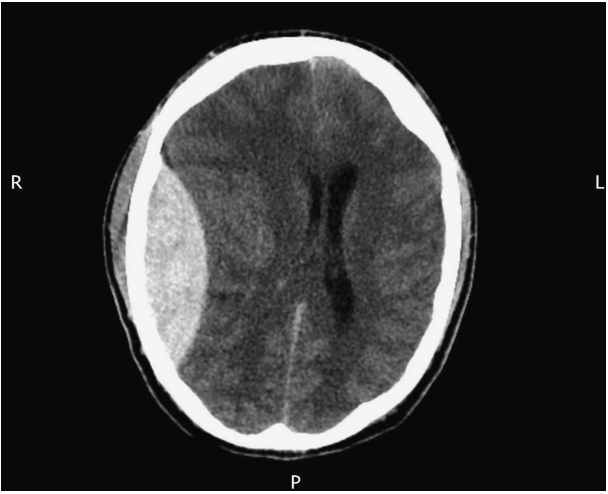

Fig. 8.12 CT of acute right extradural haematoma with associated midline shift.

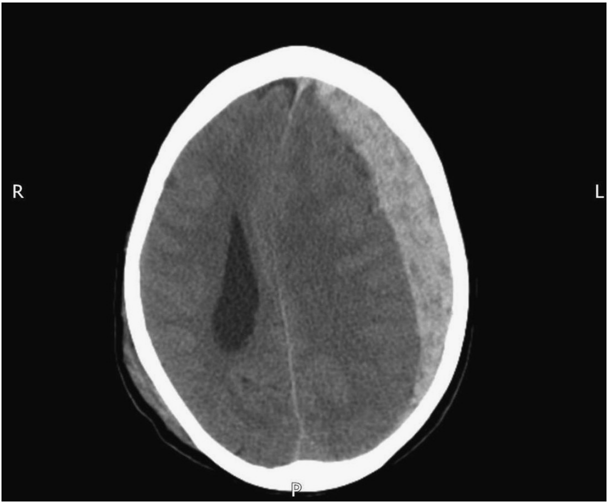

Fig. 8.13 CT showing an acute left subdural haematoma with midline shift. Note the right scalp haematoma.

Management of serious head injury

Initial management

- Clear, establish, and maintain the airway; provide O_2 as required, and protect the cervical spine (➔ Major trauma: treatment principles, p. 330).
- Check and support breathing as necessary. Treat serious chest injury.
- Check BMG and treat hypoglycaemia if present (➔ Investigations in major trauma, pp. 332–3).
- Insert two large IV cannulae, and send blood for cross-matching, FBC, clotting screen, U&E, and glucose.
- Correct hypovolaemia, resuscitate, and treat other injuries.
- If GCS ≤8/15, arrange urgent airway protection with RSI, tracheal intubation, and IPPV (➔ Emergency anaesthesia and rapid sequence induction, pp. 322–3). Call for senior ED help and request help from ICU and/or anaesthesia. Check ABG and ventilate to pCO_2 of ~4.5kPa.
- Liaise early with an anaesthetist, ICU, and a neurosurgeon.
- Arrange CT with minimum delay (consider the need for 'pan-scan').
- In the multiply or seriously injured patient who will require a CT scan, concerns of opioids masking pupillary signs are less important than ensuring adequate analgesia. Give titrated IV opioid analgesia (➔ Major trauma: treatment principles, p. 330), after recording the GCS, pupil reactions, and basic neurological examination.
- Give IV antibiotics for compound skull fractures. Cefuroxime 1.5g IV is suitable, but be guided by local policy. Regional experts vary as to whether or not they advise prophylactic antibiotics for clinical base of skull fractures—follow local policy. Consider tetanus immunization.
- Liaise with the neurosurgeon early—discuss the need for transfer and other treatments such as prophylaxis against fits (eg levetiracetam).
- Give tranexamic acid if traumatic brain injury with GCS <13 within 3hrs of injury.
- Clean and close scalp wounds to control scalp bleeding, but do not allow this to unduly delay the CT scan or neurosurgical transfer.
- Insert a urinary catheter.
- Consider the need for an orogastric tube. Avoid using NG tubes in facial injury or any possibility of base of skull fracture.

Treating complications

Early treatment of complications prevents secondary brain damage.

Deteriorating conscious level

Having corrected hypoxia, hypercapnia, and hypovolaemia, a diminishing conscious level is likely to reflect intracranial pathology, leading to ↑ ICP, mandating urgent investigation and treatment. Bradycardia, hypertension, and a dilating pupil are very late signs of ↑ ICP. Speed is of the essence. Liaise with a neurosurgeon who will advise on use of agents to ↓ ICP (eg a bolus of mannitol 0.5g/kg IV—typically 200mL of 20% for an adult). Mannitol is an osmotic diuretic which may temporarily ↓ ICP and 'buy time' to get the patient to theatre for drainage of an intracranial haematoma.

Hypertonic saline also acts as an osmotic agent to ↓ ICP and has the advantage of ↑ intravascular volume and not causing diuresis, so it is often used in polytrauma. The dose is ~100mg/kg over 10min (eg 3–5mL/kg of 3% saline or 3mL/kg of 5% saline).

Seizures

Check BMG, glucose, and ABG. Give IV lorazepam 4mg. Repeat this once if not initially effective. Start phenytoin IVI (loading dose 20mg/kg IV over 30min, with ECG monitoring) to prevent further fits (an alternative is levetiracetam). Fits which continue ≥10–15min or recur despite this require senior ED and ICU help, RSI, tracheal intubation, and IPPV.

Other examples of deterioration requiring urgent reassessment

- The development of agitation or abnormal behaviour.
- The development of severe or ↑ headache or persistent vomiting.
- New or evolving neurological symptoms/signs (eg limb weakness).

Intracranial haematoma

Causes of neurological deterioration after head injury include hypoxia, hypovolaemia, seizures, cerebral swelling, and intracranial haematomas. Intracranial haematomas are important, as prompt surgery may save lives. Patients with bleeding disorders or on anticoagulants have a greatly ↑ risk of developing an intracranial haematoma after head injury. Reverse anticoagulation as soon as possible (use prothrombin complex concentrate and vitamin K to reverse vitamin K antagonists, see ➲ Managing major bleeding on anticoagulation, p. 179).

Extradural haematoma

Classically, extradural haematoma follows bleeding from the middle meningeal artery's anterior branch after temporal bone fracture (See Fig. 8.12) Texts describe head injury with initial loss of consciousness, then return to full consciousness, before neurological deterioration, as intracranial bleeding continues and ICP ↑. However, many patients deviate from the classical 'talk and die' descriptions—extradural haemorrhage may occur in non-temporal areas, with no skull fracture and no initial loss of consciousness. Refer urgently to the neurosurgical team and prepare to transfer.

Subdural haematoma

Bridging vein bleeding between the brain and the dura causes subdural haematoma. Unlike extradural haematoma (which is separated from the brain surface by the dura), subdural haematoma conforms to the brain surface. This helps distinguish extradural from subdural haematoma on CT. Subdural haematoma may be acute or chronic.

Acute subdural haematoma (see Fig. 8.13) is associated with severe brain insult.

Chronic subdural haematoma often occurs in the elderly and alcoholics (↑ risk due to cerebral atrophy, low platelets, bleeding tendency, or anticoagulant medication). Chronic subdural haematoma develops over several days, often presenting with fluctuating conscious level, sometimes with an obscure (or even no) history of head injury. On this basis, adopt a low threshold to request a CT scan for a middle-aged/elderly patient who presents with new unexplained confusion or ↓ GCS, especially if there are risk factors present. Discuss subdural haematomas with the neurosurgical team—unlike extradural haematomas, they are often managed conservatively, especially in the elderly with multiple comorbidities and when there is no mass effect apparent on the CT scan.

Minor head injury

Introduction

Assessment and management of patients who have sustained relatively minor primary brain insults can be difficult. This is especially true when assessment is rendered awkward by virtue of age, epilepsy, or drug or alcohol ingestion. In these circumstances, adopt a cautious approach and admit the patient for observation until the picture becomes clearer.

Golden rules for managing head injury

- Never attribute ↓ GCS to alcohol alone.
- Never discharge a head-injured patient to go home alone.
- Consider admitting patients with head injury and coexisting bleeding tendency (including those taking anticoagulant drugs).

Differential diagnosis

Consider whether another condition could be principally responsible for the patient's symptoms. For example, small children who vomit after head injury may be suffering from otitis media or a throat infection. Otitis media may be responsible for both vomiting (with fever) and the head injury (by causing unsteadiness of gait, resulting in a fall).

Considerations for admission

Consider the need for admission in patients who have:

- Abnormal findings on CT scan.
- ↓ GCS (ie <15/15), neurological deficit, or post-traumatic seizure.
- Significant neurological symptoms (severe headache, vomiting, irritability or abnormal behaviour, continuing amnesia >5min after injury).
- Significant medical problems, particularly bleeding tendency (including inherited diseases and anticoagulant drugs).
- Inability to assess due to epilepsy, consumption of alcohol, or drugs.
- Clinical or radiological evidence of skull fracture.
- No one available at home or no safe home to go to (including suspected NAI and domestic violence).

Observation of those admitted

Ensure regular neurological observations (see ➔ Head injury: triage and monitoring, p. 364). Act promptly if conscious level ↓ or neurological deficit develops. Remember that the principal reason for admitting patients with apparently minor head injuries is to monitor for the development of intracranial problems. In these cases, resuscitate, liaise with a neurosurgeon, and obtain an urgent CT scan.

If after 12–24hr of observation, the patient is symptom-free and haemodynamically stable and has a GCS of 15/15, with no neurological deficit, consider discharge. Perform a CT scan (if not already imaged) on patients who do not fall into this category (ie symptomatic, ↓ GCS, or with neurological deficit).

Discharging patients

Most patients who present with minor head injury can be safely discharged directly from the ED. Ensure that there is a responsible adult available to accompany them home and someone to stay with them for 24hr once they get home. Warn the patient and the accompanying adult of the potential problems following a head injury (see Box 8.1)—and what to do if any of these problems are experienced. Give advice regarding analgesia. Most EDs have standard written instructions which are given to the patient and accompanying adult. Examples of head injury warning instructions are shown in Box 8.1.

Box 8.1 An example of head injury warning instructions

Adults

- Ensure a responsible person is available to keep an eye on you for the next 24hr and show them this card.
- Rest for the next 24hr.
- Do take painkillers, such as paracetamol, to relieve pain and headache.
- DO NOT drink alcohol for the next 24hr.
- DO take your normal medication, but DO NOT take sleeping tablets or tranquillizers without consulting your doctor first.
- If any of the following symptoms occur, then you should return or be brought back to the hospital or telephone the hospital immediately. Tel (01***)****** (24hr):
  - Headache not relieved by painkillers such as paracetamol.
  - Vomiting.
  - Disturbance of vision.
  - Problems with balance.
  - Fits.
  - Patient becomes unrousable.

Children

- Your child has sustained a head injury, and following a thorough examination, we are satisfied that the injury is not serious.
- Your child may be more tired than normal.
- Allow him/her to sleep if he/she wants to.
- Give paediatric paracetamol for any pain or headache.
- Try to keep your child resting for 24hr.
- If your child should develop any of the following:
  - Headache not relieved by paediatric paracetamol.
  - Vomiting.
  - Altered vision.
  - Irritability.
  - Fits.
  - Becomes unrousable.

Bring him/her back to the hospital or telephone for advice immediately. Tel (01***)****** (24hr).

Alternative suggested written advice is available from NICE (🖱 https://www.nice.org.uk).

Post-concussion symptoms

Presentation

Post-concussion symptoms are common after head injury and cause much anxiety in patients and relatives. The most frequent complaints are: headache, dizziness, lethargy, depression, and inability to concentrate.

Headaches occur in most patients admitted to hospital after head injury—in ~30%, headaches persist for >2 months. They are usually intermittent and become worse during the day or on exertion. Some appear to be 'tension headaches' and are often not significantly helped by analgesics. Migraine may become more frequent or severe after head injury. Headaches that do not fit these patterns may reflect serious intracranial pathology.

Non-specific dizziness is common after concussion. Detailed questioning may distinguish dizziness from vertigo due to disturbance of the vestibular mechanisms. Dizziness may be caused by postural hypotension or by drugs (eg co-codamol and other analgesics) or alcohol (to which patients are often more sensitive after a head injury).

Diagnosis

Post-concussion symptoms are diagnosed by exclusion of other problems or complications following head injury. Take a careful history, including questions about drowsiness, intellectual function, neck pain, photophobia, vomiting, and rhinorrhoea.

Examine for any specific cause of the symptoms and for any neurological deficit. Look for evidence of meningitis or an intracranial haematoma. Check for papilloedema.

Elderly or alcoholic patients or those on anticoagulants are prone to develop chronic subdural haematomas, which may cause confusion or intellectual deterioration, often without localizing signs. Adopt a low threshold for CT for these patients and for others who have worrying or worsening features.

Treatment

After a careful history and examination, with appropriate investigations to exclude other problems, reassure and explain that the symptoms are likely to resolve gradually. Since symptoms may last for some time, arrange appropriate follow-up, usually with the GP.

Concussion in sport

When assessing a patient with a head injury as a result of sport, follow the standard approach to head injury already described. Each sport has its own guideline on whether and when it is safe to return to sport, but in general, patients are advised to rest initially following a head injury, especially whilst symptomatic. Continuing symptoms may warrant specialist input and/or investigation (eg MRI). Advise patients who play high-level sport to take advice from within the sport about when it is safe to return. Returning to sport too early may risk a second injury, with more dramatic consequences (see https://www.headway.org.uk).

Carotid/vertebral artery dissection

Background

Cervical artery dissection includes carotid and vertebral artery dissection. It can occur spontaneously (typically in middle-aged individuals) or follow blunt trauma (eg after road traffic collisions). Dissection of both the carotid artery and the vertebral artery can be difficult to diagnose—adopt a high index of suspicion.

Pathophysiologically, dissection can result in ischaemic brain damage from reduced blood flow through the artery as a direct result of blood entering its wall, which can become aneurysmal. Thrombosis may occur at the site of the dissection, with subsequent embolism resulting in acute ischaemic stroke.

Occasionally, the dissection extends intracranially, in which case subarachnoid haemorrhage may ensue.

Presentation

Carotid or vertebral artery dissection may present acutely as a stroke or in a more chronic fashion. There are often additional features which are unusual in a stroke, with symptoms including:

- Headache.
- Neck or facial pain (especially around one eye).
- Pulsatile tinnitus ('whooshing sound' heard in one ear).
- TIA.

Examination findings

Physical signs are variable but may reflect an acute ischaemic stroke, with signs being determined by the brain territory affected (eg posterior circulation stroke from vertebral artery dissection). In addition, there may be other features, including Horner's syndrome and lateral medullary syndrome. Check for a carotid bruit.

Investigations

CT angiogram is the standard investigation of choice. Doppler ultrasonography can also identify abnormal blood flow in the carotid artery.

Management

Take advice from the regional neurosurgical centre. Standard initial treatment (NICE, 2019—see https://www.nice.org.uk) is with either an antiplatelet drug or an anticoagulant.

Maxillofacial injuries: introduction

These injuries often look dramatic and can be life-threatening, as well as cause significant long-term morbidity. Common causes are assaults, road traffic collisions, and sport.

Emergency resuscitative measures

- Perform a rapid initial assessment to look for, and treat, airway obstruction or major bleeding (see ➔ Major trauma: treatment principles, p. 330). Remember the possibility of an associated neck injury. Blood may rapidly accumulate in the pharynx, requiring anterior ± posterior nasal packing for control (see ➔ Epistaxis, p. 568).
- Management of airway obstruction is complex and intubation often difficult, and occasionally a surgical airway is required—obtain experienced ED and anaesthetic assistance early. Use jaw thrust, chin lift, and suction to establish a patent airway.
- With bilateral mandibular fractures, the tongue may fall backwards. Restore airway patency by pulling the fractured segment anteriorly or by inserting a large (0 silk) suture in the tongue and pulling anteriorly.
- Maxillary fractures may be displaced far enough backwards to compromise the airway by contact of the soft palate against the posterior pharyngeal wall. This can be relieved by hooking two fingers behind the hard palate and pulling forward and upward, but this can produce considerable bleeding.

History

Important clues may be obtained from knowing the causative events both in relation to the facial injury itself and also of injury to the head, spine, etc. Drug history (eg anticoagulants or bleeding tendency) may be important.

Examination

Inspect the face from the front, side, and above (by standing above and behind the patient). Look for:

- Asymmetry.
- Flattening of the cheek (depressed zygomatic fracture).
- 'Dish face' deformity (flattened, elongated face due to posterior and downward displacement of the maxilla).
- Nasal deviation or saddle deformity. Measure the intercanthal distance—if >3.5cm, suspect naso-ethmoidal fracture—see ➔ Naso-ethmoidal fractures, p. 381.
- Uneven pupillary levels (due to orbital floor fracture).
- CSF rhinorrhoea (causes 'tramline' effect with central CSF and blood on either side).
- Subconjunctival haemorrhage without a posterior border (suggests an orbital wall or anterior cranial fossa fracture).

Palpate the facial bones systematically. Start over the superior orbital margins. Work down, feeling both sides at the same time, checking for pain, deformity, crepitus, and movement. Feel specifically for steps in the inferior orbital margin and zygoma. Subcutaneous emphysema implies a compound fracture—often of the maxillary sinus.

Check for hypo-/anaesthesia of the cheek, side of the nose, and the upper lip (infra-orbital nerve injury) and for numbness of the upper teeth (anterior superior alveolar nerve in the infra-orbital canal) and lower teeth and lip (inferior dental nerve damage due to mandibular fracture).

Examine inside the mouth, checking for dental malocclusion (ie the teeth do not meet together properly when the mouth is closed), loose or lost teeth (this may need CXR), bruising, and bleeding.

Examine the eyes carefully (see ➲ Approach to eye problems, pp. 550–1)—assume any laceration below the medial canthus involves the lacrimal duct until proven otherwise.

Investigations

In patients with multiple injuries, imaging of the chest, pelvis, and cervical spine will take precedence. Even with 'isolated' facial injuries, perform imaging of the cervical spine and head, where indicated, before facial X-rays or CT scanning.

Facial X-rays are often both difficult to perform (because of poor patient co-operation) and difficult to interpret. Get maxillofacial specialist advice regarding the views required and their interpretation. CT scanning is often required prior to definitive maxillofacial surgery.

The commonly required views include:

- Occipitomental 10°, 30°, and 45°.
- Lateral.
- Orthopantomogram (for the mandible).

Treatment

Treatment of specific facial fractures is considered in ➲ Middle third facial fractures, pp. 380–1, ➲ Zygomatic, orbital, and frontal sinus fractures, pp. 382–3, and ➲ Mandibular injuries, pp. 384–5. Remember that even in the absence of a visible fracture on X-ray, patients in whom there is clinical suspicion of facial fracture (swelling, tenderness, asymmetry, numbness, etc.) require expert attention and/or follow-up (see Fig. 8.14).

Fig. 8.14 X-ray showing fluid levels in the left frontal and maxillary sinuses.

Middle third facial fractures

Dento-alveolar fractures

Involve only teeth and their bony support. Look for deranged occlusion and stepped malalignment of teeth, bruising of gums, and palpable fracture in the buccal sulcus.

Le Fort facial fractures

These lie between the frontal bone, the skull base, and the mandible. They involve the upper jaw, teeth, nose, and maxillary and ethmoid air sinuses

- *Le Fort I* involves the tooth-bearing portion of the maxilla. Look for lengthening of the face due to the dropped maxillary segment. There may be movement or a split of the hard palate, a haematoma of the soft palate/buccal sulcus, and malocclusion (See Fig. 8.15).
- *Le Fort II* involves the maxilla, nasal bones, and the medial aspects of the orbits. Look for a 'dished-in' face, a step in the infra-orbital margin, infra-orbital nerve damage, malocclusion, and surgical emphysema. The maxilla may be 'floating'. Check for epistaxis, CSF rhinorrhoea, diplopia, and subconjunctival haematoma. Facial swelling occurs rapidly and is often severe. Later, bilateral peri-orbital bruising may be evident.
- *Le Fort III* involves the maxilla, zygoma, nasal bones, ethmoid, and small bones of the base of the skull (see Fig. 8.15). The entire midface is fractured from the base of the skull. Features include those of type II plus: flattened zygomatic bones (which may be mobile and tender), steps over the fronto-zygomatic sutures, movement and deformity of the zygomatic arch, and different pupillary levels. There is usually severe facial swelling and bruising. Pharyngeal bleeding may severely compromise the airway and cause hypovolaemic shock.

Le Fort fractures may be asymmetrical (eg Le Fort II on the right; III on the left).

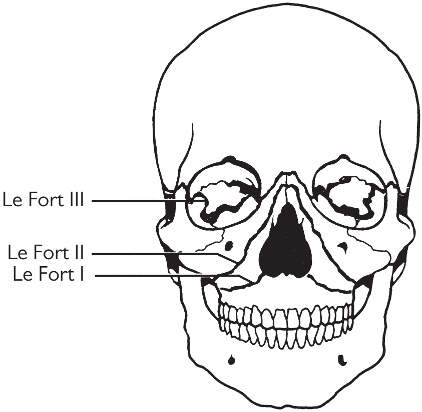

Fig. 8.15 Le Fort classification of facial fractures.

Naso-ethmoidal fractures

These produce a flattened nasal bridge, with splaying of the nasal complex, saddle-shaped deformity of the nose, traumatic telecanthus, peri-orbital bruising, subconjunctival haematoma, epistaxis, CSF rhinorrhoea, and supraorbital or supratrochlear nerve paraesthesiae.

Management of middle third facial fractures

- Resuscitate and establish a clear airway, as described in ➲ Airway obstruction: basic measures, pp. 334–5.
- Refer dento-alveolar fractures for repositioning and immobilization with acrylic/metal splints ± wiring.
- Refer all patients with middle third or naso-ethmoidal fractures to the maxillofacial surgeons for admission. Continuing haemorrhage may need packing—leave this to the specialist. Tell the patient not to blow the nose (↑ subcutaneous emphysema and may drive bacteria into fracture sites and intracranially). Prophylactic antibiotics are often advised by maxillofacial surgeons. Ensure tetanus prophylaxis (see ➲ Tetanus prophylaxis, p. 424).
- Discuss patients with CSF leaks with the neurosurgeons.
- Clean and dress compound facial lacerations, but do not close them (unless actively bleeding); they may need formal debridement and they provide access to fractures for open reduction and internal fixation.

Fig. 8.16 Left 'tripod' fracture following an assault, involving fractures of the left infra-orbital margin, the zygoma, and the lateral orbital wall.