The Injured Patient

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3.1 Initial Assessment of the Injured Patient

Trauma is generally recognised as the leading cause of death in individuals under the age of 40. Although there has been greater acceptance and enforcement of traffic safety measures, serious injuries, particularly those resulting from motor vehicle collisions, are still prevalent worldwide with more than one million deaths annually. When assessing the multiply injured patient in many trauma centres and hospitals today, the injury severity score (ISS) is generally regarded as the gold standard for scoring the severity of their injuries, although other scoring systems exist.

The ISS is an adaption of the Abbreviated Injury Scale. Scores from the three most severely injured anatomical sites (one injury per body region) are added together, resulting in an ISS that usually correlates well with the overall severity of injury and survivability of the patient. An ISS of 16 or greater is regarded as a critical injury. In many countries today, such patients are assessed and treated in accordance with the American College of Surgeons' Advanced Trauma Life Support (ATLS) program®. ATLS has now gained widespread acceptance across most of the world and has been validated as an efficient and safe approach in the management of the multiply injured patient.

When a patient has multiple injuries it can be easy to become distracted and difficult to decide which injury to treat first. The ATLS system of care prioritises injuries according to their immediate threat to life. In this way injuries compromising the airway (A) are treated first, followed by those likely to affect ventilation and the delivery of oxygen to the blood (B—Breathing). This is then followed by those injuries likely to affect the delivery of the oxygenated blood to the brain

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(C—Circulation). Head injuries are then evaluated and treated as part of D—Disability. Finally the entire body is exposed to assess for any other injuries and the patient kept warm (E—exposure/environment).

This algorithm is not surprisingly referred to as the 'ABCDE' approach. Other systems have been designed that continue this alphabetical theme and act as an aide memoire. They include F—foley catheter/Farenheit (temperature), G—gastric tube/Get vital signs (ECG, Pulse Oximetry), H—Head to toe exam, I—Interventions, Inspect back etc. However, whilst these are useful prompts they are not recognised as part of the ATLS system. Initial assessment in ATLS consists of an initial rapid primary survey to identify and treat immediate life-threatening conditions (based on the ABCDE approach). The exception to this sequence is in patients with an obvious external exsanguinating wound. In these circumstances control of haemorrhage is undertaken before or at the same time as assessing, and if necessary securing the airway. This should only take a few seconds. Following the primary surgery and when the patient is stable, appropriate investigations and a more detailed head to toe examination (secondary survey) can then be performed.

Within this context, any head, neck or facial injuries that threaten life (and sight—discussed later) need to be recognised and dealt with urgently during the primary survey. As such, it is important to be especially vigilant towards injuries that can place the airway at immediate risk. This is discussed further, later in this chapter and in the chapter on anaesthesia. Spinal immobilisation is also frequently required with significant injuries above the collarbones, as cervical spine injuries can be fatal (see the chapter on the back of the neck), and this in itself can bring problems in patients with significant facial injuries. Uncontrolled bleeding from the scalp, face and neck can also quickly impair the patient's circulation, resulting in haemodynamic shock, drowsiness and loss of the anyway.

Injuries above the collar bones may also disrupt the cranium or visual system. These must be identified and managed during the disability stage—D and are discussed elsewhere. With regards to facial injuries, most patients usually present without life-threatening complications. So long as the airway is secure and there is no active bleeding from the face, these injuries can be assessed during the secondary survey and should not be allowed to distract us from the primary survey and more serious conditions. At the end of the primary survey patients will undergo investigations such as a 'pan-scan' (CT of the head, neck, chest, abdomen and pelvis) or plain X-ray of the chest, cervical spine and pelvis. In many trauma units today, multislice CT (MSCT) now serves as the main imaging technique, due to its high diagnostic precision and speed in obtaining images. Throughout the initial stages of assessment is important to continuously reassess the patient injuries can evolve over time. Once the primary survey has been completed and the patient is stable, facial injuries can then be addressed and treated (Figs. 3.1 and 3.2).

3.1.1 Life-Threatening Injuries to the Head, Neck and Face

These are discussed in further detail in the relevant chapters throughout this book. Here an overview will be presented. One of the commonest causes of death following severe facial injury is airway obstruction. This may be because of the tongue

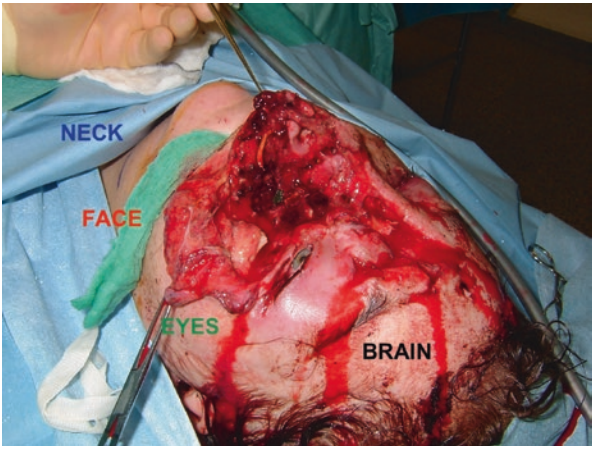

Fig. 3.1 Obvious facial injuries following a high-speed motor vehicle collision. The brain, eyes, and cervical spine require careful evaluation

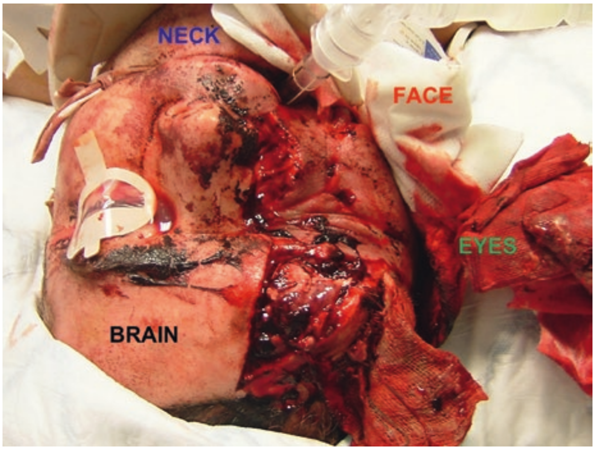

Fig. 3.2 Obvious injuries to the face and forehead with exposed brain and rupture of the globe. Remember the cervical spine as part of the assessment

obstructing the hypopharynx in an unconscious patient, massive swelling, or secondary to uncontrolled haemorrhage, effectively drowning the airway. However in many patients a combination of factors contribute to progressive airway obstruction.

3.1.2 Secretions and Bleeding Compromising the Airway

The airway is generally considered to be the passage between the nasal and oral cavities, passing down to the tracheal bifurcation. Much of this passage is contained within the head, neck and face and this places the airway at significant risk from injuries above the collar bones. Bleeding and secretions are common and can quickly accumulate, resulting in obstruction. Coughing and clearing of the airway may be impaired and ineffective, especially in supine or drowsy patients. Frequent causes of bleeding and secretions include mucosa lacerations or facial fractures. Obstruction must therefore be anticipated and alleviated early with careful examination and gentle suction. Retropharyngeal haematoma, although rare, can occur following spinal injuries. This can also occasionally compromise the airway.

3.1.3 Oedema

More insidious compromise can arise from swelling in the adjacent tissues. This may not be present initially, but can develop over time. This emphasises the importance of reassessment, as the patient's physical well-being can change over time. Swelling can be particularly troublesome following midface and mandible fractures, as a result of generalised oedema or the development of haematoma. In such patients early consideration should be given to formal intubation and ventilation, especially if transfer to another hospital is anticipated. More sinister swelling can occur rapidly following inhalation injuries and smoke exposure and from high energy impacts, including facial gunshots. These patients can quickly develop massive airway compromise. This will be difficult to manage if it is not anticipated on arrival. These cases are almost always advised to undergo early intubation, as airway obstruction will inevitably occur. Circumferential burns of the neck will also cause significant swelling and restriction of the airway (Fig. 3.3).

3.1.4 Other Causes of Blockage of the Airway

The tongue is supported within the oral cavity via its attachments to the mandible. Displaced anterior fractures can disrupt this support causing the tongue to flop backwards into the oropharynx if the patient is supine. Similarly, displaced midface fractures can physically reduce the space within the oropharynx, especially if fracture fragments are mobile and accompanied by bleeding and swelling. Foreign bodies may also block the airway passage. This may include avulsed teeth, dentures and external objects such as broken glass from a windshield (Figs. 3.4, 3.5 and 3.6).

Fig. 3.3 Progressive facial swelling following isolated midface fractures. The mandible is intact. This patient is being nursed on her side but will require very close observation for the next 24 h

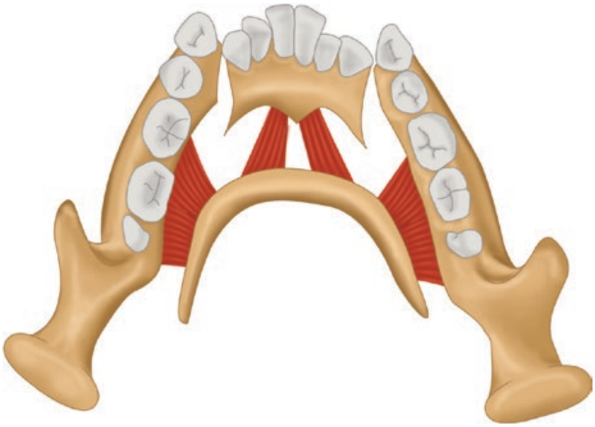

Fig. 3.4 "Bucket handle" or comminuted fractures of the mandible place the airway at risk. The tongue is attached to the central mobile fragment(s) (**a**). If the patient is supine, any displacement can allow the tongue to fall back and obstruct the upper airway (**b**). Snoring is a sign of impending obstruction

Fig. 3.5 This patient received a localised blow to the face when the door of a lorry swung round and struck him. He was walking around at the scene with significant facial bleeding, when the paramedics arrived. A good example of "primum non nocere"—if he had been placed supine his airway could have obstructed

Fig. 3.6 This patient was kicked in the face by a horse, sustaining comminuted fractures of the mandible. He developed airway-threatening swelling over the next few hours, which required urgent intubation and placement of a temporary (percutaneous) tracheostomy, prior to repair

3.1.5 Cervical Spine Injuries

These are discussed in greater detail in the relevant chapter of this book. As part of initial airway management, the cervical spine is simultaneously immobilised to prevent or exacerbate cervical cord injuries. Unstable injuries to the cervical spine that move can result in spinal cord haemorrhage, oedema, or direct neuronal injury, resulting in severe and permanent disability. The innervation to the diaphragm is derived from levels C3, C4 and C5 (discussed in the chapter on embryology). Any paralysis of the diaphragm will quickly compromise the patient's ability to breathe and therefore adversely affect ventilation and oxygenation. The cervical spine is therefore protected very early, during assessment of the airway, either manually (inline immobilisation), or using a hard cervical collar, blocks and straps/tape (Figs. 3.7, 3.8 and 3.9).

3.1.6 Haemorrhage

Together, the head, neck and face comprises one of the most vascular regions of the body. The brain receives 25% of the total cardiac output, all of which passes through the carotid and vertebral vessels and returns to the heart via a number of large veins. Due to its proximity, the face also receives a considerable amount of

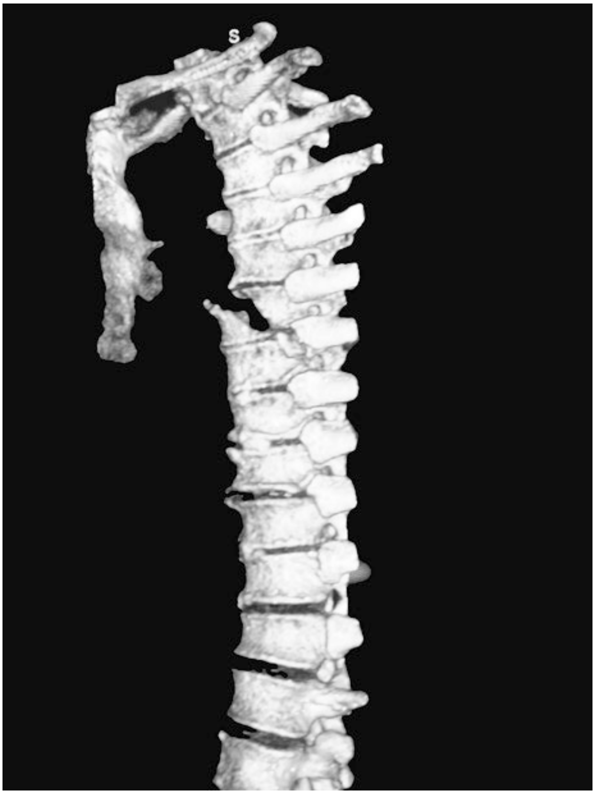

Fig. 3.7 A vertical split in a thoracic vertebra following a crush injury. This patient required spinal immobilisation and certainly would not have been able to sit up if coexisting facial injuries were obstructing the airway. This would have required urgent intubation

this high blood flow. The neck is therefore a highly vascular structure, with many vessels carrying blood from the heart to the brain (and upper limb), as well as to a multitude of organs and tissues within the face and neck itself. Penetrating injuries to the head, neck and face can therefore lead to circulatory collapse if not treated promptly. Damage to the carotid or internal jugular vessels can be devastating, due to their high output. Many patients will arrest at the scene of injury, unless bleeding can be immediately controlled.

In the limbs, haemorrhage will often slow due to localised and generalised vasoconstriction. However in the head and neck, the blood supply is maintained at a high pressure to maintain perfusion of the brain. Therefore unless head and neck haemorrhage is stemmed by first responders, paramedics or the resuscitation team, it will not arrest spontaneously. A well known example of this is the patient with a slowly bleeding scalp laceration. These can be easily overlooked, but will continue to bleed until the patient develops haemodynamic shock. Blood loss from injuries to the external carotid artery and its branches can also cause circulatory compromise. These vessels are smaller than those passing to and from the brain and can therefore also be overlooked. A common injury is to the temporal artery. Vessels such as this

Fig. 3.8 This elderly patient was seen as an outpatient, having tripped and fallen flat on her face. In addition to her facial injuries she was also complaining of some mild weakness in her right hand. MRI confirmed a central cord syndrome. The clue is the mechanism of injury, which resulted in hyperextension of the neck

Fig. 3.9 Devastating injury, incompatible with survival

have a superficial path and can be easily damaged by simple lacerations around the temple and forehead.

Midface fractures can sometimes be associated with rupture of the venous plexus systems around the skull base. It is not possible to see the bleeding source directly. These will present with profuse bleeding around the oro and nasopharynx. If these fractures are not reduced promptly, blood loss will continue.

3.1.7 Head Injuries (Brain Injuries)

These are also discussed in greater detail in the relevant chapter of this book. The brain is the most important organ within the body. Any injury above the clavicles should raise suspicion of the potential for a head injury. However, patients can sustain head injuries without any obvious signs of trauma to the head or face. This can occur following rapid deceleration (e.g. high speed vehicle collision or bungee jumping). Therefore careful assessment is important to avoid overlooking occult injuries. The risk of injury to brain can be assessed based on the mechanism of injury, the patient's symptoms and following neurological examination. Head injury should be suspected if the mechanism of injury involves a high energy impact or rapid deceleration, such as a fall from height or motor vehicle collision. Patients with head injuries can present with vomiting, retrograde amnesia or impaired consciousness. Neurological examination should always include the Glasgow Coma Scale. If there is any concern, the patient should undergo an urgent CT of the head (and neck).

3.2 Understanding the (Rapid) Primary Survey

Through its various steps and techniques, the ultimate aim of the primary survey is to ensure delivery of adequate oxygen to the vital organs of the body, notably the brain. To fully understand how this process is applied, it is important to appreciate the steps that enable oxygen from the air to reach is destination—the cells and organs.

3.2.1 Providing Oxygen

Normal air has an oxygen concentration of around 21%. This meets the needs of most uninjured persons. However, in the trauma setting the body's oxygen requirement increases substantially. This can often be met by providing a higher concentration of inspired oxygen. The greater percentage of inspired oxygen increases the oxygen saturation of the blood perfusing the alveoli of the lung. This helps compensate for any reduced respiratory effort, structural lung damage or impaired circulation.

3.2.2 Airway Patency

Inspired oxygen must have a clear passage to the alveoli (i.e. a patent airway). Following trauma and in some diseases this can become blocked by distorted anatomy (such as an unsupported tongue), foreign bodies, swelling, secretions or blood. If the airway is completely blocked the patient will only have a few minutes to survive. This is why airway care is the first system in the ATLS algorithm. At the same time the cervical spine is protected.

3.2.3 Breathing (Ventilation)

Within the lungs, the main gasses that are exchanged between the alveoli and blood are carbon dioxide and oxygen. Carbon dioxide (CO_2) is primarily dissolved within the plasma. This must effectively pass from the blood into the alveoli and be expelled. If it is not, CO_2 retention can quickly result in acidosis and adversely affect the intracranial pressure (and cerebral perfusion). Oxygen in turn, passes from the inspired air within the alveoli, into the blood and is transported principally bound to haemoglobin within the red blood cells. The amount of oxygen that is bound to haemoglobin can be estimated with the oxygen saturation. Breathing must therefore be adequate, that is to say, exchange of oxygen and CO_2 must be adequate within the alveoli. This exchange process is known as ventilation. Passage of oxygen into the blood is known as oxygenation.

Injury to the lungs can result in poor gas exchange and inefficient ventilation. Outwith the lungs, the thorax (rib cage) and diaphragm are also essential to normal breathing. The diaphragm is the chief muscle responsible for breathing at rest. Nerves from cervical spine levels C3, C4 and C5 provide its motor supply. This is remembered using the phrase ‘C3, 4, 5, keeps the diaphragm alive’. Protection of this neuronal pathway from the cervical spine is thus essential to life. This is achieved primarily by triple immobilisation, discussed elsewhere. Immobilisation occurs during ‘A’ and is maintained throughout. This and other measures will optimise the integrity of neurological outflow from the cervical spine, even in the presence of cervical spinal injury (Fig. 3.10).

3.2.4 Circulation (Haemorrhage Control)

Oxygenated blood has to circulate to the vital organs, most notably the brain. This requires the heart to effectively pump the blood as well as an adequate circulatory volume. Both can be compromised if there is any damage to the heart, or following significant haemorrhage. The average 70 kg man requires around 5 L of blood in their circulating volume. However following trauma, fluid requirements may be

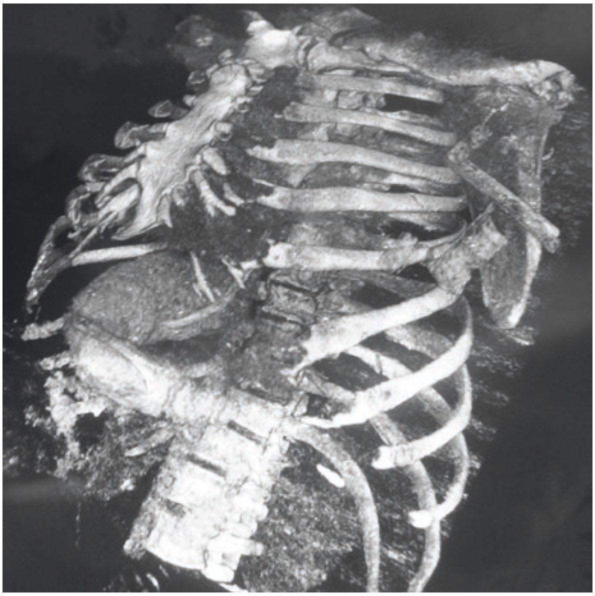

Fig. 3.10 Multiple rib fractures resulting in a "flail chest". Not only is respiration inefficient, but it is also very painful. In some trauma centres the rib fractures maybe surgically repaired, to reduce painful movements

higher. This is partly due to the systemic response to trauma. In addition to blood loss, the presence of damaged tissue causes the release of vasoactive chemicals. This increases systemic capillary permeability and the leakage of fluid and electrolytes from circulatory system into the extra and intracellular spaces. Clinically this appears as oedema and swelling. Furthermore, depending on the type of trauma (notably muscle damage), toxins such as myoglobin (rhabdomyolysis) and electrolytes (potassium) may also leak into the circulation. These need to be excreted as they are toxic to the heart and kidneys.

The ability of cells to metabolise the delivered oxygen at a cellular level is chiefly a product of the integrity of each cell. This can be disrupted by a number of process and toxins such as cyanide (a problem following inhalation of fumes and smoke).

3.2.5 Disability

The brain itself must be sufficiently vital for meaningful function. This requires structural integrity, neurotransmitter balance and adequate perfusion with oxygen and nutrients. This can be compromised with significant parenchymal injury or following intracranial swelling or haemorrhage. The presence of these is investigated with an urgent CT of the head. Severe or focal injuries such as haemorrhage will require neurosurgical intervention and intensive care. This is discussed further in the chapter on the head.

3.2.6 Critical Steps in the ABCDE Algorithm

Based on the understanding of trauma and the pathophysiology of cerebral hypoxia, a number of critical steps in the management of the injured patient have thus been developed.

1. The first step is to evaluate the airway, by eliciting a coherent verbal response and by visual confirmation. When necessary removal of foreign bodies from the anterior oral cavity and/or suction of blood and secretions may be performed. Airways adjuncts may also be required. Sometimes subtle signs, such as abrasions on the neck, or a change in the voice may indicate potential airway compromise and the need for early intubation. At the same time the patient's cervical spine is also immobilised until injury to the cervical spine has been evaluated.
2. All trauma patients are provided with high flow oxygen. This should be through a non re-breathable mask to prevent inhalation of expired gases. At this stage any obvious chest injuries are identified and treated.
3. Assessment of the circulation involves assessment of both the circulatory volume and cardiac function. Injuries to the heart must be treated urgently. These include penetrating injuries and cardiac tamponade. At the same time the circulation is supported by IV fluids and if necessary, with blood. Multiple large bore intravenous cannulas are placed.
4. Disability assesses the level of consciousness (Glasgow coma score) and pupils (localising signs in the unconscious).
5. The final step in the primary survey is exposure and environmental control. This involves inspection of the entire patient (including their back), to identify any injuries. Examination of the back must be undertaken with controlled movement of the patient if spinal cord injury has not yet been ruled out. This involves log rolling the patient. Log rolling enables safe movement of the patient whilst maintaining the spine in a neutral position. During all this time, the patient is kept warm with blankets and if necessary overhead heating. Care must be taken to avoid hypothermia. This is often overlooked. In the presence of hypothermia, essential circulatory proteins, such as clotting factors, fail to perform. This can further exacerbate ongoing haemorrhage.

The ABCDE algorithm is typically applied in this order, based on the time frame in which each threat to life can kill. However, recent experiences in the Iraq and Afghanistan wars have suggested a slightly more flexible approach may be required. In some circumstances, massive external haemorrhage is quickly addressed with pressure before continuing with the ABCDE algorithm. This has led to the development of the acronym MARCH (Massive haemorrhage, Airway, Respiration, Circulation, Hypothermia).

Today, most trauma victims are managed by a trauma TEAM. This allows for each member to be allocated a role, such that multiple steps can often be completed simultaneously. A designated team leader oversees and coordinates management. Team leaders generally are not given a 'hands-on' role in this manner

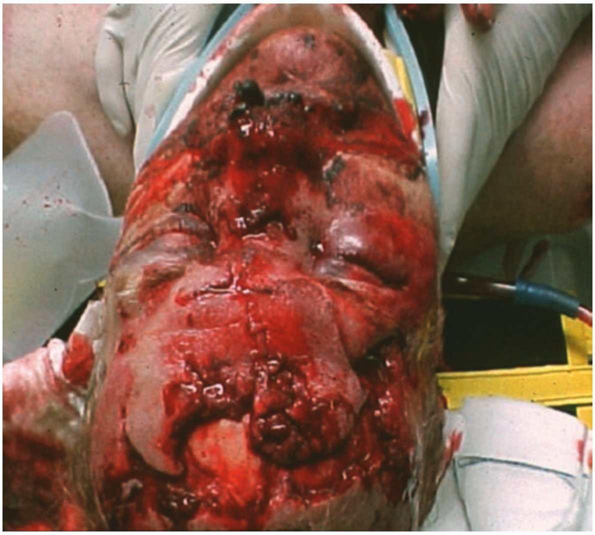

Fig. 3.11 Severe trauma to the face and head, potentially affecting all the elements of the primary survey

to allow him/her to supervise the complete management of the patient and direct each team member (Fig. 3.11).

3.2.7 History Taking in Trauma: The "Ample" History

In general medicine, the usual approach in the assessment of patients, starting first with a detailed history and then examination, is not appropriate for the acutely injured or unwell patient. Nevertheless, a simple but relevant history is still needed, in order to quickly collect vital information. Often, the pre-hospital team obtains and shares this either during the pre-alert call, or on arrival at the emergency room. Ambulance and paramedic colleagues usually ask standardised questions when they arrive at the scene of an accident, but they also have the advantage of being able to see the environment where injuries have occurred. They therefore often have a better appreciation of the mechanism of injury and the likely forces that the patient may have been subjected to. This can be very helpful in the initial assessment. In other circumstances, the history may be collected from relatives or witnesses. Searching the patient's personal property may also identify medication, medical devices or medical alert documentation. The acronym AMPLE is a useful guide to obtaining the relevant information. This stands for—Allergies, Medications, Past medical history, Last meal and Events.

3.2.7.1 Allergies

This refers to any medications that are known to cause anaphylaxis in the patient. Anaphylactic reactions can be life-threatening and in the shocked patient can go unrecognised and complicate resuscitate. Patients with anaphylactic reactions often wear a medical alert bracelet or necklace. They may also carry a medical alert card or Epipen. Beware of descriptions of drug side effects. This is different to an allergy and side effects should not contraindicate the use of life saving medication.

3.2.7.2 Medications

It is important to obtain a list of prescribed and non prescribed drugs. This includes recreational and herbal medications, both of which can affect the body's physiology and interact with administered drugs. Despite widespread public perception that herbs and dietary supplements are safe, research has shown that some of these products carry the same dangers as prescribed medications. Interactions may occur between prescription drugs and these over-the-counter compounds. Such interactions involve mainly inhibition or induction of cytochrome P450 enzymes and/or drug transporters. This can increase the risk in patients taking drugs with a narrow therapeutic index (e.g. warfarin, cyclosporin and digoxin). Potential interactions can occur with the herbal medicines black cohosh, garlic, Ginkgo, goldenseal, kava, milk thistle, *Panax ginseng*, *Panax quinquefolius*, saw palmetto and St John's wort. *Ginkgo biloba* extract, for example, has been reported to cause spontaneous bleeding and can interact with anticoagulants and antiplatelet agents. Salvia miltiorrhiza may enhance anticoagulation and bleeding among people taking warfarin. St. John's wort may have monoamine oxidase–inhibiting effects and can increased levels of serotonin, dopamine and norepinephrine. It should not be used with prescription antidepressants. Ephedrine-containing herbal products have been associated with adverse cardiovascular events, seizures and even death. A list of all medications should therefore be obtained. Such a list may also provide clues to the patient's baseline health and past medical history.

3.2.7.3 Past Medical History

This refer to the patient's co-morbidities, which is discussed in the chapter on general assessment of patients. With an increasing number of patients living to older age, accumulation of co-morbidities is common. This includes chronic organ failure (notably heart, lung and renal). Beware patients with chronic organ failure who are compensating. They may appear 'well' to their relatives, but should be considered at high risk of rapid deterioration. Once stabilised there should be a low threshold to transfer these patients to high dependency or intensive care settings.

3.2.7.4 Last Meal

This is important to the timing of non-emergent surgery. Timing will depend on the urgency of the injury versus the safety of anaesthesia. During induction of anaesthesia and intubation patients may reflux and aspirate stomach contents. This is more likely if the stomach is full, in which case surgery is deferred or (if clinically urgent) rapid sequence induction can be performed with cricoid pressure to reduce the risk of aspiration. Recent consumption of water is of less significance.

3.2.7.5 Events

These include the mechanism of injury and the circumstances in which the patient was found (environment). The mechanism of injury will help estimate the forces that have been applied to the patient. This sets the threshold of suspicion for injuries, patterns of injury and their severity. For example, a patient who has fallen from the top of the stairs is more likely that have cervical spine injury than a collapse in the street. They type of surface onto which the individual has fallen is also important. Not all injuries come from impacts and deceleration injuries can result in severe mediastinal bleeding (the 'Bell clanger' effect). In broad terms, mechanisms of injury are considered as (1) blunt impacts, (2) rapid deceleration (such as motor vehicle collisions and falls) or (3) penetrating injury, such as shooting or stab wounds. Less common mechanisms include (4) burns and (5) explosive injuries. Each mechanism can produce a different pattern of injury and the amount of force involved in the injury will then dictate the severity of injuries suffered by the patient.

If the mechanism involves a single blow, the risk of injury is usually localised to the associated anatomical region. In the head and neck for example, following a neck stabbing, we need to know how long the blade was, which direction the assault was from (above/below, in front/behind) and whether the blade broke. In this situation, pelvic, abdominal and lower limb injury is unlikely, although chest, head and upper limb injury are all possible. In such a confined anatomical space there is also the potential for airway, cervical spine, breathing and circulatory problems, all from a single wound. Other mechanisms may be more complex (MVC, fall from a height, explosion). With MVCs cases speed of impact, seat belt usage, vehicle deformity, and injuries sustained by others (notably fatalities) are useful clues. A pedestrian struck by a vehicle travelling at 20 mph has a 5% chance of sustaining fatal injuries, compared to someone struck by a vehicle travelling at 50 mph, who has an 85% chance of being killed. Infants and children have more elastic bones than adults. This can result in significant soft tissue and organ injury with relatively little bone deformity. Some important mechanisms of injury and related sequelae in head and neck trauma include

A. Head on vehicle collisions can result in head and scalp injuries, facial injuries from impact with the steering wheel, dashboard or windscreen and flexion/extension injuries to the cervical spine
B. A fall or jumping from a height of 10 feet or more is likely to result in calcanial and other lower limb fractures depending on how the patient lands and what they landed on. If they land on their feet, the energy transfer can progress axially, resulting in hip, pelvic and spine fractures, and even skull base fractures.
C. Falling from a bicycle is a common cause of orbitofacial injuries in children, typically resulting in ocular blunt trauma. Penetration of the orbit by a bicycle brake handle is a rare but devastating injury. Traumatic globe subluxation and skull base fractures may occur.
D. Explosions can result in penetrating injuries and retained foreign bodies. Occasionally the entry wound seems innocuous and can be easily under appre-

ciated. Many cases of foreign bodies in the middle third of face, notably the antrum and nasal cavity, have been reported in the literature.

E. Whenever children hold objects in their mouths, oral injury is likely. Penetrating injuries of the palate have been reported with pens, screwdrivers and even chopsticks. Carotid injuries have been reported. Organic material may be difficult to identify on CT or MRI.
F. Anterior–posterior directed impacts to the forehead or face can result in hyperextension injuries to the neck, resulting in ligamentous and possibly spinal cord injury. This is particularly common in the elderly.
G. Strangulation/hanging type injuries can fracture the hyoid/larynx and avulse the trachea.
H. A high-velocity projectile can penetrate both the eye and the brain. Cavitation can occur anywhere along the path of the projectile. This can be permanent or temporary depending on the amount of energy transferred and the elasticity of the tissues involved. Temporary cavitation can be easily overlooked as the structures involved return to their original position once the energy has been dissipated. Untreated, this can lead to significant tissue destruction and sepsis.
I. Blunt trauma to the forehead can result in blindness, even in the absence of fractures. At the moment of impact, energy is transferred to the orbital apex, resulting in injury to the optic nerve.
J. Fractures following an impact to the bridge of nose can extend deep to involve the skull base and orbit (with risks of CSF leaks and blindness)
K. Successful airbag deployment has been reported to result in ocular injury.
L. Compressed air or blast injuries can result in massive surgical emphysema in the face, neck, and chest. Pneumothorax can also occur. These can result in pressure fracture on adjacent structures, and can expand. Positive pressure ventilation carries significant risk if this involves the thorax.
M. Rapid deceleration (for example seen in bungee jumping) has resulted in retinal haemorrhages, whiplash, carotid dissection, and stroke.
N. Rapid deceleration (for example seen in MVCs) can result in torn cerebral blood vessels, brain stem contusions and spinal cord contusion or transection. Common injuries include subdural haematoma, diffuse axonal injury, whiplash, detached retina, or traumatic optic neuropathy.
O. Rebound injuries, which occur due to recoil following deceleration, can include spinal fractures and contra-coup injuries to the brain.
P. A blow directly on the chin can result in a ‘guardsman’s fracture’ (an anterior mandibular fracture, together with bilateral condyle fractures). Alternatively, if the mandible does not break, energy can be transferred directly to the brainstem resulting in serious injury.
Q. Prolonged hypotension (from any cause) has been reported to result in blindness
R. Because of the plastic nature of bone, localised impacts can temporarily or permanently deform the facial skeleton. Blows to the cheek can result in isolated orbital floor “blowout” fractures, with no associated fractures of the cheek.

S. Crush injuries to the face (as unusual mechanism) can result in significant elastic deformation of the bone with little in the way of displaced fractures. In more extreme cases craniofacial dysfunction can occur.
T. Widespread ("Panfacial") fractures are associated with bleeding, swelling and airway compromise. However these complications can also occur in the absence of any fractures, in patients taking anticoagulants or with clotting abnormalities. Swelling worsens when supine, from elevated venous pressures and reduced lymphatic drainage.
U. Hypertension during resuscitation may precipitate intraocular bleeding. In the elderly patient a dilated pupil may precipitate ocular problems. Acute angle closure glaucoma can be precipitated by drugs and general anaesthesia—this should be considered in any tense, painful, red eye.

In many countries, the most common mechanism of injuries are motor vehicle collisions and falls. Before the introduction of in-car safety features, drivers and passengers suffered vehicle ejection through the front windshield or head collision onto the dashboard. Mid-face fractures were thus common following traffic accidents. These have now been vastly reduced by the use of vehicle safety features. However, beware of deceleration injuries. Seat belts and air bags will cause rapid deceleration in the patient which can result in shearing forces and avulsion of vessels with significant bleeding.

3.3 Airway Management

The airway is best considered as consisting of a collapsable, partly muscular tube, which requires muscle activity and neurological stimulation to maintain its patency. In this way deformity within the walls of the tube can occur from swelling, haematoma or from external displacement (facial fractures). The air passage within the tube itself can be obstructed by foreign material such as teeth, secretions or blood. Any loss of consciousness can result in loss of muscle tone, both within the wall and surrounding it. Snoring can be an early sign of this. It is important to remember that the status of the airway can quickly change over time and should therefore be reassessed regularly.

Talking patients are considered to have a patent airway at the time of their assessment. But this can change. Vocalisation of appropriate dialogue shows that there is free passage of air to the lungs in an alert patient. Sensible speech also confirms the absence of confusion and neurological integrity. A normal sounding voice shows that there is no significant deformity of the passage. A 'hot potato' voice is associated with swelling around the oropharynx and tongue base (often noted in Ludwig's angina). Snoring implies either loss of tongue or pharyngeal wall support. Noisy breathing and stridor are usually associated with deformity around the larynx and vocal cords. Confused or drowsy patients in the supine position lack the ability to keep their tongue out of the pharynx. They are also unable to coordinate effective swallowing and prevent aspiration. In such cases careful consideration must be made whether to intubate these patients early.

When assessing the airway following facial trauma several key questions need to be considered.

A. Is the patient conscious? If so, sedation should be avoided if possible and analgesics should be given cautiously
B. Is the patient breathing spontaneously? If so, this allows time to call for help, transfer the patient to the operating room if immediate surgery is required and manage the airway under the best possible conditions, by the most experienced personnel. Failed attempts at endotracheal intubation by inexperienced clinicians in complex injuries will compound the problem, especially if the patient has a coexisting head injury.
C. What is the extent of the injury? Fractures of the mandible and midface, particularly if they are highly mobile and associated with bleeding and swelling, will make all aspects of airway care difficult. Mask ventilation may not be possible as it may be difficult to achieve an effective seal. Aggressive ventilation via a tight fitting mask may also result in progressive surgical emphysema. If there are fractures of the cribriform plate, high-pressure ventilation by bag may also force air intracranially.
D. Is there a limitation in mouth opening? If so, is this mechanical or as a result of pain. If secondary to pain analgesia and sedation will improve opening during anaesthesia.

Assessment of the airway is often divided into the three steps of Look, Listen, and Feel. If detailed examination is essential (following a localised facial/anterior neck impact), the patient's mouth must be sufficiently open and the neck adequately exposed to allow you to inspect for injury. This can be difficult if the patient has been fully immobilised with a collar, blocks and tape. In such cases, it is permissible to release the collar, so long as manual immobilisation is continued by someone else. Releasing the front half of the hard collar will also enable a clear view of the front of the neck and allow the patient to fully open their mouth. The anterior neck is an important anatomical site—clinical signs here can signify problems not only to the airway but also in the chest. Bruising, swelling, surgical emphysema, distended, bubbling wounds and laryngeal distortion or crepitus should all be assessed for. There should also be free movement of the thyroid cartilage prominence on swallowing (Figs. 3.12 and 3.13).

At the same time the oral cavity and pharynx should be inspected. This is also an important guide to airway status. The uvula should be central, the pharynx should be symmetrical and the soft palate should move symmetrically with swallow. Ask the patient to 'stick out' their tongue. If this is freely mobile, the floor of the mouth is probably undamaged. When examining the oral cavity note the presence of secretions and fresh blood. If these are present they may need careful suctioning. Monitor the patient for active bleeding. If active bleeding is evident it is important to identify

Fig. 3.12 When diseases and injuries involve the face, mouth and anterior neck, assessment of the airway requires more than just talking to the patient. The mouth must be fully open and carefully inspected

the source and if possible control it. If severe this may require formal intubation. Be mindful of blood trickling down the nasopharynx from the nose. In the awake patient this can be easily overlooked as the patient swallows the blood. Any foreign bodies should also be noted and removed taking care not to push these further backwards. Mobile teeth that appear imminently at risk of avulsion should also be noted, but if they are still attached do not attempt to remove them—this will be painful, often difficult and can lead to further bleeding.

In the awake patient with facial injuries, oral secretions may need regular suctioning. However it is important to avoid sucking too deep and touching the soft palate or pharynx with the suction tube. This may elicit a gag reflex which can agitate the patient and lead to vomiting. A common mistake is to pass the suction tube blindly into the oropharynx. This can cause discomfort, distress, push foreign bodies deep and elicit vomiting. Suctioning should always be performed carefully and under direct vision.

It is also important to listen and note the quality of sound of the patient breathing. This may be difficult in a noisy resuscitation room, but if the patient is unconscious

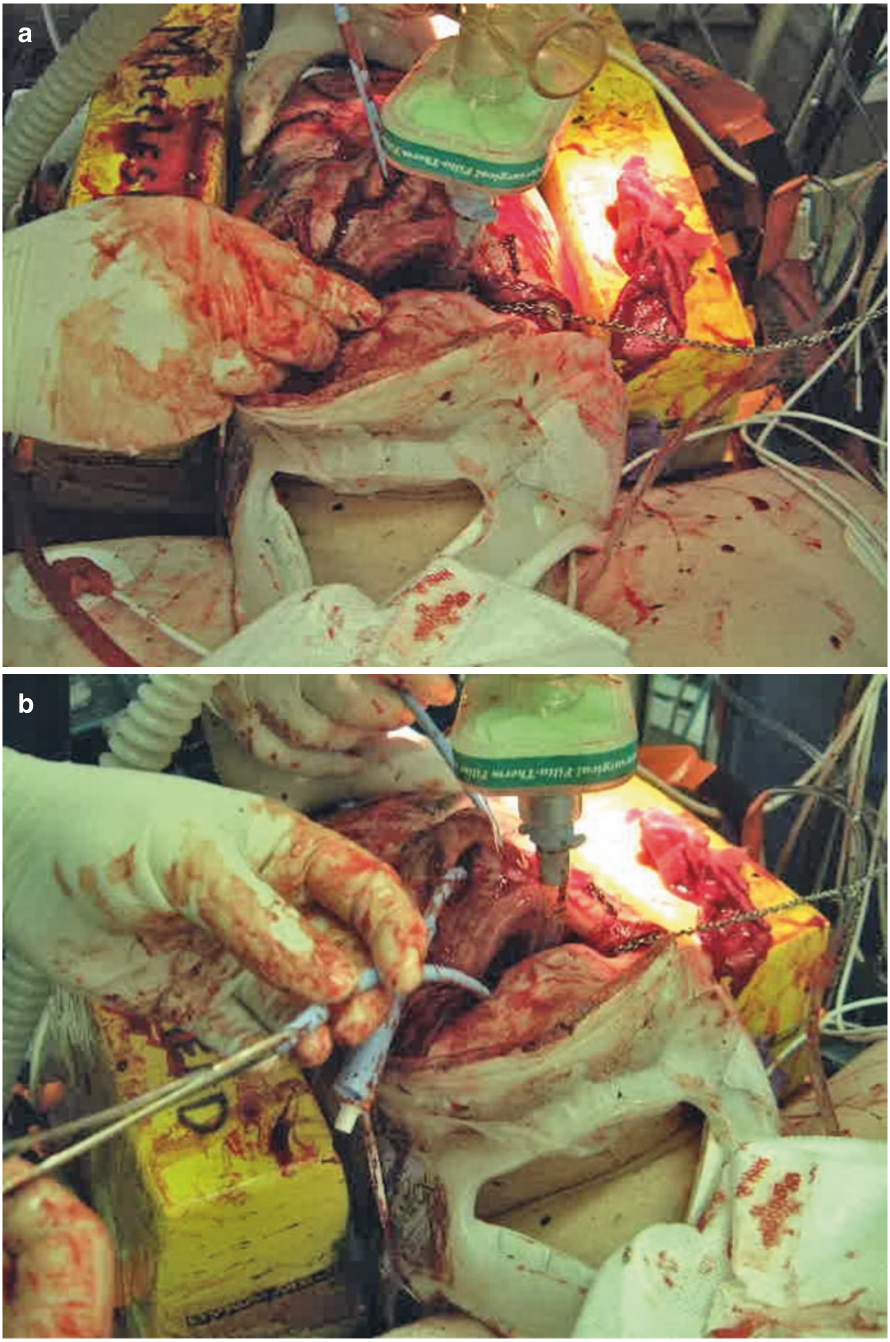

Fig. 3.13 Nasal packing using a urinary catheter. This technique requires good access to the oral cavity and pharynx (**a**). In an emergency, the hard collar will need to be unfastened and the head supported by an assistant (**b**)

or asleep any sounds may provide useful clues. Noisy breathing or stridor suggests airway restriction and impending obstruction. An abnormal voice can also be a precursor to airway compromise. A hoarse voice suggests poor mobility of one or both vocal cords. In the unconscious or asleep patient feel also for airflow from the mouth and nose. This may be the only sign of airway patency in a comatose patient.

Finally, feel the neck for surgical emphysema. The larynx, thyroid cartilage, cricoid cartilage and trachea should all be central and in-line. Any steps in continuity may suggest laryngeal fracture or tracheal avulsion. Displacement of the trachea suggests tension pneumothorax or an expanding haematoma in the neck. If the patient is already intubated and being ventilated, look specifically for surgical emphysema (arising from a chest injury). This may indicate the need for a chest drain and possibly a tracheostomy. Air will continue to expand as a result of the raised airway pressures, which if unreleased can result in mediastinal compression.

3.3.1 The 'Difficult Airway' in Facial Trauma

Complete obstruction of the airway in facial trauma rarely occurs. More often, partial obstruction arises as a result of a combination of factors. Each in itself may not be significant, but when combined these can rapidly compound and escalate the problem. Agitation of a patient suggests hypoxia, whilst obtundation suggests hypercarbia. Cyanosis suggests hypoxemia, secondary to inadequate oxygenation.

Contributing factors that make an airway 'difficult' include

A. Bleeding from the nose or oral cavity
B. Swelling around the lower jaw, neck, floor of mouth, pharynx and soft palate. This can continue to progress over 24 h. Swelling over the cheeks and upper face generally does not have a significant impact on the airway.
C. Trauma to the front of the neck. It is always important to look for evidence of injury to the larynx and trachea. Clinically the patient may have noisy breathing, snoring, gurgling, or croaking. Hoarseness, subcutaneous emphysema and a palpable fracture are very suggestive laryngeal fracture. Check that the trachea is central.
D. Loose or foreign bodies in the mouth (teeth, fillings, dentures etc.). If obstruction is significant and prolonged, the patient will soon become obtunded. This will then allow passage of a laryngoscope to check there is no foreign body, such as denture impacted in the vocal cords. If present this should be removed with a Magill's forceps. If the foreign body cannot be removed quickly it should be left and a surgical airway performed. If no foreign body is visible an endotracheal tube should be inserted.
E. Mobile fractures of the mandible or midface. In comminuted or bilateral fractured mandible, the central portion of the mandible with its attached tongue may fall backwards obstructing the airway. Pulling the anterior part of the mandible forward may clear the airway, but if the patient cannot sit up it is likely that an

endotracheal tube will need to be passed. In severe midface fractures the maxilla may be collapsed backwards causing obstruction. This will need to be pulled forward to disimpact the fracture.

F. Alcohol or recreational drugs
G. A reduced level of consciousness
H. A full stomach. All trauma patients should be considered as having a "full stomach", since there has been no time for stomach emptying prior to intubation. In addition, patients with facial injuries often swallow blood which accumulates in the stomach, with the risk of regurgitation and aspiration. Evacuating stomach contents via a naso-gastric tube is ideally done, but insertion of a tube in a confused, uncooperative, sometimes intoxicated patient may by itself, trigger vomiting.
I. A restrained patient in the supine position. Conscious patients with maxillofacial injuries are usually more comfortable sitting upright as this allows blood and secretions to drain out of the mouth.
J. Patients on anticoagulants.
K. An anxious patient
L. Inability to bag-valve-mask ventilate a patient. This is a contraindication to administering a muscle paralysing agent (used during rapid sequence induction).

Whilst many of these factors may be obvious in patients following facial trauma, others are not. For this reason all supine, restrained patients should never be left unsupervised. As can be seen, obstruction has many potential causes. The more common of these are secretions, blood and solid material, such as loose teeth and extraneous fragments such as gravel, dirt etc. Loose dentures can inadvertently fall back into the oropharynx. Material that is easily visible can be retrieved with fingers or blunt forceps. Magill's forceps have a right angle shape that makes them ideal for this. However do not chase after material that you cannot see directly. Blindly poking around in the back of someone's throat carries a high risk of pushing this further down and inducing vomiting. The patient won't thank you either.

Bleeding from the nose and nasopharynx can often go undetected in the supine patient. An awake patient will often be able to swallow this safely. This is particularly a problem for the immobilised patient who cannot sit up. Similarly, a drowsy patient will have a weakened swallowing reflex. These patients need close observation and ideally should be allowed to sit up as soon as other significant torso injuries (notably the spine and pelvis) have been excluded.

Disrupted anatomy can occur following high impact injuries, resulting in comminuted or displaced fractures. Midface fractures can collapse into the nasopharynx and restrict the oropharyngeal space. These injuries are usually quite apparent as patients are either very swollen, or bleeding significantly from the face. Bilateral anterior mandible fractures ('bucket handle' fracture) can sometimes result in loss of tongue support. This will allow the tongue to flop back into the oropharynx in the supine patient. Occasionally it can lead to airway obstruction if the patient has reduced consciousness. These fractures require urgent temporary support (bridle wire fixation) which is discussed elsewhere. Sublingual haematoma (following mandibular fracture) can further displace the tongue.

Progressive swelling is perhaps a more worrying concern. Swelling may not be immediately apparent, or significant, when the patient first attends. However this can progress over the next 36 h, by which time the patient may be on the ward and unsupervised. The face does not have a deep fascial layer, like the rest of the body, which is why swelling can be so extensive. The concern however is more with internal swelling (around the airway) rather than around the midface and eyes. The airway is a relatively small space and only a small amount of swelling is required to impact on its patency—much like sucking through smaller diameter straws. Any trauma involving the floor of mouth, pharynx or larynx can lead to oedema and quickly compromise the airway. For this reason comminuted mandibular fractures are more of an immediate concern than midface fractures, although the latter can still result in significant swelling and bleeding. The combination of both midface and mandibular fractures is therefore an indication to seek senior advice and urgent anaesthetic input. It is important to anticipate this early and reassess the patient regularly. Once the airway has been compromised it will be much harder to intubate the patient. Injuries to the soft palate and base of the tongue, inhalation burns and midface fractures will all lead to localised airway oedema. Fractures of the upper cervical spine can sometimes results in bulging of the posterior pharyngeal wall secondary to bleeding (retropharyngeal haematoma) and swelling.

Vomiting is another potentially severe problem in all traumatised patients who remain supine. It is therefore important to have an agreed plan of action within the trauma team on how to manage vomiting should it occur. If you are on your own, tilting the trolley head down tilting is a safe approach. This will allow vomitus to flow out of the mouth, which can then be suctioned away. Any continuing risk to the airway may require intubation and a definitive airway. When there is a question regarding the need for intubation, there should be a low threshold for securing the airway. Blind intubation, either orally or nasally, carries with it a risk for exacerbating an already delicate situation.

3.3.2 The Front of the Neck

This is a key anatomical structure which is often overlooked both clinically and in many texts. Minor injuries can very quickly become life-threatening, due to the many vessels and delicate structures confined to this tight space. It is useful to divide the anatomical structures of the neck into five major functional groups, as an aide memoire to comprehensive assessment. These are

A. Airway—pharynx, larynx, trachea, lung.
B. Major blood vessels—carotid artery, innominate artery, aortic arch, jugular vein, subclavian vein
C. Gastrointestinal tract—pharynx, oesophagus.
D. Nerves—spinal cord, brachial plexus, cranial nerves, peripheral nerves.
E. Bones—mandibular angles, styloid processes, cervical spine.

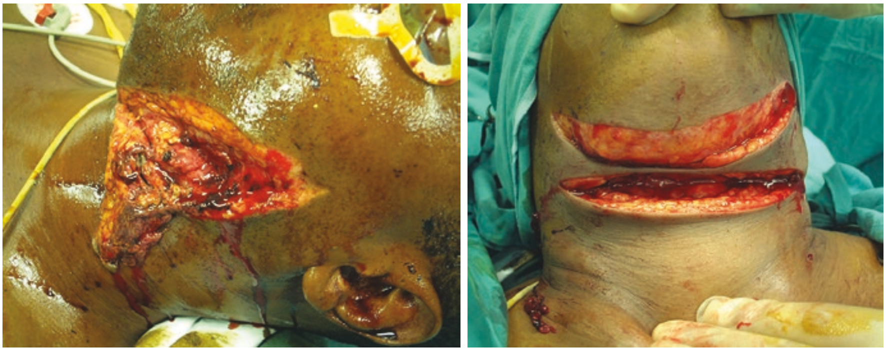

Fig. 3.14 Penetrating neck injuries—what structure are at risk?

The platysma is an important anatomical landmark. This separates the superficial and the deep structures of the neck. Wounds that do not penetrate the platysma, are not significant penetrating neck injuries. Bleeding may still be profuse, but is usually easily controlled by direct pressure or simple ligature. The sternocleidomastoid muscle divides the neck into the posterior triangle (which contains the spine and muscles), and the anterior triangle (which contains the airway, vasculature, nerves, oesophagus and salivary glands) (Fig. 3.14).

Pathologically, three mechanisms are reported to be responsible for the consequences of the blunt anterior neck trauma, (1) external haemorrhage, (2) soft tissue haematoma resulting in airway obstruction and (3) impaired cerebral circulation. Injuries include direct blows during sports, 'clothes-line' type injuries, fast moving soccer balls, hockey pucks and in rare cases strangulation. Signs and symptoms arising in the front of the neck may indicate a number of serious problems involving many different systems. This structure should therefore be closely assessed, particularly if the patient has sustained an impact or deceleration injury to the chest. Many vital structures traverse the neck. These are all at risk of injury from these mechanisms. Only a thin layer of skin only protects these structures, unlike other internal organs which are relatively sheltered.

Trauma to the larynx and trachea can results in significant surgical emphysema and haematoma which can compress the airway. Signs include ecchymosis, swelling, tenderness, and a change in voice. Crepitus on palpation of the neck may suggest airway injury or communicating pneumomediastinum. Laryngotracheal separation is rarely seen but should be thought of following strangulation-type injuries. Fractures of the hyoid bone can destabilise the airway although this is unusual. The hyoid is part of the supporting mechanisms for both of the larynx and tongue. Fractures can sometimes be seen on lateral cervical spine film. Deep to these midline structures is the oesophagus. Whilst this is rarely damaged following blunt trauma, injuries to the oesophagus can occur from penetrating or explosive injuries. These injuries are very difficult to recognise clinically, yet the consequences of a missed oesophageal rupture and mediastinitis are serious (Fig. 3.15).

Fig. 3.15 Dog bite to anterior region. The hyoid bone was fractured

A number of important vessel pass through the neck. The larger arterial vessels such as carotids are relatively deep, but are still at risk from penetrating injuries. Bleeding is often profuse and is almost immediately life threatening. Smaller vessels such as the branches of the external carotid can also lead to life threatening haemorrhage, but are often easier to control. Veins tend to bleed more slowly and this can sometimes be mistaken for a minor ooze. Distended veins may indicate raised intra thoracic pressure (tension pneumothorax) or cardiac tamponade. Care should always be taken when investigating any active bleeding. This often requires general anaesthesia. Until then, firm pressure should be applied (being careful not to occlude the internal carotid). In the case of a small penetrating injury it should be assumed that the injury is deep until imaged or formally explored. Consider also the possibility of a growing haematoma. The presence of spreading ecchymosis or a pulsatile swelling with an audible systolic bruit should arouse suspicion of traumatic pseudoaneurysm and needs further investigations. If the patient is stable CT and MRI are useful in diagnosis. US and Colour Doppler are also helpful diagnostic tools, but CT angiography remains the gold standard.

Early endovascular or surgical intervention is often required. Rigorous spinal precautions should not be maintained at the expense of managing life-threatening airway or vascular injuries. "Hard" clinical signs mandating immediate exploration of the neck include

A. Uncontrollable haemorrhage
B. Rapidly expanding haematoma
C. Palpable thrill or audible bruit
D. Focal neurological compromise
E. Absent or decreased pulses in the neck or upper extremities

Many important nerves also traverse the neck. Damage to these, although rarely life-threatening, can result in significant morbidity. These include branches of the facial nerve, hypoglossal nerve, accessory nerve, phrenic nerve and vagus. It is also important to remember that there are a number of important glands and organs contained within the neck and whilst injury to these is quite rare, the consequences can be serious. These include the thyroid gland, parathyroid gland and carotid bodies. Injuries to the salivary gland are usually not serious.

3.3.3 Clearing the Cervical Spine

This is discussed in greater detail in a chapter on the back of the neck. Although clearance of the cervical spine is often recorded, it is important to appreciate that the entire spine needs to be cleared, not just the neck. This usually requires initial imaging followed by clinical examination. The most appropriate time to clear the spine depends on the clinical circumstances, other injuries and suspicion of spinal injury in the patient. Although clearance may not be an immediate priority (since the spine is being protected) it is well known that prolonged immobilisation can result in the development of pressure sores. Patients are also easier to manage once they are giving freedom to move and sit up. This especially applies to patients with facial injuries (Fig. 3.16).

For these reasons the spine should be cleared as soon as is practically possible. Patients can sometimes be combative against spinal restraint. Even for a well patient, the simple action of being restrained onto a hard spine board with interventions being performed on them can be quite distressing. This anxiety will be heightened if compromised from anxiety, pain, intoxication, drugs or hypoxia. Every effort should be made to correct these problems early. Providing the patient with continuous reassurance is vital.

Fig. 3.16 Infectious, chronic, non-healing scalp pressure ulcer in the right parietal area. Note the purulent dressing

3.3.4 Airway Procedures

Facial trauma often presents problems with mask ventilation and difficult intubation. The injuries may disrupt the normal anatomy with oedema and bleeding in the oral cavity. Consequently masks cannot fit closely with loss of effective mask ventilation. An injured airway may also prevent efficient transference of gases to and from the lungs. Intubation is difficult if the vocal cords cannot be seen. The oral cavity, pharynx and larynx may be filled with blood, secretions and debris, all of which preclude good visualisation of the cords. This is all made worse by the presence of a possible C-spine Injury. Definitive airway management is highly specialised and usually undertaken by anaesthetists or other appropriately trained specialists. In the first instance however there are a few simple techniques we can all do to initially maintain an airway.

3.3.4.1 Simple Manoeuvres and Adjuncts

The chin lift and jaw thrust are commonly known techniques that manually open the oropharyngeal space. However, the chin lift places the patient's neck in a hyperextended position and therefore should not be undertaken if the patient is in a hard collar or the neck has not been cleared. Alternatively, the jaw thrust manipulates the mandible forwards, lifting the tongue base out of the oropharynx. This technique is only effective if the mandible is not fractured and the attachments of the tongue are intact. Nevertheless, it is safe to perform whilst awaiting anaesthetic support.

At the same time, suction may be applied. This should be available at the bedside for all immobilised patients. Suction can be applied via a large bore Yanker sucker. Smaller size Yanker suckers are available for children. In some patients suction can also be applied (cautiously) via the nasal passages using a fine bore flexible catheter. When applying suction to clear the airway remember to only suck what can be seen with the naked eye. Never pass the suction blindly into a space. This can displace foreign material. Remember also that touching the soft tissues beyond the anterior palatine pillars (innervated by the glossopharyngeal nerve) can elicit a gag reflex and can cause vomiting.

If there are mobile jaw fractures impeding the airway, these are can sometimes be temporarily stabilised using wires. The bridle wire technique involves passing a wire around teeth either side of the fracture to reduce and then hold mandibular fragments together. This is best done with fine wires which are easy to manipulate, although a heavy suture may also suffice. In an awake patient be aware that manipulating fragments will be painful. Administration of local anaesthetic into the fracture area will help if there is sufficient time to allow this. Once the fragments are stabilised, the patient will be much more comfortable. Clearly this is not definitive management of the fractures, but it does buy time and provides comfort for the patient. It is mostly used in anterior fractures.

The oropharyngeal airway is a curved plastic device which can be placed into the oropharyngeal cavity. The curvature of the device acts as a hook in the vallecula to support the base of tongue. This prevents it from falling back into the oropharynx and obstructing the airway. This device can often be used to augment and sometimes replace the jaw thrust. However in a conscious patient this will elicit a gag reflex. Any patient who can tolerate an oropharyngeal airway is unable to protect their airway independently. These patients need to have a definitive airway established early. With conscious patients a nasopharyngeal airway may be placed. This is a small caliber flexible tube which is passed through one or both nasal passages to provide a patent nasal airway as far back as the nasopharynx. This should not elicit a gag reflex but can be difficult to place if the nose has been previously injured. It can also be uncomfortable for the patient. Other concerns relate to the possibility of anterior skull base fractures, although in reality safe passage of a nasopharyngeal airway should still be possible.

3.3.4.2 Definitive Airways

Placement of a definitive airway, that is intubation of the patient, should only be undertaken by clinicians who have received appropriate training and experience.

The term ‘definitive airway’ is often used to refer to the placement of a cuffed tube within the trachea (with the cuff then inflated). Placement of the tube into the trachea ensures an uninterrupted passage for gasses and affords a degree of protection against aspiration (although this is not guaranteed). The balloon helps seal the airway tube but it is not always an absolute barrier. Foreign material, especially liquids can still leak slowly pass it. This leakage is believed to be the cause of hospital acquired pneumonia that is commonly experienced by intubated patients in intensive care.

The laryngeal mask airway, although not a definitive airway, may also have a role in trauma, in selected cases. This is a tube with a mask like end which sits over the epiglottis and vocal cord complex. There are multiple mask designs. This provides some protection of the airway from aspiration, however it is not a tight seal and if applied incorrectly is prone to dislodge. The main advantage of this technique is the ease of placement. It does not require direct visualisation of the larynx. Practitioners can also be easily trained to perform this technique. It has now become a standard airway technique to be achieved by Advanced Life Support Providers.

Patients with complicated airways such as those with facial fractures and oedema may not tolerate placement of a laryngeal mask airway. In this case a smaller device may be used. Alternatively, inflatable laryngeal masks are now available which can bypass the area of difficult anatomy. All these devices should be regarded as temporary measures only, to be used if intubation is not possible. They do not fulfil the criteria of a definitive airway, long term ventilation is unreliable and they provide significantly less protection from aspiration.

Tracheal intubation is the most common technique for airway provision in trauma. This can be placed via the mouth or nose, although in the acute stages of assessment the nasal route is generally avoided. This is technically much more difficult and maybe contraindicated in patients with signs of head or facial injuries. Both techniques require direct visualisation of the vocal cords and therefore should only be undertaken by an appropriately trained and experienced practitioner. Direct visualisation of the vocal cords can be difficult if the patient has poor mouth opening or altered pharyngeal anatomy. In these circumstances, video assisted laryngoscopic devices and flexible fiberoptic nasendoscopy may be used. Flexible fiberoptic intubation under local anaesthesia may be possible in selected cases but can be difficult in the presence of some facial injuries. Blood, vomitus and secretions in the patient's airway may preclude visualisation of the cords. Accomplishing effective local anaesthesia may also be difficult and relies on the patient's cooperation. The Glidecope is a video-assisted laryngoscope which enables indirect visualisation of the epiglottis.

Extubation of the patient with a difficult airway requires careful consideration and planning. This is also at high risk of complications. As a result of the injuries themselves, or their repair, the soft tissues and mucous membranes will be swollen and oedematous for several days. These may place pressure on the airway, which is held patent by the endotracheal tube. The neck only has a limited amount of expandability and therefore only a small amount of bleeding or swelling in the region is required to result in airway compromise and potentially raise intracranial pressure. In patients with coexisting facial trauma, extubation should be deferred until all swelling has settled and the vocal chords can be clearly visualised. During and after extubation the patient should be monitored closely and staff should be prepared for the possibility of urgent re-intubation. Alternatively, if prolonged intubation is anticipated a tracheotomy may be placed.

3.3.4.3 Surgical Airways

If intubation but becomes difficult, there should be a low threshold to move onto surgical access. Multiple failed attempts can lead to unnecessary prolonged periods of hypoxia, which is extremely detrimental to the injured brain. Surgical airways are therefore occasionally required. This can be difficult. Placement can be challenging without manipulating the neck. Unless the neck has been cleared all movement should be avoided. The anterior half of the hard collar will need to be removed and therefore help is required to maintain manual immobilisation. Needle cricothyroidotomy is commonly described as a simple temporary measure that can provide oxygenation for 30 min (although the lack of ventilation will result in an increase in CO_2) build-up. However it is probably simpler to progress immediately to placement of a surgical cricothyroidotomy. Most emergency departments will have the necessary equipment as part of their resuscitation kit (Fig. 3.17).

Surgical cricothyrotomy refers to the technique in which the cricothyroid membrane is incised with a scalpel and a tracheostomy tube or modified ET tube is passed to maintain the airway. Most anaesthetists, surgeons and ATLS providers are now trained in this technique. Compared to a tracheostomy, cricothyrotomy is simpler to perform, does not require neck extension, and is less likely to encounter significant bleeding. However the stoma opening is closer to the larynx and this technique has therefore been reported to be associated with a higher risk of causing laryngomalacia. For this reason many specialists argue that it will need to be replaced by a tracheostomy at the earliest opportunity (although this is a little uncertain). The cricothyroid membrane is a fibro-elastic membrane located anteriorly and midline in the neck. It lays between the thyroid cartilage above and the cricoid cartilage below. Laterally, the membrane is partially covered by the cricothyroid

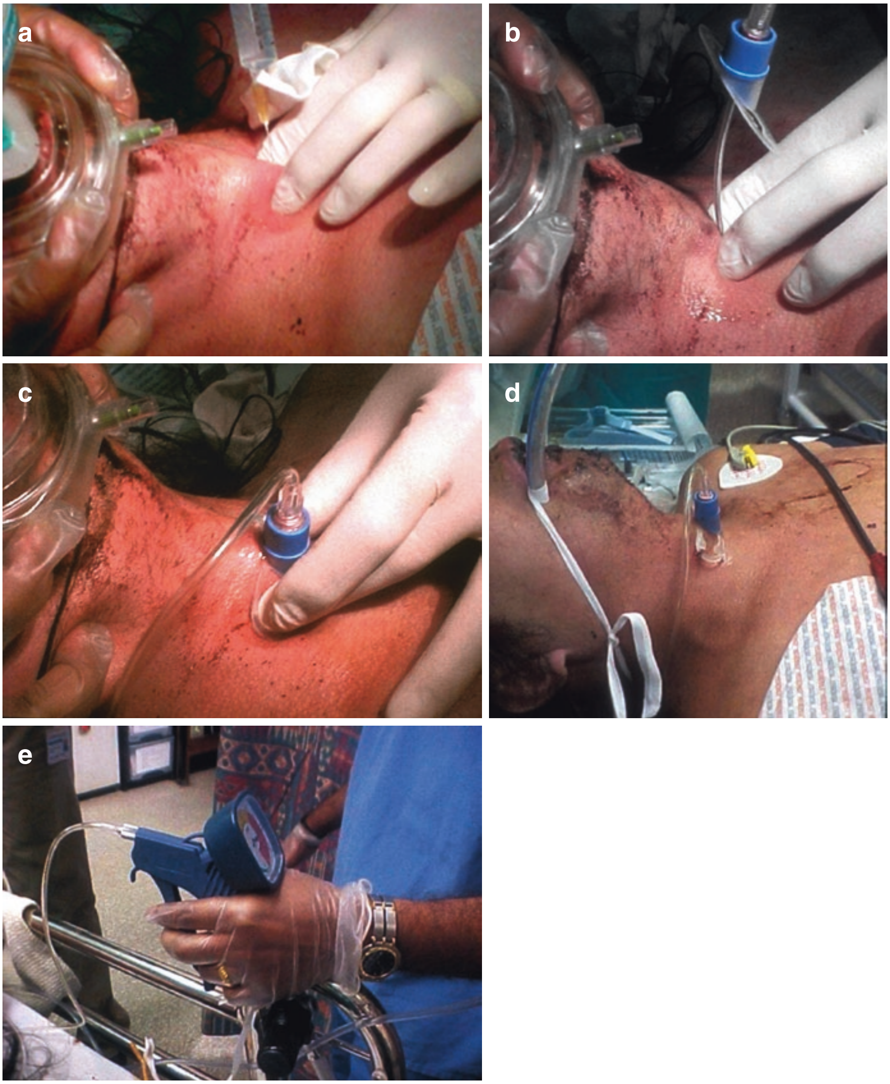

Fig. 3.17 Needle cricothyroidotomy in an awake patient. (**a**) Local anaesthesia is infiltrated first. (**b**, **c**) Placement of the cannula. (**d**, **e**) The cannula is secured and "jet insufflation" commenced

muscles, but the central portion is subcutaneous and often easily palpable, making it ideal for accessing the airway in an emergency. This may be identified by locating the prominent "Adam's apple" (thyroid cartilage) superior to it. This is more pronounced in men but can be difficult to identify in fat necks of if there is swelling. The tissues overlying the cricothyroid membrane are relatively avascular and do not contain any significant anatomic structures. The isthmus of the thyroid gland usually overlies the second and third tracheal rings, although rarely an aberrant pyramidal lobe may extend just superior to the cricothyroid membrane. Following identification of the cricothyroid membrane the area is cleaned and local anaesthetic is infiltrated. An incision is then made with a scalpel, through the skin and ligament into the airway. This is dilated to allow the passage of a size 6 tube. In an emergency situation a tracheostomy tube may not be available. The insertion of a size 6 endotracheal tube is then an adequate alternative. Care should be taken not to insert the tube too far down the trachea. It should then be secured with sutures and tape. Complications include

A. Bleeding
B. Incorrect or unsuccessful tube placement
C. Subcutaneous emphysema
D. Obstruction
E. Oesophageal perforation
F. Pneumothorax, pneumomediastinum
G. Vocal cord injury
H. Laryngeal disruption
I. Subglottic or glottic stenosis
J. Tracheoesophageal fistula (Fig. 3.18)

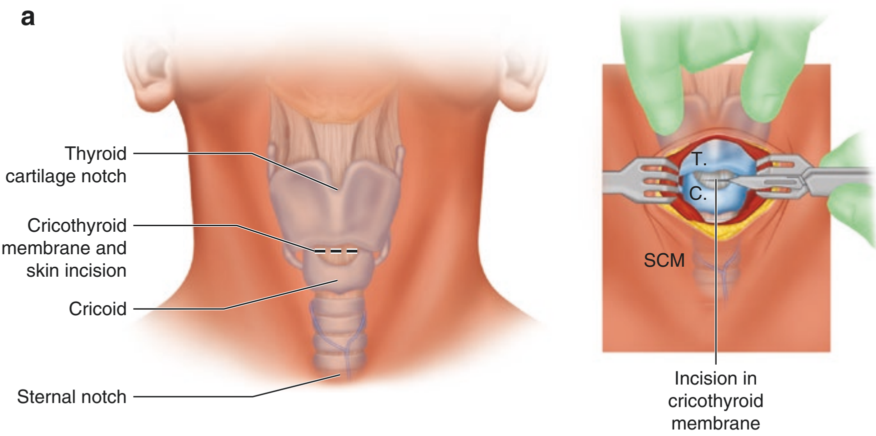

Fig. 3.18 Surgical cricothyroidotomy. (**a**) The cricothyroid (C-T) membrane passes between the thyroid cartilage (Adam's apple) and cricoid ring. It is usually covered by a relatively thin layer of skin and subcutaneous tissues, making access to it relatively simple. (**b**) Case 1. The patient is positioned supine and the thyroid cartilage is gently grasped from above (**c**). Some surgeons describe its contour like the keel of a boat, with the membrane at the lower end. The C-T membrane is then palpated by the index finger. It has a slightly "bouncy" feel to it. (**d**, **e**) Initial skin incision. (**f**, **g**) The skin and subcutaneous tissues are bluntly dissected to expose the C-T membrane immediately below. (**h**, **i**) The membrane is then incised. Some surgeons insert the handle of the scalpel blade and gently twist it to open up the hole. (**j**, **k**) The incised membrane is opened with either the handle of the scalpel or a spreader. (**l**, **m**) The tracheostomy tube (or endotracheal tube) is then placed under direct visualisation. (**n**, **o**) Case 2. In experienced hands this procedure can be done in 10–20 s. It is very rapid and provides a safe secure (but relatively small diameter) airway

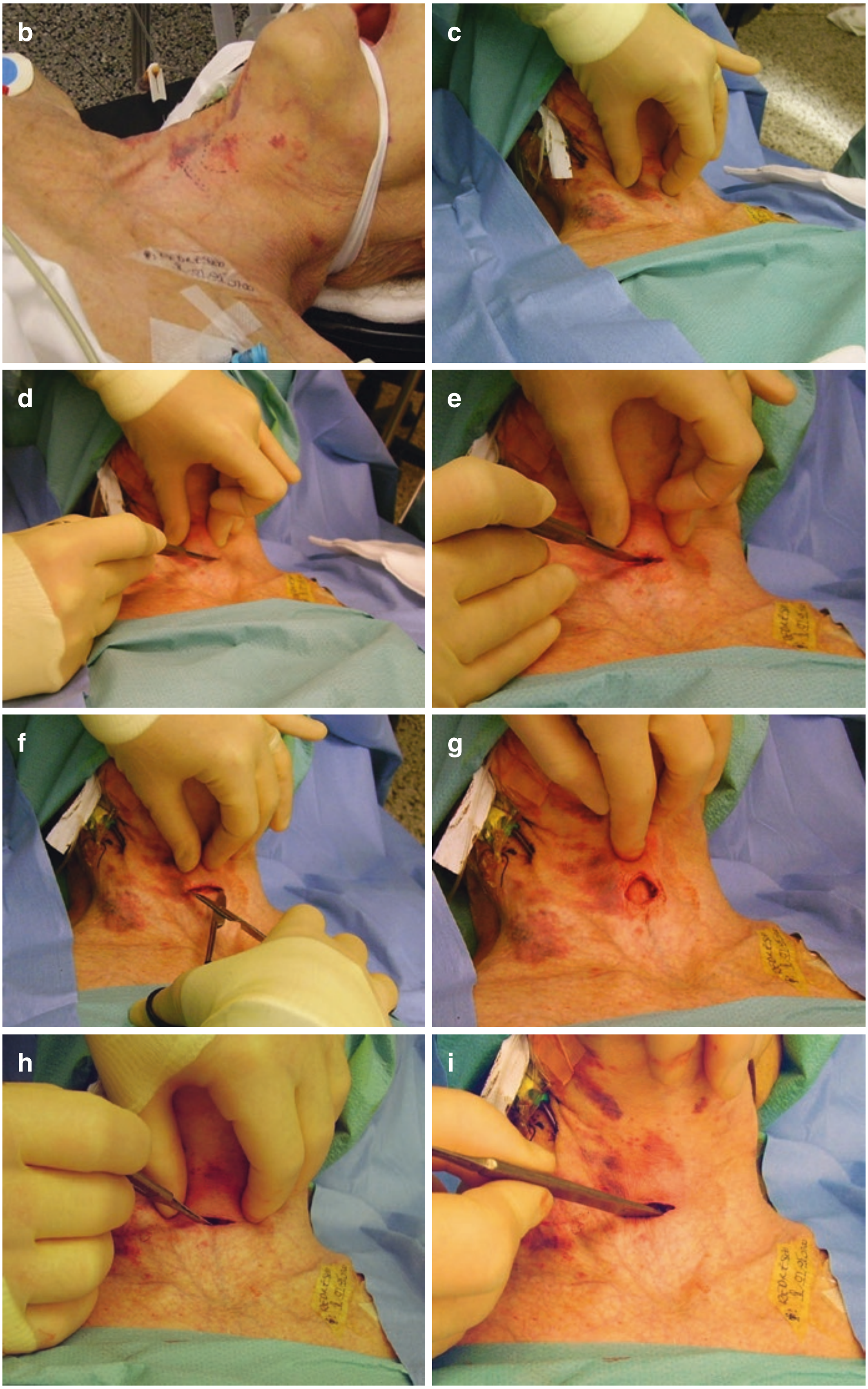

Fig. 3.18 (continued)

Fig. 3.18 (continued)

Alternatively, and if time allows, a percutaneous cricothyrotomy may be undertaken. This uses the Seldinger technique to place a tracheostomy tube over a guidewire. Most prepackaged commercial kits come with a 6-mL syringe, an 18-gauge needle with an overlying catheter, guidewire, tapered dilator, and airway catheter in lieu of a tracheostomy tube. For this technique the cricothyroid membrane must be easy to identify because no initial skin incision will be made. Anatomic distortion can therefore make locating the membrane difficult. The procedure is contraindicated if the neck is highly vascular or the thyroid gland cannot be avoided. This is often undertaken by anaesthetists but is rarely undertaken in the acute trauma setting. In many units, surgical tracheostomy is not an emergency procedure. The mortality from this can be as high as 1% and much higher in unfavourable circumstances. Therefore it is generally recognised that only a trained surgeon with adequate light, haemostasis facilities and with assistance should perform this.

3.3.5 Breathing and Ventilation

On arrival (if not before), all patients should be given 100% oxygen through a non-rebreathing reservoir and mask. This allows every breath to contain 100% without mixing of inhaled and exhaled gasses. Once the patient's saturation is measured, the oxygen supplied can be titrated appropriately. Assessment of patient's breathing should be undertaken quickly and includes inspection, palpation, auscultation, percussion and investigations. Inspection is best undertaken at the end of the bed or trolley. Signs of respiratory compromise include use of accessory muscles of respiration. This may appear as the patient bracing themselves, movement of shoulders and neck with breathing and pursed lips. The inability to complete sentences is a concerning sign. An increased respiratory rate is a non specific indicator of abnormal physiology. It does not necessarily relate to respiratory problems and can occur in shock. Nevertheless it should be noted. The chest can also be palpated to determine symmetrical chest movement and the position of the trachea. Asymmetrical position of the trachea is often an indicator of chest pathology. Auscultation with a stethoscope confirms equal air entry into each lung. Resonance on percussion is perhaps less commonly undertaken in trauma but can detect increase air or blood in the chest such as pneumothorax or haemothorax. Pulse oximetry is a noninvasive method of continuously measuring the oxygen saturation of arterial blood. An oxygen saturation of 95% or greater using pulse oximetry is good evidence of adequate peripheral arterial oxygenation. However this measures haemoglobin saturation only, not ventilation and should therefore not be relied upon totally in the assessment of respiratory sufficiency. It should not be regarded as a substitute for arterial blood gases, as it provides no information on base deficit, carbon dioxide levels, blood pH, or bicarbonate. Falsely reassuring readings are also possible—in severe anaemia, the circulation will have less total oxygen, despite a haemoglobin saturation being high 100%. Erroneously low readings can be caused by hypoperfusion of the extremity, poor sensor placement or movement (shivering). A false reading will also occur if haemoglobin binds to something other than oxygen (notably carbon monoxide and cyanide). Methaemoglobinemia, from a variety of causes, can result in low readings. Nevertheless, changes in oxygenation can occur rapidly and may not be detected clinically. For this reason all patients should have continuous pulse oximetry.

A number of conditions can significantly affect ventilation. In the context of the head and neck trauma, loss of consciousness and damage to the phrenic nerve (spinal-cord injuries) would be the two most important conditions. With facial injuries, breathing problems may occur following aspiration of teeth, vomit, dentures and other foreign bodies. If teeth or dentures have been lost, a chest X-ray and soft tissue view of the neck should be taken to exclude displacement into the pharynx or lower airway. These must be viewed carefully—acrylic, from which most dentures are made, is not very obvious on a radiograph. All foreign bodies in the airway need urgent referral (Figs. 3.19, 3.20 and 3.21).

Within the chest itself there are a number of specific injuries which should be considered. If you are a member of the "ATLS Fan Club" then you will have a useful pneumonic to remember life threatening problems in the chest (mostly "B" problems).

A. Airway
B. Tension pnuemothorax—A one way valve effect results in air becoming trapped in the pleural space. As the cavity expands, the lung is compressed and eventu-

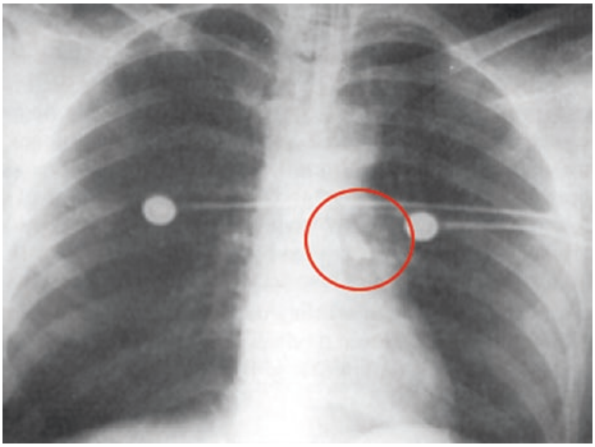

Fig. 3.19 Tooth in lung. These can easily be missed on a plain film. With the newer adjustable digital images this is less likely

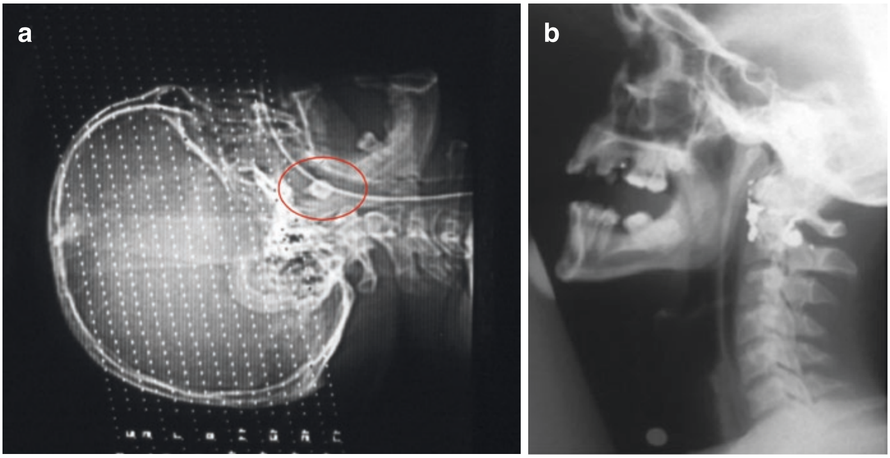

Fig. 3.20 Foreign bodies in the upper airway (**a**, **b**). Often there is a history of loss of consciousness, but the absence of this is no safeguard

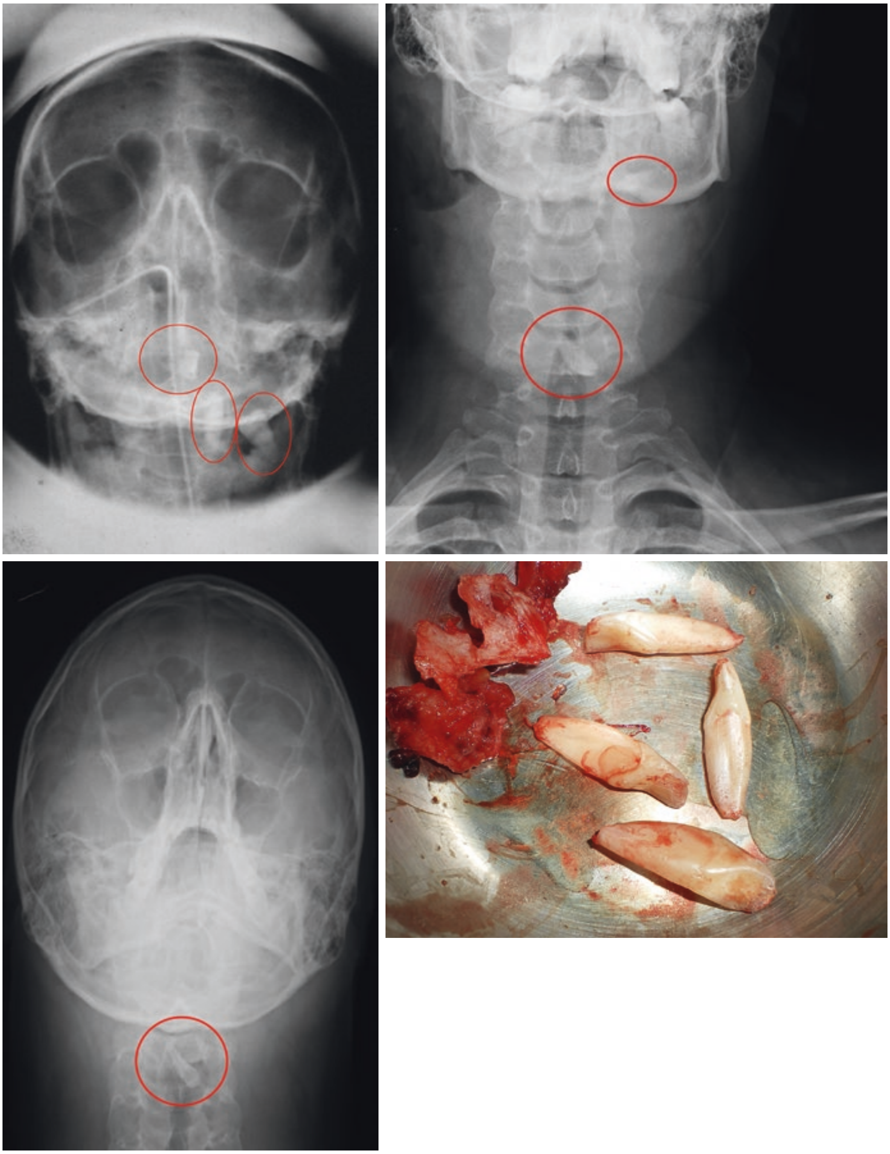

Fig. 3.21 Further examples of teeth in the upper airway. A chest radiograph alone is inadequate

ally collapses. This increase in chest pressure will further restrict air entry into the lungs and reduce the venous return to the heart. This leads to hypoxia and circulatory collapse. The classical signs are distended neck veins, hyperresonant percussion, reduced air entry on auscultation and respiratory distress. Treatment requires urgent needle decompression followed by formal placement of a surgical chest drain.

C. Large (massive) haemothorax—The collecting blood causes compression of the lungs. This is alleviated with placement of a surgical chest drain. The blood loss should also be replaced with a transfusion.
D. Sucking chest wound (open pneumothorax)—This is similar to a tension pneumothorax but air passes in and out of the pleural space. It therefore does not lead to circulatory collapse. However efficiency of oxygenation is compromised. Treatment is by placing a three sided dressing initially, followed later by a chest drain. The dressing will allow air to escape the pleural space but not re-enter on inspiration.
E. Flail chest—This is caused by multiple rib fractures. The loss of coordinated chest movement and restricted breathing secondary to pain reduces the patients ability to move air in and out of the lungs. Treatment depends on the degree of respiratory compromise and ranges from simple analgesia, to nerve blocks and urgent ventilatory support
F. Cardiac tamponade—This is caused by blood entering the pericardial space. As this increases, the heart becomes compressed and compromised. Treatment requires drainage, analgesia, monitoring and ventilatory support

Initial management of breathing is to ensure adequate oxygen enters the lungs. The airway should therefore be clear and the patient should be able to breathe oxygen enriched air. If the patient is unable to self ventilate effectively this will need to be augmented following intubation. Intubation is also indicated if the patient's airway is at risk from oedema or aspiration. Initial management of serious blunt chest injuries will, in part, be guided by the injuries seen on an initial antero-posterior (AP) chest X-ray. Although other investigations are available to assess thoracic injury (computed tomography, angiography, magnetic resonance imaging and pleuroscopy), in the very early stages resuscitation in most cases will be determined by clinical assessment and standard radiography. Chest ultrasonography (US) is also gaining more attention in the critical care and emergency medicine literature. This has been used recently in the evaluation of pneumothorax and other lung pathologies. Several early trials have been supportive of its potential in the diagnosis of pneumothorax, but mediastinal evaluation is poor and widespread usage is currently not undertaken.

3.3.6 Circulation and the Control of Bleeding

Hypovolaemia is the commonest cause of preventable death following trauma. Rapid blood loss leads to a depression of organ and immune function that, if prolonged, quickly progresses to the sequential failure of multiple organ systems. Reported incidences have it shown that acute blood loss accounts for approximately 40% of all deaths following trauma. This is most notably seen following penetrating injury or high velocity impacts, in which patients can rapidly lose significant amounts of blood into several large body cavities (chest, abdomen, pelvis), or externally. Life-threatening blood loss can also occur following injuries to the neck and

Fig. 3.22 Angiogram demonstrating a tear in the aorta. This occurred following a deceleration injury. Rapid deceleration can result in life-threatening mediastinal injuries

face, although this is less common. Blood loss in children is more significant than in adults (Fig. 3.22).

Timely diagnosis, surgical control of on-going loss and physiologically directed fluid replacement are the cornerstones of management. Any injured patient who is cold to the touch and has a rapid pulse should be regarded as being in hypovolaemic shock until proven otherwise. The degree of hypovolaemia is usually classified based on the patients pulse rate, blood pressure and perfusion. These are all indicators of cardiac function and its effectiveness. When the patient first arrives, the simplest way to assess perfusion is by examining their skin colour, capillary refill time and conscious status. As soon as shock is recognised treatment can be initiated, whilst more definitive and precise tests are being arranged. Urinary output is also a good indicator of renal perfusion but requires a catheter and so cannot be assessed immediately.

The earliest sign of blood loss is tachycardia. Blood pressure is a poor guide and will not identify all trauma patients who are in shock. Compensatory mechanisms prevent a significant decrease in systolic BP until the patient has lost around 30% of their blood volume. Attention should therefore be paid initially to the pulse, respiratory rate, and skin perfusion. However caution should be taken when interpreting the pulse rate, particularly with children, the elderly, athletes and patients taking medication which affects cardiac function (beta-blockers). These patients do not respond physiologically to blood loss in the same way as other patients and therefore a normal pulse rate is no guarantee that the patient is not shocked. Whilst haemorrhage is usually the presumed cause of shock in all injured patients, it must be distinguished from other possible causes. These include cardiac tamponade (check for muffled heart tones, distended neck veins), tension pneumothorax (check for deviated trachea, asymmetrically reduced breath sounds) and spinal cord injury (check for warm skin, normal or slow pulse rate and neurological deficits). Once tension pneumothorax and cardiac tapenade have been excluded, all hypotensive trauma patients should be considered to be in severe hypovolaemic shock until proven otherwise (ATLS).

Arterial blood gases are essential in the evaluation of shock. A negative base excess and raised lactate (lactic acidosis), are good indicators of ischaemia and reduced tissue perfusion. Changes in these are also very reliable in indicating the patients recovery or demise, compared to other measurements. Bleeding patients should also be investigated for coagulopathy. They should be kept warm to allow the proteins of the clotting cascade to function optimally. To aid the arrest of haemorrhage, it is now advised to administer tranexamic acid intravenously in some patients. Drugs causing coagulopathy such as warfarin should be reversed as per local protocol with vitamin K or prothrombin complex concentrate, depending on the clinical circumstances.

All trauma patients should be provided with good intravenous access and blood taken for cross match. Initially warmed fluids (this varies in different units) may be infused and the patient's response reassessed. However which fluid to use and how much to give are still being evaluated and therefore may depend on where you work. It is important not to just give the 'standard' 2 L of Saline—rather, find out what your local protocol is—fluid administration may be different (smaller boluses) and will vary depending on the patient's response. Resuscitation often depends on the clinical circumstances and should be tailored accordingly. Some specialists advocate 250 ml boluses of warmed crystalloid—hypotensive resuscitation. The problem with early and aggressive fluid administration is that it may result in (1) dislodgement of blood clots (by increasing blood pressure), (2) dilution of coagulation factors and (3) hypothermia. Thus the concept of 'permissive hypotension' has been developed in which the blood pressure is maintained at lower physiological levels (but enough to maintain cerebral perfusion), until haemorrhage is controlled. During this time a rapid search is undertaken to identify any sites of significant blood loss. Sources of major blood loss are usually

A. External wounds
B. Chest
C. Abdomen
D. Retroperitoneum
E. Pelvis
F. Limbs
G. Face

3.3.6.1 Damage Control

This term interestingly is derived from naval warfare. Following damage to a ship, only repairs necessary to enable it to complete its mission were undertaken. All other repairs were completed on return to port. Acute blood loss can result in a combination of acidosis, hypothermia and dilution of clotting factors, sometimes referred to as the "the lethal triad", which physiologically results in a "first biologic hit". The severity of this significantly affects the prognosis for survival. Over the years, damage control resuscitation and surgery has gained popularity in the management of severely injured patients. This focuses on rapidly stabilising and improving the patients adverse physiological and biochemical changes that have arisen. Comprehensive anatomical and functional repair of all injuries is deferred until the patient is in a better condition. Damage control surgery involves techniques such as rapid control of haemorrhage and contamination, temporary wound closure, and rapid stabilisation of fractures. Patients are then transferred to the ICU for further resuscitation, with delayed re-exploration and definitive repair of their injuries following restoration of their normal physiology. These principles have been applied successfully in abdominal, thoracic and orthopaedic trauma and have similarly been applied following trauma to the head and neck.

Severe maxillofacial and neck trauma, both blunt and penetrating, may be sustained in various military and civilian circumstances. Major haemorrhage from the head and neck area is however uncommon and is usually quite apparent when the patient arrives. The scalp and face are highly vascular regions and may be associated with significant blood loss. It is however, extremely difficult to estimate the volume of bleeding from these sites and other lacerations due to blood loss at the scene and en route to the hospital. External blood loss requires careful visual inspection. The chest, pelvis and limbs can be quickly assessed clinically and then radiographically. Ideally a chest and if necessary pelvic X-ray, should be performed within 10 min of the patients arrival. The abdomen is a difficult region to examine, especially in the unconscious patient and this often requires further investigations (ultrasound or CT). Even a single long-bone fracture can result in up to 10–30% loss of total blood volume. This is usually evident from swelling due to haematoma formation.

In some patients surgical intervention or embolisation may be required very early to control bleeding—therefore surgeons/radiologists should be involved in management early. They need time to set up. Rapid immobilisation of limb/pelvic fractures (and when necessary a laparotomy), should all be regarded as part of "C" and therefore not be delayed. In any a patient who fails to respond to fluid replacement, it is important to think of other causes of shock, especially following injuries to the upper torso (myocardial contusion, tension pneumothorax, cardiac tamponade, spinal injuries and sepsis). Injuries are not mutually exclusive and therefore one or more of these may present in the same patient.

Rapid assessment is the key to success. CT is increasingly being used in the overall evaluation of otherwise stable patients—a "pan scan". Other investigations may include

A. Chest X-ray—look for pneumo/haemothoraces, mediastinal widening, rib fractures, tracheal disruption.
B. Echocardiography—this is used to rapidly diagnose a pericardial effusion
C. FAST scan. This is commonly used in the emergency department to identify free fluid in abdomen and visualise solid organs (spleen, liver and kidneys).
D. Pelvic X-ray—fractured pelvis

3.3.7 Blood Loss Following Head, Neck and Facial Trauma

Significant blood loss from the head, neck and face can occur following penetration, rupture or tearing of the major vessels. This may present as an expanding mass under a penetrating wound. Not all bleeding from this area is massive. Rather, patients tend to continually ooze from a wound, which may not be recognised at first. Bleeding from a broken nose or from an occipital scalp laceration in the supine patient are two good examples, which can result in significant blood loss. Whilst greater bleeding from facial fractures can occur, it is usually self-evident as soon as the patient arrives. This is common following high energy midface fractures. Control of haemorrhage can be difficult and may require early intubation to enable access in and around the mouth.

At first, active bleeding should be controlled by pressure until the airway and breathing have been stabilised. Once the airway is secured, direct pressure and aggressive packing of open bleeding wounds will control all but the most major haemorrhages. If time permits and the patient is stable wounds should be cleaned first with sterile water and gauze applied. Generalised oozing from a wound can be controlled by firm pressure. Clamping obvious spurting vessels with a blunt artery clip can arrest bleeding if this is localised. The vessel can then be tied off using a suture tie. Needless to say, know your anatomy. Blindly clamping vessels deep in the neck is not to be recommended. Only clamp those that are small and superficial, when all else fails. Bleeding from a "hole" (following a gunshot or stabbing injury) can sometimes be controlled by placing a urinary catheter in the hole and inflating it. Obviously be careful and consider carefully what structures may be in the depths of the hole before attempting this. Very small superficial vessels can be arrested by application of sliver nitrate. This is often useful in epistaxis. Heavy bleeding from extensive scalp or neck wounds where the bleeding vessels cannot be identified can be controlled with the application of sealants such a Celox. This can be in a powder of gel form. It is applied directly over the wound and will accelerate clotting. Compression bandaging can then be applied (be aware of possible injuries underneath this). External fixation of unstable anterior mandibular fractures using available means (orthopaedic pin fixators, wire ligatures etc.) may help protect the airway, as well as reduce bleeding, pain and morbidity. Bleeding may also stem from the base of the skull. This is often an ominous sign. Once the patient is stabilised, angiography may be necessary, with embolisation if possible.

3.3.7.1 Midface Bleeding

The midface extends between the eyebrows and upper teeth and contains the air-filled paranasal sinuses. The bones are mostly thin and lined by mucosa. Fractures here can result in profuse bleeding from terminal branches of the maxillary artery. Ocular injuries, vascular injuries, and intracranial penetration are also commonly associated injuries, especially following penetrating trauma. Midface bleeding rarely results in massive blood loss. Nevertheless, following high impacts displacement of the bones can tear soft tissues and rupture the venous plexus around the pterygoid plates. This can lead to significant blood loss and shock. Ongoing bleeding from the palate or into the pharynx will suggest this. The patient may also describe the need to swallow frequently and a feeling of liquid in the back of the throat. Such bleeding needs to be arrested at the earliest opportunity, at first by manually reducing the midfacial bones (gently lifting the maxilla back up and against the skull base). This is then held in place using bite blocks as far back as possible between the teeth. If bite blocks are not available, several gauze swabs or stacked wooden tongue depressors can be tied together and placed. If bleeding continues, posterior nasal packs should be inserted. Needless to say, all this requires a cooperative patient. Ideally the patient should be sitting up, but depending on the mechanism of injury this may not be permitted. If control is not easily attainable, or if the patient is combative, it may be necessary to anaesthetise them and secure the airway. With high energy impacts to the face this will probably be necessary anyway, as the face is likely to swell significantly over the next few hours. It is therefore important to anticipate this and get senior help early (Figs. 3.23 and 3.24).

Fig. 3.23 Temporary reduction of midface fractures to control haemorrhage

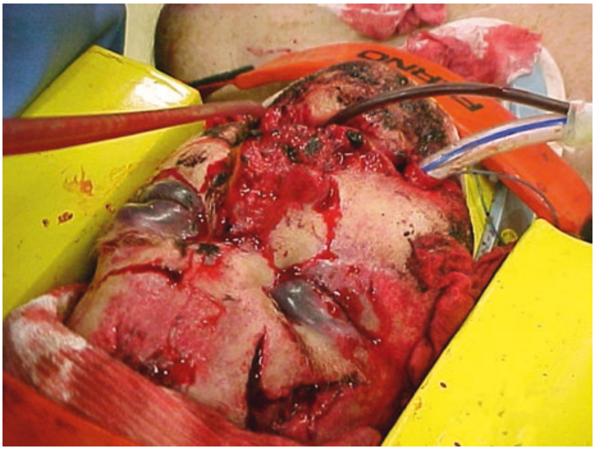

Fig. 3.24 This patient initially presented with hypovolaemic shock, but only minor facial bleeding. There were no significant injuries below the clavicles. It was only when his systolic pressure was restored that profuse bleeding from the face became apparent. This should have been anticipated in view of the extensive fractures

Fig. 3.25 Epistaxis balloons. Passing catheters, balloons and packing of the nose does carry a risk of intracranial intubation in the presence of skull base fractures, as shown here. Nevertheless, if a patient is pouring blood from the nose and mouth something clearly needs to be done. The actual risk of intracranial intubation is probably very low in experienced hands. Only pass these if you are trained to do so and know what you are doing. If not then get urgent help

3.3.7.2 Epistaxis

Bleeding from the nose can be considered as anterior or posterior. This can often be seen with good lighting and with suction. Bleeding from visible vessels (commonly septal) can be cauterised with silver nitrate. This should only be performed under direct vision. Cauterisation of both sides of the septum should be avoided to prevent necrosis of the septum. If bleeding is significant or there is inadequate time to investigate, it should be controlled by nasal packing. Multiple nasal packing materials are now available. Many are self-expanding nasal packs that gradually fill the nasal cavity and provide light compression. These should be inserted parallel to the palate. Other nasal packing systems require inflation with air (Fig. 3.25).

Alternatively, the anterior nasal space can be packed using ribbon gauze. This requires long thin forceps such as Tillie's. The gauze is soaked in saline for comfort. Preparations such as adrenaline or tranexamic acid can also help with achieving haemostasis. BIPP (Bismuth iodoform paraffin paste) infused gauze has antibacterial action. Following packing, the pharynx should then be carefully examined. If bleeding is still visible, the source may be from the posterior nasal space. This requires posterior nasal packing (which will require removal of the anterior nasal packs).

Posterior nasal packing can also be achieved using proprietary devices, such as the Rapid-rhino. These are often in the form of 'double balloons', one for the nasopharynx, the other for the nasal cavity. Alternatively, a perhaps more historical technique, is to use two Foley catheters. Each catheter is inserted through the nose parallel to the palate. The tip with balloon should be observed as it passes behind the soft palate into the oropharynx. The balloon can then be inflated and then gently pulled back into the nasopharynx. This can then provide compression of the posterior nasal passage. Care should be taken to inflate the balloon under direct vision only. The catheter should be secured to avoid falling back into the pharynx and the anterior nasal cavity lightly packed (Figs. 3.26, 3.27 and 3.28).

Contrary to popular belief, even in the presence of basal skull fracture posterior nasal packs can still be inserted. The likelihood of intracranial packing is negligible if this is done with due diligence and care. A patient should not be allowed to continue to bleed (and possibly exsanguinate), based on a perceived risk of intracranial complications. It is of course important to pass the catheter or pack parallel to the palate and ensure visual confirmation of its entry into the pharynx. Patients should be reviewed to ensure that the bleeding has stopped. Nasal packs can remain in place for over 24 h and therefore there should be no rush to remove them. Patients will usually require antibiotic prophylaxis.

If all these measures fail the patient may require surgical ligation of the sphenopalatine artery. This is located in the posterior nasal space and is the main source of blood supply to the nasal mucosa. This procedure is performed under general anaesthesia. Nasal packing should be kept in place to temporarily stop or slow down the bleeding. With more widespread injuries, blood may also come from the sinuses rather than the nasal mucosa. This will be secondary to fractures of the sinus walls. Bleeding often presents later, where the blood may be slightly darker and usually resolves spontaneously.

3.3.7.3 Oral Bleeding

Bleeding from the mouth can appear profuse. This is commonly from lacerations of the tongue, lips, inner cheeks or from the sockets of avulsed teeth. Unless the patient has abnormal clotting, this should quickly settle with compression. Bleeding sockets can be addressed by replacing the avulsed teeth (if they are available) or with gauze and local pressure. Sockets can also be packed with surgicel. If the patient is otherwise stable, consideration should be given to suture the sockets and lacerations. Occasionally these measures are inadequate and there may be a need to use whiteheads varnish or bone wax. Only an appropriately trained professional who is familiar with managing bleeding sockets should undertake this (Fig. 3.29).

Fig. 3.26 Nasal packing using a urinary catheter (case 1). (**a**, **b**) Control of epistaxis using a urinary catheter. The hard collar is unfastened and the head supported by an assistant (**c**). The catheter is then passed backwards through one nostril, parallel to the palate and its end grasped and withdrawn out the mouth (**d**). (**e**, **f**) This is then repeated on the other side so the ends of both catheters are visible. (**g**, **h**) The catheters are then inflated with sterile water or saline. (**i**) The water-filled balloons are then gently guided back into the mouth and gently wedged in the nasopharynx. The catheters are then put on gentle traction and the hard collar replaced. (**j**) The nasopharyngeal balloons act as a stop and now enable the nose to be packed without the pack slipping into the pharynx. This technique is really only required in severe or protracted cases of bleeding when other measures have failed. Careful traction is required. If too heavy, the balloons can be pulled out through the nostrils. Also protect the nasal tip from pressure necrosis by the tube. (**k**) The nasal cavity is then packed in a layered arrangement. This is often easier said than done. The nasal cavity should now be almost water tight. If skull base or orbital fractures are suspected, this needs to be packed lightly

Fig. 3.26 (continued)

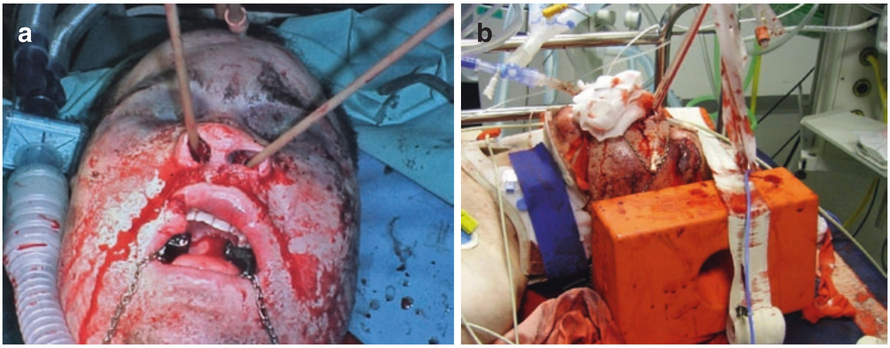

Fig. 3.27 Nasal packing using a urinary catheter. Packs are usually left in situ 24–48 h. Consider the use of antibiotics during this time (risk of toxic shock syndrome and sinusitis). With extensive fractures, bleeding may continue from the mouth. The oral cavity can also be packed (this patient has been intubated). At this stage, consider acquired coagulation defects, if this has not already been considered

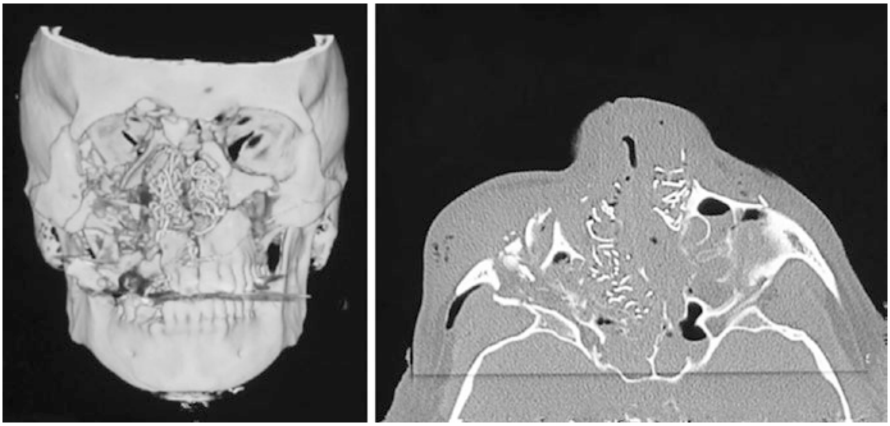

Fig. 3.28 Overpacking of the nose when the surrounding fractures are unsupported can lead to displacement. Be careful

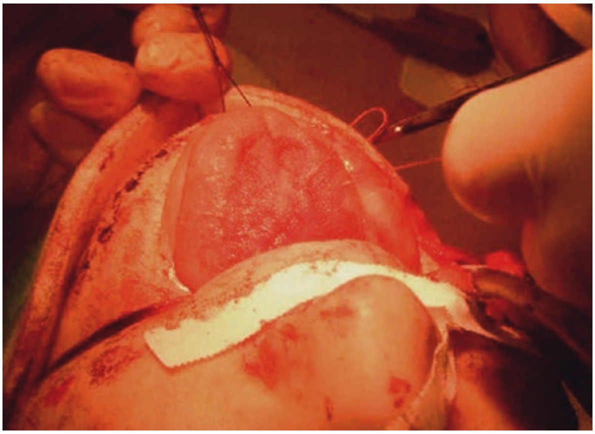

Fig. 3.29 Use of a tongue suture to facilitate intubation. A large deep tongue laceration is also being rapidly closed. Bleeding from it was preventing a clear view of the vocal cords

3.3.8 Urgent Surgical/Radiological Intervention in Bleeding

The measures described above are primary measures that can be undertaken in the emergency room. These should temporarily arrest or slow down bleeding and allow completion of the primary survey and stabilisation of the patient. After this, bleeding may have resolved as a result of the body's own coagulation cascade and localised vasoconstriction. However large, extensive or deep sources of bleeding, or the presence of coagulopathy may prevent this from taking place. Ongoing bleeding in patients with a normal clotting profile, may require surgical intervention to arrest haemorrhage. These patients should be urgently prepared for transfer to the operating room. Surgical intervention will often involve making surgical incisions or access via existing lacerations. This will allow exploration of the damaged tissue to identify and ligate/cauterise bleeding vessels. Similarly, bleeding from comminuted fractures can be arrested by surgical reduction and fixation. Alternatively, supra selective embolisation may be undertaken by an interventional radiologist in certain cases. Bleeding may be recognised following CT angiography. This may be followed by image guided interventional embolisation of feeding vessels to the site of haemorrhage. This can only be performed once the patient has been resuscitated and is reasonably stable (Figs. 3.30, 3.31 and 3.32).

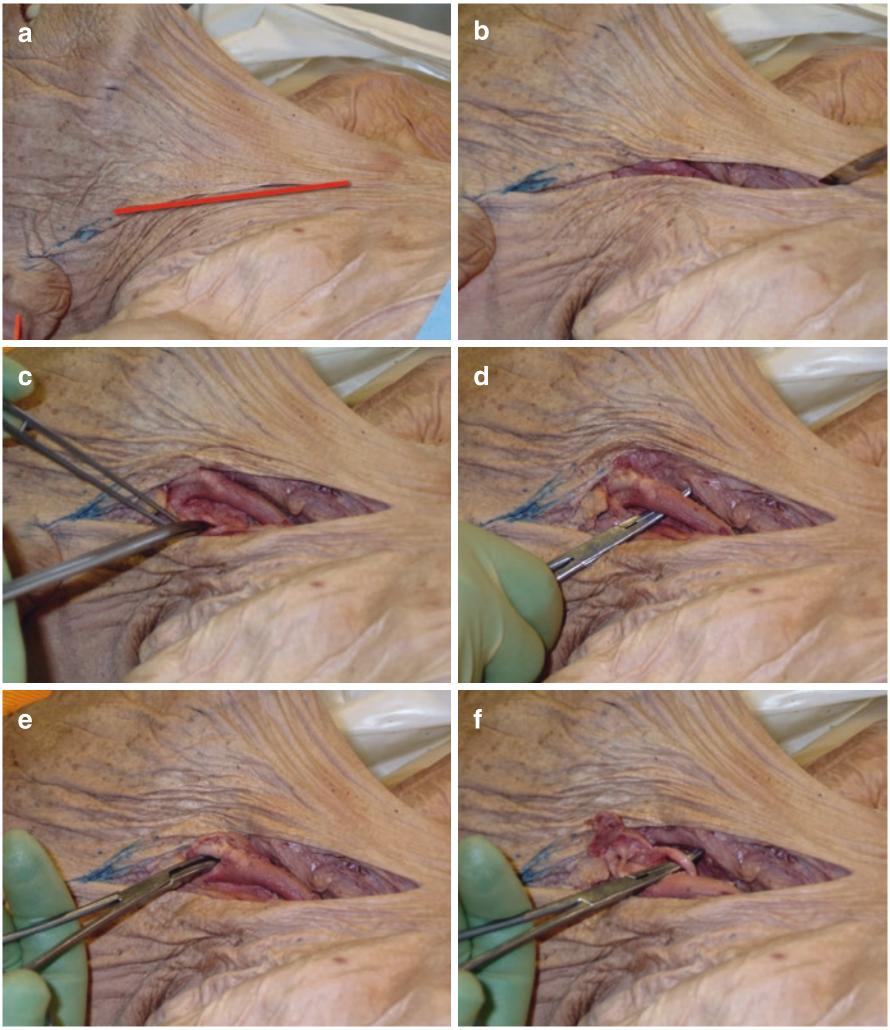

Fig. 3.30 External carotid artery ligation. (**a**, **b**) The skin is incised parallel to the anterior boarder of the sternomastoid muscle. Red line represents the incision. (**c**, **d**) The muscle is retracted and the surrounding tissues quickly (but gently) opened up. The common carotid artery is identified by palpation. (**e**, **f**) Dissection proceeds superiorly along the artery to identify the bifurcation into the internal and external carotid arteries. The external carotid artery is then identified (it gives off further branches—the superior thyroid is usually just above the bifurcation). This needs confident identification; otherwise there is a risk of ligating the internal carotid artery. (**g**, **h**) A tie is then passed around the vessel and secured. (**i**) Ligated vessel. This procedure may need to be repeated on the other side. Remember the head cannot be turned to improve access unless the neck has been cleared. Therefore this is a very difficult procedure

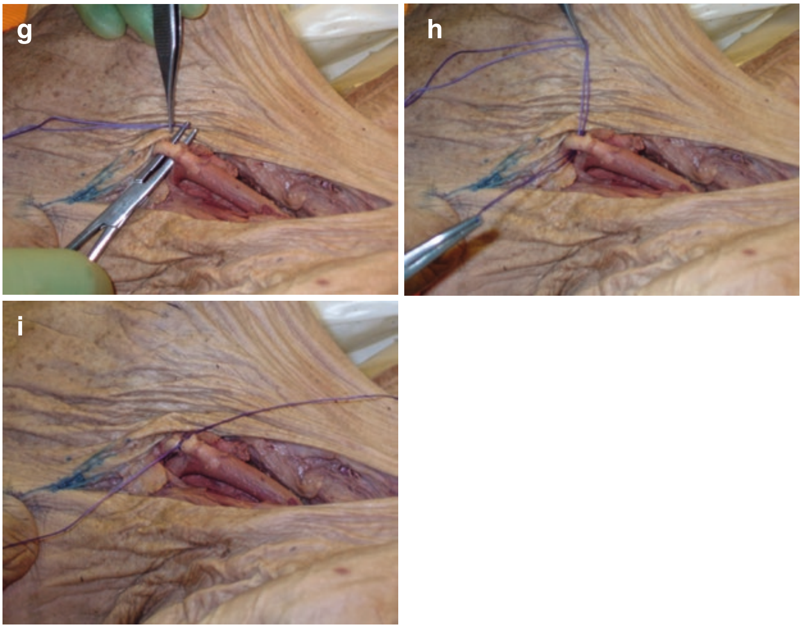

Fig. 3.30 (continued)

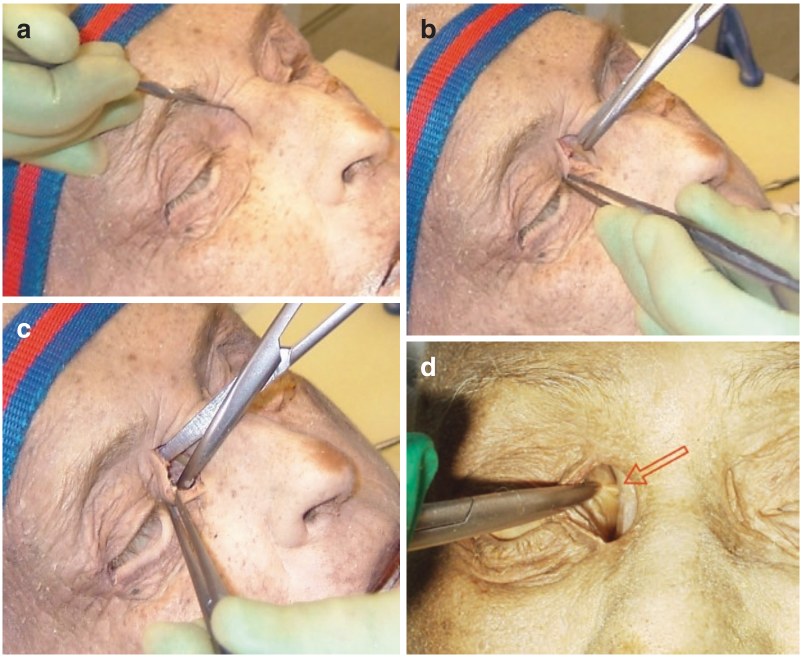

Fig. 3.31 Anterior ethmoidal artery ligation (cadaver dissection). A small curved incision is made just in front of the medial canthus (**a**, **b**). Subperiosteal dissection rapidly finds the vessel. Depending on the extent of exposure and associated injuries, the medial canthus may be disrupted (**c**, **d**)

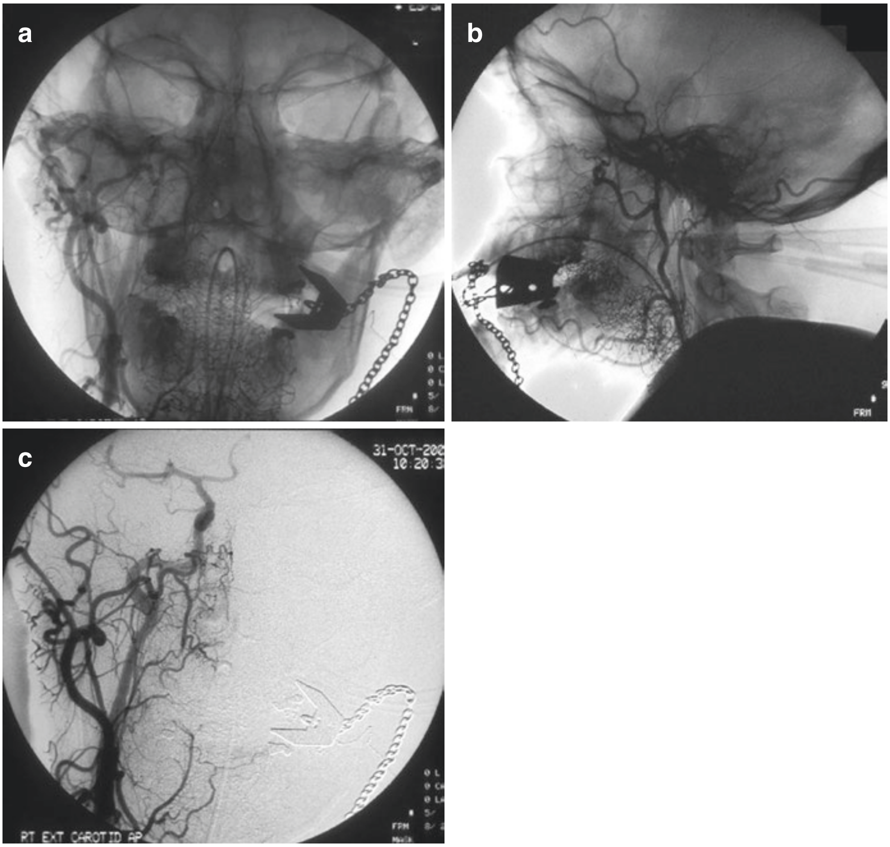

Fig. 3.32 Preliminary angiography prior to embolisation. (**a**) Initial angiogram showing the external carotid artery and some of its branches. (**b**, **c**) Digital subtraction techniques have considerably improved identification

3.3.9 Disability

Head (more precisely brain) injuries are a common cause of morbidity and mortality following trauma. It has been estimated that 3.2 million people are living with long-term disability related to traumatic brain injury (TBI). This is the leading cause of morbidity and mortality between the ages of 1 and 45 years. Teenagers and the elderly are most at risk, although the causes vary demographically. Motor vehicle crashes are a main cause of head injuries in most ages, whilst falls are most common in people aged 65 or older. Head injuries may be classified as primary (occurring at the time of the traumatic episode), or secondary (occurring later, as a result of reduced perfusion, inadequate oxygenation or raised intracranial pressure—ICP). Secondary injuries can develop hours or days after the initial trauma and may be a major factor in prognosis. The two most common causes of secondary injury are intracranial mechanisms (e.g., haematoma and elevated intracranial pressure [ICP]), and systemic mechanisms (e.g., shock and hypoxaemia) (Figs. 3.33 and 3.34).

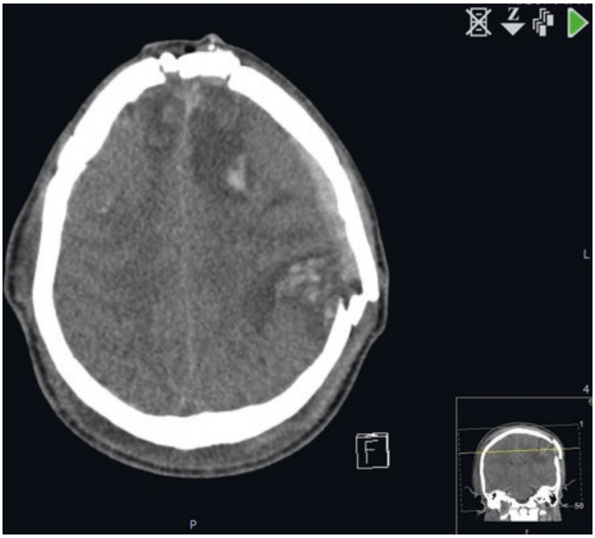

Fig. 3.33 Severe brain trauma following a high energy impact. The CT shows multiple pathophysiological processes. Note how the fractured skull fragment is displaced outwards as result of raised intracranial pressure

Fig. 3.34 Large extradural haematoma, resulting in raised intracranial pressure

Moderate to severe traumatic brain injury can result in prolonged or permanent changes in a patient's state of consciousness, awareness or responsiveness. These may be classified as

A. Coma. The patient is unconscious, unaware of anything and unable to respond to any stimulus. This usually results from widespread damage to all parts of the brain.
B. Vegetative state. The represent widespread damage to the brain. Although the patient is unaware of their surroundings, he or she may be able to open their eyes, make incomprehensible sounds and move.

C. Minimally conscious state. Here, there is a severely altered level of consciousness but with some signs of awareness of self and the environment. This is often a transitional state
D. Brain death. There is no measurable activity in the brain and brainstem. This is irreversible.

Assessment of these levels of neurological function (following initial ABC management) involves the Glasgow Coma Scale (or AVPU) and pupillary responses. AVPU is a more succinct assessment classifying patient responses to Alert, Vocal, Pain and Unresponsive. However this is somewhat crude and gives no indication of cause or prognosis. The GCS is more structured and is discussed further in the chapter on the head. It provides a practical method for assessment of impairment of conscious level in response to defined stimuli. However, it is important to appreciate that the GCS cannot be relied upon until A, B and C have been normalised. Hypoxia, in the absence of a head injury can result in drowsiness, as can hypovolaemia. Nevertheless, the Glasgow coma scale (GCS) is universally used as a quick and simple method to determine the level of consciousness. It is well known to be reliable and predictive of outcomes. Changes in the patients score over time are more significant than individual measurements. A decrease by two or more points, especially if associated with a dilated pupil, indicates a severe brain injury, usually from raised intracranial pressure. This requires immediate management. A GCS of eight or less (from whatever cause) requires the placement of a definite airway. Hypoglycemia, alcohol and drugs can also alter the patient's level of consciousness and should be active considered. Nevertheless, a reduced level consciousness following trauma should always be considered secondary to brain injury unless proven otherwise. Hypoxia (PaO_2 < 60 mm Hg) after head injury also correlates poorly with patient outcome. Patients may therefore need to be rapidly intubated, and ventilated with frequent arterial blood gas measurement and pulse oximetry monitoring. Unfortunately this removes the ability to clinically assess their level of consciousness, mandating CT.

CT scanning is thus now commonly undertaken to assess head injured patients. Patients must therefore be stabilised prior to transfer to the radiology department. Traumatic brain injury (TBI) is commonly accompanied by varying degrees of intracranial bleeding. Around one third of patients with TBI have laboratory evidence of abnormal fibrinogen, fibrin degradation products and antithrombin levels. Bleeding can therefore develop or continue after the initial injury, sometimes whilst the patient is in hospital. Large bleeds and delayed enlargement of intraparenchymal contusions and haematomas can then result in rapid deterioration and death, even in patients who have previously had a lucid interval. In recent years a number of randomised controlled trials have shown that antifibrinolytic agents such as Aprotinin and Tranexamic acid (TXA) are effective in reducing bleeding in elective surgery. The use of these drugs is promising and has now been extended to trauma, including patients with head injuries. Evaluation is still ongoing as use of TXA is not without risk.

It is important to remember that all facial injuries are technically head injuries. However the head injury takes priority over the face in assessment (so long as the airway is protected and there is no active facial bleeding). Patients with head injury should also be considered at risk of a cervical spine injury. If in doubt, the patient should be immobilised. Clearance of the c-spine is discussed in the chapter on the back of the neck.

Penetrating head injuries need careful consideration. These are open injuries in which the dura mater has been breached. These are often caused by high-velocity projectiles, but can also occur from objects such as knives, or depressed bone fragments following fracture. These injuries are at an increased risk of infection and haemorrhage may be harder to control. It is important to be especially careful when assessing penetrating, or wounds overlying a skull fracture, especially those in the midline. Manipulation can result in torrential blood loss if a dural venous sinus is torn. Exploring such wounds in the emergency department is therefore not recommended. Otherwise initial management is the same as closed injuries although antibiotics should also be given.

3.3.10 Exposure, Environment (And the Eye)

To complete the primary survey patients are exposed—"E" in order to look for other injuries which may be hidden, either posteriorly or beneath their clothing. It is during this time that patients are often log rolled. Posterior scalp lacerations may only then be noted. This step in the primary survey is important in all major trauma patients or patients with injuries that do not respond to initial treatments. Clearly it is inappropriate to strip down every patient that attends the emergency department with an injury…but at the same time it is important to remember that not all injuries may obvious. Alleged assaults may involve repeated and varied mechanisms of injuries, including stabbings. Within cities, knife crime is common, but any sharp implement can be used as a weapon. If blood is visible on clothing it is important to carefully examine underneath it (the blood may not be coming only from the obvious epistaxis or scalp laceration). Any clothes that are removed should be kept, even if they have been cut off. They are the patient's property and may also contain important forensic evidence. "E" also stands for environment—without protection or warmth, a naked patient can quickly become hypothermic, especially if they have lost blood. Warm blankets should be provided and if necessary overhead heaters used to prevent hypothermia. The patient's comfort and prevention of heat loss is more important than the clinicians.

3.3.10.1 Vision Threatening Injuries in Trauma

"E" can also be a useful reminder to assess the globe and visual pathway—"E for eyes". Once life-threatening injuries have been managed, the next priorities are to assess and save sight and limb. In all patients who present following trauma to the face and head, the possibility of vision threatening injuries should always be considered. This is especially important following high energy injuries and in those patients rendered unconscious either from their injury, or following urgent general anaesthesia and who therefore cannot report visual problems. This assessment should only occur after A, B, C and D have been managed and stabilised. Nevertheless, when examining the pupils as part of the assessment of "D", this provides a good opportunity to look for any obvious ocular findings. Simple inspection will often identify many of the severe ocular injuries requiring immediate first aid measures, such as gaping lid lacerations, corneal abrasions and burns, traumatic iritis, hyphaema, lens injuries, retrobulbar haemorrhage, penetrating injuries and ruptured globes. Other injuries may be less obvious and require careful examination (vitreous haemorrhage and retinal detachment). Still others may only be diagnosed following investigations (traumatic optic neuropathy). Nevertheless, all of these require early detection, or at least suspicion of presence, so that initial management can be commenced and urgent referral made. A number of reports have shown that it only requires 1.5–2 h of ischaemia is required for irreversible visual loss to occur. This is not a surprise. The optic nerve, like the spinal-cord, is an outgrowth of the brain, rather than a separate cranial nerve (discussed in the chapter on embryology). As such is as susceptible as the brain and spinal cord to ischaemia and other injuring mechanisms (Figs. 3.35 and 3.36).

Ideally, visual acuity and testing for a relative afferent pupillary defect should be performed in all injured eyes if the condition of the patient allows this. These simple assessments are useful because of their prognostic significance. If a patient requires a brain CT and also has suspected periorbital or ocular pathway injuries, the orbits should also undergo imaging at the same time. Foreign bodies, globe rupture, intraocular bleeding, dislocated lens, retrobulbar blood and injuries to the optic nerve can all be identified on CT and this will also avoid (unnecessary) additional transfers later for scanning. Intraocular foreign bodies may also preclude the use of the MRI scan later.

Following trauma both to and around the globe the visual pathway can be severely damaged anywhere from the globe to cortex. Common and potentially treatable causes include

Fig. 3.35 Upper eyelids are more important than lower eyelids in terms of globe protection. Nevertheless, injuries like this can result in drying of the eye and ulceration, especially if the patient is unconscious

Fig. 3.36 Essential tools for simple eye examination

A. Direct injury to the globe (Global rupture, penetrating and perforating globe injuries)—These require urgent ophthalmic referral. All foreign bodies should be left where they are and the globe protected. If globe rupture is suspected or confirmed, an eye shield should be immediately placed and further direct examination should be avoided to avoid putting pressure on the eye.
B. Retrobulbar haemorrhage/Orbital compartment syndrome—This is an ophthalmic emergency. Bleeding and swelling results in a compartment syndrome phenomenon which can lead to compression and ischaemia of the optic nerve, obstruct its venous drainage and result in central retinal arterial occlusion. Diagnosis is clinical and is made when there is severe pain, proptosis and loss of vision. If this is left untreated it can result in irreversible ischaemia of the retina and optic nerve. Initial treatment requires immediate relief of pressure with lateral canthotomy/cantholysis, followed if necessary by surgical decompression. To avoid permanent damage, it has been shown that intervention must be carried out within 2 h of onset.

Fig. 3.37 This patient was struck on the nose by a "rubber bullet," resulting in a localised high-energy impact. The left globe was injured and could only perceive light

C. Optic nerve compression/traumatic optic neuropathy—This occurs when compression or shearing forces are applied to the optic nerve. With direct injury, anatomical disruption of the optic nerve fibres occurs as a result of penetrating orbital trauma, boney impingement within the optic canal, or nerve sheath haematoma. Indirect damage to the nerve results from shearing forces to the intracanalicular portion of the nerve, which results in axonal injury and disruption of the blood supply. Swelling in the optic canal further increases luminal pressure and secondary ischaemic occurs. This is the most common form of traumatic optic neuropathy, occurring in 0.5–5% of all blunt head trauma cases. Although the degree of visual loss may be variable, approximately 50% of patients are left with "light perception" or "no light perception" vision, making traumatic optic neuropathy a significant cause of permanent visual loss. Treatment may be medical or surgical. At present, there is no proven form of treatment for this condition and there is controversy over its optimal management.

D. Loss of eyelids/incompetent eyelids—Inability to close the eyelids can result in drying out of the cornea, ulceration, infection and scarring. Thus, loss of the eyelids, or more commonly, gaping wounds in the lids can result in blindness. In the first instance the globe must be protected, simply by realigning the gaping wounds, or placing plenty of ophthalmic lubrication. Immediate repair of the lids is not essential. Patients can survive without a lower eyelid. But they cannot survive without an upper eyelid (Fig. 3.37).

These injuries are discussed in greater detail in the chapters on the Eye, Cheek and Orbit.

3.3.11 Reassessment and the "Secondary Survey"

In some patients the full extent of some injuries may not be obvious during the initial assessment. Haemorrhage, swelling, and some injuries may take time to manifest. Patients should therefore be continually reassessed during the early stages of their initial management. Until all injuries had been identified and managed the patient is at risk of sudden deterioration from out on recognised problem. These may be physiological (such as an enlarging pneumothorax), or mechanical (such as dislodgement of an endotracheal tube, chest drain or IV access). All procedures that have been done should therefore be reassessed. If at any point during the initial survey (or later) the patient deteriorates, then they should be reassessed, following the same steps as the primary survey. Only when the patient is stabilised can a more thorough secondary survey examination be undertaken. This is a complete "head to toe" assessment of the patient. It includes taking a more complete history and detailed clinical examination, along with ongoing reassessment of the patients vital signs, laboratory test results and any other investigations. It is usually during this time that detailed attention to any facial and ocular injuries is made.

Although this book focuses on diseases and injuries in adults, it is probably worth noting here that the general management of children following trauma requires special attention. This is the case whether there are or are not facial injuries. Key points to note are

A. Children are more prone to hypothermia due to their larger body surface area-to-weight (volume) ratio, compared to adults.
B. Children may initially maintain a normal or near normal blood pressure, even though they may have lost significant blood. If untreated this will eventually result in sudden decompensation and a rapid drop in blood pressure.
C. Infants are obligate nasal breathers. Their nasal passages are relatively narrow and can be easily obstructed.
D. Bones are more elastic in children. They often deform without breaking. The chest wall in a children is more pliable than an adult. Major thoracic injuries may therefore occur in the absence of rib fractures.
E. Children frequently swallow air when they are injured or frightened. This can result in gastric dilatation and diagnostic confusion when evaluating for abdominal injuries.
F. Significant intra-abdominal bleeding results in a rapid change in girth.
G. Children are often more difficult to examine both clinically and radiologically.
H. Facial fractures are less common in children under 5 years of age. It has been suggested that this is because young children are lighter in weight and therefore fall less heavily, with a lower likelihood of fracture (Figs. 3.38 and 3.39).

3.3.12 Facial Injuries: Triage and an Overview of Treatment

Facial trauma varies widely in its severity, from relatively trivial injuries, to those associated with both life and/or sight-threatening complications. Due to its varied aetiology it is also frequently associated with intracranial, cervical spine and ocular injuries, as well as significant injuries below the collarbones. This can make overall prioritisation of injuries difficult in many patients. For the non-specialist,

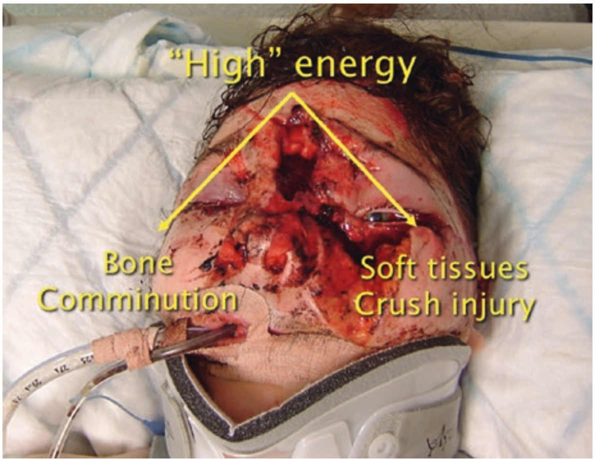

Fig. 3.38 High energy injuries to the face can result in significant comminution and extensive soft tissue injuries. As with orthopaedics, these injuries are extremely difficult to treat

Fig. 3.39 Following initial repair, this patient developed unusual complications—reactivation of HSV (secreted in saliva)

assessment of facial trauma can be a rather worrying area of clinical practice, which is not made easier by their often dramatic appearances. Yet relatively few patients actually require immediate interventions or immediate complex surgery and can safely be left, so long as a few key features are addressed. Effective triage is important to ensure this.

For the inexperienced clinician, a helpful mindset is the application of orthopaedic principles to facial injuries—"facial orthopaedics". This is on the premise that many of the principles used in the management of facial trauma are shared with our orthopaedic colleagues (for example, ATLS assessment, fracture evaluation, our understanding of fracture healing process and how to use it to the patient's benefit, the importance of the soft tissue envelope and the principles of internal fixation). At the same time we often encounter the same problems as our orthopaedic colleagues (notably Infection, neurovascular injuries and compartment syndromes). There are of course a few notable differences—the term "soft tissues" when applied to facial trauma also includes highly specialised tissues such as the brain and eyes. Furthermore, the significantly greater blood supply to the entire head and neck region often results in less risks of infection, despite significant contamination. Finally, by virtue of their high visibility, repair of facial injuries also mandates a very high level of surgical precision, typically in the region of 1–2 mm, or less.

When initially confronted with facial trauma it is important to be aware that these injuries can be deceptive, distracting and sometimes difficult to manage.

A. Deceptive—Even seemingly minor injuries can evolve, or go unrecognised unless they are specifically looked for. This is especially the case in the supine and possibly restrained patient. Nasal bleeding and CSF leaks may not be apparent in conscious patients, since they may be swallowing the fluids. A clue to this is repeated requests by the patient to sit up. This can often indicate their awareness of an impending threat to the airway. Progressive swelling may interfere with clinical examination of the eyes. In severe injuries swelling can quickly place the airway at risk. Patients on anticoagulant medication are also at particular risk. Blindness can occur in absence of fractures. Surgical emphysema can extend into the mediastinum. This can contain commensal organisms from the nasal cavity or sinuses, placing the patient at risk of infection. Infection within emphysema (notably orbital) is the reason why patients with midface fractures should be advised not to blow their nose. All these problems can arise following apparently trivial injuries to the head and neck and therefore may not be immediately evident when the patient arrives in the emergency department. Partially avulsed and highly mobile teeth not only pose a threat to the airway in supine patients, but can result in claims of medical negligence later, in our increasingly litigious society. The intubated and drowsy patient poses further diagnostic difficulties, (notably the ability to confidently exclude spinal injuries, raised intracranial pressure and treatable causes of blindness).
B. Distracting—Significant open injuries, whilst clearly concerning, can often be left in the early stages of assessment—providing the airway is secure and there is no ongoing bleeding. Whilst these injuries are clinically urgent, they can nevertheless be deferred for at least a few hours, if not longer, permitting comprehensive assessment of all the patient's injuries
C. Difficult—In the early stages of assessment, facial injuries can pose difficult management decisions. For example, what is the best way to manage an awake supine patient (with a Glasgow coma scale 15) with significant facial injuries placing the airway at risk, who repeatedly wants to sit up, but who, based on the mechanism of injury, is at risk of spinal or pelvic injuries? Endotracheal intuba-

tion would secure the airway, but at the cost of loss of contact with the patient and the ability to regularly reassess them clinically. Observing and maintaining the airway facilitates repeated clinical assessment, but can be difficult and places the patient at risk from unexpected and sudden vomiting. Sitting the patient up will help protect the airway and enable clinical reassessment, but places the spine at risk and axially loads the torso.

Unexpected vomiting is also an ever present risk in many patients, but especially so in those with facial injuries. Swallowed blood is a potent stimulus to vomiting. But does this mean the airway should be secured in all patients requiring transfers, just in case they vomit? And if done, when should they be extubated? These considerations would need to include patients with relatively minor facial injuries as well as those with the more obvious ones. Effective haemorrhage control in facial bleeding may also require intubation at an early stage. Management of the intubated patient with progressive proptosis of the globe, requiring life-saving surgery is also a difficult problem. Surgical decompression of the orbit in the absence of a precise diagnosis carries risk (is the proptosis secondary to blood, bone, air, oedema or frontal lobe herniation? Are there any mobile bone fragments or foreign bodies around the orbital apex or globe, which may be disturbed?) However, any delay waiting for a CT scan of the orbit will certainly reduce the prognosis for visual recovery.

3.3.12.1 Triaging Facial Injuries: A Simple Approach

The importance of the triage process in facial trauma is self evident—those injuries that require immediate attention are most often life and sight-threatening and usually require specialist input at a very early stage. All other injuries, even if dramatic in appearance can safely be left (at least a short while) until the entire patient has been assessed. These may require a few basic ‘first aid’ procedures which any member of the trauma team should be able to undertake (such as dressings, temporary would closure and globe protection). So long as the airway is secure, the face is not actively bleeding and the globes are protected the management of facial injuries can otherwise wait. Comprehensive (and sometimes lengthy) repair of complex facial fractures is rarely required within the first 24 h of injury. In some cases, advantage of the situation may be taken (for example following urgent craniotomy when access to the fractures has become available), but the surgeon must then weigh up the pros and cons of the additional operating time in a potentially unwell patient, possibly with an ‘uncleared’ neck. There are also consent issues to be considered, especially when operating around the orbit. From a practical point of view, maxillofacial injuries can be broadly placed into one of four groups, based on the urgency of treatment required.

A. Immediate treatment: In this group interventions are either resuscitative or emergent (life or sight preserving) but they are usually not definitive. Procedures include surgical airways, control of significant haemorrhage and lateral canthotomy and cantholysis. These injuries usually present (although not always) following high energy transfer or penetrating injuries with vascular disruption. High energy impacts will almost always result in comminution and significant swelling and (as with facial burns) loss of the airway should be anticipated early. Except for the parotid gland and buccopharngeal fascia (covering the buccinator muscle) there is no deep fascia on the face, which is why swelling can be so extensive. Definitive repair of these injuries is usually carried out on a 'planned urgent' basis when the swelling has resolved (typically 5–10 days), or sooner if there are significantly open wounds.

B. Treatment within a few hours: In this group interventions are aimed at preventing infection and protecting the globe. These form the 'Clinically urgent' group and include heavily contaminated wounds and some open fractures. Once the patient has been stabilised, wounds are carefully debrided and cleaned. Depending on the condition of the patient and the extent of their facial injury, either comprehensive repair of the injury is then undertaken, or it is deferred pending further investigations or planning. Perforations or penetrating injuries of the globe may also require early repair.

C. Treatment can wait 24 h. This (and the last group) make up the majority of facial injuries. Examples include clean lacerations and fractures of the jaws. In this group treatment can be safely deferred if necessary until the next day with no significant risk to the patient or poor outcomes. Temporising measures may be required if wounds are gaping (i.e. dressings) or mandibular fractures are very displaced or mobile ('bridal wiring'—the maxillofacial equivalent to a 'backslab').

D. Treatment can wait over 24 h. In this last group treatment can be safely deferred for several days, or weeks if necessary. Examples include nasal, orbital and zygomatic fractures, as well as some fractures of the frontal sinus. Deferment may be required to allow the swelling to settle, enable model making, undertake further evaluation (such as assessment of the globe and extra ocular muscles) and to obtain detailed imaging.

Put another way, interventions for facial injuries are required within (1) Minutes, (2) Hours, (3) Days, or (4) Weeks. Deciding which category an injured face falls into typically relies on four main elements.

The mechanism of injury and known injury patterns

- Initial assessment—ABCs (See Damage control)
- Applied anatomy—"Buttresses" and awareness of 'at risk' structures
- Experience

Apart from the last, these elements have been previously discussed and are considered further throughout this book. It is important to remember different specialty injuries can coexist in craniofacial trauma. Always think

- Could there be a neck (C Spine) injury?
- Could there be a head (Brain) injury?

- Could there be an ocular injury?
- Could there be a facial injury?

For suspected neck/brain/ocular injuries follow local protocols. If you are uncertain ask your senior for advice. Most facial injuries do not require immediate management and can wait while other injuries are being assessed. Many facial injuries look worse than they actually are. Be careful with supine immobilised patients with facial injuries. They could be bleeding and swallowing the blood (so may suddenly vomit).

Facial fractures should be temporarily stabilised whenever possible. Separation of fractures and movement between them is not only painful, but can result in continued bleeding and swelling. Temporising methods include mouth props, wires, splints, intermaxillary fixation (IMF) or occasionally plating techniques (if fracture sites are exposed). The aim of all these treatments is to rapidly reduce and stabilise the fractures. Reduction at this stage does not need to be anatomical, it just needs to be sufficient enough to arrest haemorrhage. External fixation is also very effective in providing rapid "first aid" stabilisation in the multiply injured patient, or prior to transfer. However this can be difficult to apply to mobile bone fragments and is perhaps best done once the patient has been stabilised. With gunshot wounds or other types of contamination, this method also provides good "medium-term" temporary fixation. The optimal time to definitively repair facial fractures is still not known, although it has been suggested that better outcomes may be possible with earlier or immediate repair. This ideal has to be balanced against the patient's overall condition. Unfortunately, when facial injuries and injuries below the collar bones occur in the same patient, what we would ideally like to do, as maxillofacial surgeons, may be compromised by injuries elsewhere, and we may have no choice but to modify our treatment plan. Occasionally, the development of life-threatening complications (e.g. sepsis, multi-organ failure) may preclude repair of facial injuries altogether. Even potential injuries can alter our management until they are ruled out ('can I turn the head?'). In the multiply injured patient with major facial injuries we can therefore either carry out damage control, with a view to a planned delayed repair, or we can go straight to immediate definitive repair which from the literature would suggest better outcomes. However applying this philosophy in multiply injured patients could result in potentially very sick patients, or perhaps those with as yet unrecognised but serious injuries undergoing complex and lengthy surgery at a time when arguably they would do better in intensive care. Tracheostomy may be required, depending on the degree of anticipated swelling. This allows the patient to be woken up for further assessment, with a secure airway.

3.4 The 'Walking Wounded'

Minor injuries to the head, neck and face are very common in the UK. Around 80% of these occur in children. In most emergency departments, these patients generally attend as "walking wounded", that is, with isolated or multiple (but not life threatening) injuries. Common causes include assaults, falls and sporting injuries. Such patients should still undergo a primary survey, although this will not take long if the patient is well. Once this has been carried out, attention can then be focused on the specific injuries. Examination of the head, face, eyes and neck should be undertaken in a systematic fashion. Overall inspection may reveal asymmetry, contusions, swelling, or haemorrhage. However, asymmetry may be hidden from facial swelling. Good exposure is important and any blood and debris must be cleared away. Palpation of the entire face will often identify any steps or instability in the underlying skeleton. A top-down approach makes examination more efficient and focused. Whilst some injuries may be obvious, these should not distract from less obvious but equally significant problems. Soft tissue injuries should be noted, and assessed taking into account the local anatomy (for example, a deep cheek laceration and the facial nerve). The scalp and face should be inspected for abrasions, lacerations, ecchymosis, and palpated for tenderness and step deformities. Intraoral inspection should assess the occlusion (bite) and look for loose/missing teeth and mucosal lacerations/ecchymoses. Assessment should also include a careful examination of the cranial nerves. More details of these anatomical regions can be found in the relevant chapters in this book. Documentation is important. Many of these injuries are the result of an alleged assault. A police medical report may therefore be required at a later date. Clear and accurate documentation of the initial clinical findings in the notes is thus very important.

3.4.1 "Soft tissue" Injuries

Injuries of the soft tissues in and around the head and neck may occur from road traffic accidents, industrial injuries, domestic and interpersonal violence, dog bites, human bites and conflict. In this book, the term "soft tissue" refers to all non-bony structures, including the skin, fat, muscle, glands, nerves and vessels. Surgeons often refer to this as the "soft tissue envelope" when talking about fractures. This is a very important functional layer. Triage of patients is often dictated by the extent of soft tissue injury (bleeding/swelling) and the success of fracture management is highly dependent on maintaining a good blood supply, most of which comes from the surrounding soft tissues. Crush and blast-type injuries can therefore have a major impact on prognosis, even if the soft tissues initially appear to be relatively uninjured. Any injury to the microcirculation will adversely affect tissue perfusion. Management must therefore be planned carefully. Excessive stripping of the soft tissues to exposure a fracture will also impair its vasculature. Not surprisingly smoking, diabetes, chronic ill health and malnutrition can also have a negative impact on healing.

Physiologically the skin has many functions, some of which include protection of deeper structures from ingress of microorganisms. Following trauma any breach in the epidermis can result in contamination and the potential for infection. Fortunately the very rich blood supply of the head and neck helps defend this site against infection and promote healing. Despite diverse and high bacterial counts within the nose and mouth, infected wounds within these sites are surprisingly uncommon. Saliva and exudates from around the gingiva contain antibodies and various growth factors, which facilitate rapid wound healing and prevent infection. Skin however does not have these protective mechanisms and infection may arise from external sources and commensal organisms. This is more likely to occur can in devitalised tissues. Penetrating injuries also need particular attention. Bacteria can be driven deep into hypoxic, crushed tissues which are then difficult to treat.

Breaches of the skin can be classified as lacerations, abrasions or burns. Lacerations are incised or penetrating injuries that pass into the dermis or the deeper structures. Abrasions involve partial loss of the superficial skin, but not the full thickness of the dermis. Burn injuries are classified by type of injury. Any wound that breaches the dermis will result in a permanent scar. Patients need to be advised of this. No other part of the body is as conspicuous or aesthetically significant as the face. The final amount of scarring and cosmetic deformity depends on a number of factors (such as the type of trauma, the patient's age, their general health and the management of the wound itself, including aftercare). The final cosmetic outcome is therefore partly outside our control. However, outcomes can be influenced by good surgical technique and gentle handling of the tissues. Thorough wound toilet, careful debridement and meticulous tissue handling are all necessary to achieve the best possible aesthetic and functional outcomes. Even if the skin is intact following an impact, subsequent neglect or mismanagement can still result in significant deformity or disability. This can occur following the development of a large subcutaneous haematoma. These may require surgical drainage. If neglected, they can become fibrosed and even ossified (myositis ossificans), although this is rare.

3.4.2 Assessment and Classification of Soft Tissue Injuries

Although patients with soft tissue injuries often present with extremely disfigured appearances, these are seldom life threatening. However because the face is extremely vascular, even minor injuries may result in profuse bleeding. With scalp laceration is for example, due to its rich vascularity, the amount of bleeding that has occurred may not be proportionate to the size the injury. In children, this can result in significant blood loss. Assessment of facial lacerations therefore takes time and needs to be undertaken with care. Copious irrigation should be used to clean and accurately assess the injury. The facial soft tissues has an abundant sensory input compared to much of the body. Many important sensory nerves exit at multiple locations on to face. Together with the fine motor nerves supplying the 'muscles of facial expression' this makes their repair difficult. Assessment must therefore take into account not only the wound but also the underlying skeletal and specialised tissues. In view of the fact that many of these wounds (notably facial) will be highly visible, it is important not to cut corners and risk a suboptimal cosmetic result. Revision of facial scars can be extremely difficult. Before exploring a wound it is important to consider the possibility of deeper injuries (fractures, nerves, specialised tissues etc.) which may require specialist referral. Consider also the likelihood

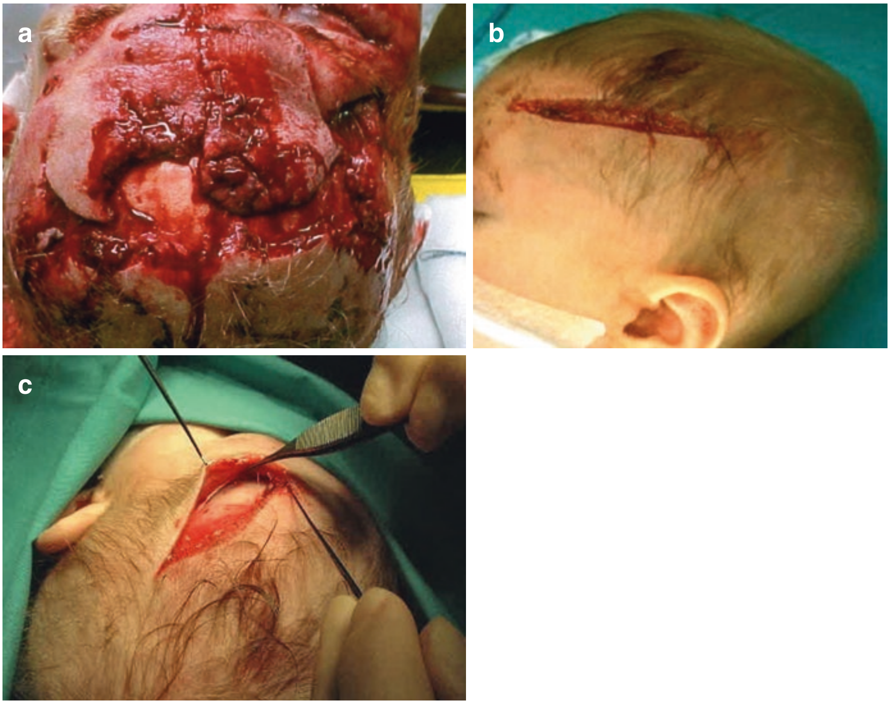

Fig. 3.40 Bleeding from the scalp can quickly result in haemorrhagic shock, especially in children

of further bleeding and have the appropriate equipment to hand. Be especially careful with scalp and neck wounds and wounds around the eyelids (Fig. 3.40).

Note the location, size, shape, and depth of the wound and consider the need for exploration of the wound for foreign bodies. Palpate for areas of crepitus or bony discontinuity. Gross asymmetry may signify underlying nerve damage. Assess neurologic function by evaluating sensory and motor function. A good working knowledge of anatomy is essential (e.g. parotid duct/facial nerve/eyelid and canthal anatomy). Children can be difficult to manage and may require sedation or general anaesthesia, depending on local policy. They also tend to heal with exaggerated scarring. When necessary involve appropriate specialists (often Maxillofacial/Plastics/ENT/Ophthalmology) at an early stage and according to local referral policy. Consider this with anything more complex than a superficial wound (abrasions). Remember, patients have to live with the results of your handiwork and poor scars may result in litigation if they feel they have not been managed well. Eyelid lacerations associated with facial trauma should not be underestimated and the eye should be evaluated thoroughly. This includes examination of the inner aspect of the lid to ensure that it is not a through and through laceration.

The following checklist may be helpful in the assessment of soft tissue injuries

A. Control haemorrhage: apply pressure with a clean pad of gauze, but avoid heavy pressure if fractures are present.
B. Consider the mechanism of injury. Incised tissues are easier to clean and repair than crushed tissues. High blunt force impacts will not only crush tissues but will probably result in underlying fractures. Burns can initially appear innocuous. Bites and agricultural injuries are at high risk of infection.
C. Consider injuries to the underlying structures, (fractures/large vessels/motor and sensory nerves/dentition/bones/globe/lacrimal gland and ducts/eyelid levators/canthus/parotid duct). If injury to any of these are suspected imaging and urgent referral may be necessary. Prior to transfer wounds should be cleaned and gently apposed with tacking sutures or an adhesive dressing (Figs. 3.41, 3.42, 3.43 and 3.44).

A. If ptosis is present, injury to the levator aponeurosis should be suspected.
B. With any injury involving the side of the cheek, massage and milk the parotid gland, and look in the mouth for saliva flowing from the parotid duct. If saliva is leaking from the wound itself, assume a duct injury is present.
C. Is there tissue loss, or is it just displaced? Rarely is there significant loss of tissue. This usually following bites, avulsion injuries (e.g. scalp avulsion following hair trapped in machinery), blast or ballistic injuries. More commonly, the tissues are present, but unsupported and just gaping, creating the appearance of missing tissue. These wounds require careful layered closure. Simply suturing the skin will result in sagging of the deeper tissues and an unsightly depression or distortion (Figs. 3.45 and 3.46).

Fig. 3.41 Forehead haematoma in patient taking anticoagulants

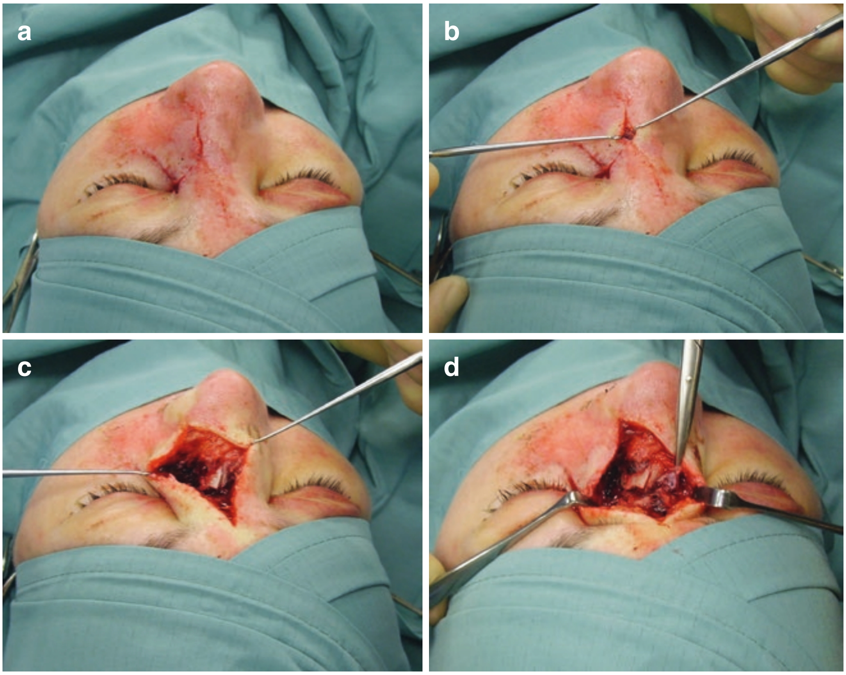

Fig. 3.42 A deceptive laceration, revealing underlying fractures

Fig. 3.43 Complex nasal tip laceration

Fig. 3.44 Deep laceration from knife assault, resulting in nerve injury and fracture

Fig. 3.45 Blast injury to the face: certain injuries may be so extensive that neither laryngoscopy nor traditional surgical air-ways are feasible. In the case, minor exploration revealed adequate visualization of the vocal cords leading to intubation

Fig. 3.46 (**a**) Clinical picture of a high-energy penetrating injury. Notice the avulsive injury producing a composite defect characterized by loss of both soft and hard tissue. (**b**) CT demonstrating the hard tissue damage caused by high-velocity penetrating injury. (**c**) Clinical picture of the same patient after treatment which includes restoring facial form. (**d**) CT scan demonstrating reduction and fixation of facial fractures with restoration of facial form

A. If tissue is twisted, this must be realigned and supported as soon as possible. If not, the flap may become congested and thrombosed. Failure to remember this can make the difference between an ischaemic, but recoverable area of tissue and an infarcted one, requiring reconstruction. Tissue that is attached by even a small pedicle can do surprisingly well if realigned early. This is due to the excellent blood supply to the head and neck. Anecdotally a small GTN patch on the flap may help salvage it if congested. Rarely leeches have been reported.

B. Consider if imaging is required. In addition to fractures, foreign bodies may need to be located. This often requires imaging. Plain films usually suffice, but computed tomography (CT) may be indicated to identify deeper foreign bodies and to locate them precisely. Alternatively, in experienced hands ultrasound may be used. This has the advantage of being available in theatre, but is technically demanding. If metallic foreign bodies are suspected, magnetic resonance imaging (MRI) is contraindicated. MRI is more useful in identifying non-metallic foreign bodies such as plastic, but even so, some materials may still be very difficult to see (notably vegetation, such as leaves, etc.). Do not forget to enquire if any teeth have been lost—a chest and neck X-ray may be necessary.

C. How bad will the scarring be? Although this can never be predicted with certainty, there are a few indicators of poor outcomes. These include delayed presentation/wound orientation/contamination/tissue loss/crush injury/underlying fractures and patients with chronic medical conditions. Patients in these categories may need to be referred to the appropriate specialists at an early stage (Fig. 3.47).

A. Consider if the wound can be managed thoroughly under local anaesthetic in the emergency department/clinic or if general anaesthetic would be better. Extensive wounds make take considerable time to close. Children may be uncooperative (Fig. 3.48).

A. Consider the need for tetanus prophylaxis and antibiotic treatment. Clean, superficial wounds may not require these (Figs. 3.49 and 3.50).

Wounds are generally classified according to their condition and manner in which the skin or tissue is broken or the agent that caused it. These include

Fig. 3.47 Significant delay in repair of this laceration will now result in greater likelihood of poor scarring

Fig. 3.48 Extensive scalp laceration following agricultural injury—in addition to debris, there was an underlying skull fracture. Careful debridement and two layer closure was undertaken

Fig. 3.48 (continued)

A. Contusion. This is a bruising injury caused by blunt trauma. It may or may not be associated with a haematoma. Consider the possibility of underlying fractures. In most cases no specific treatment is required. The haematoma slowly resorbs. However, occasionally haematomas may need evacuation if large or in critical sites (such as the pinna, or upper eyelid). Unevacuated haematoma can sometimes lead to permanent deformity, as seen in cauliflower ear and myositis ossificans.

Fig. 3.49 Air rifle wound

B. Abrasions. These are partial-thickness disruptions of the epidermis, usually following tangential friction. They commonly contain grit, gravel and other foreign material and therefore require meticulous cleaning. If this is not removed tattooing can occur.
C. Puncture wounds. These arise following a piercing type mechanism, which includes animal bites. Similar to abrasions they may contain foreign bodies such as pencil tips, paint, rust particles and splinters. Depending on the mechanism and the extent of contamination these wounds may also have a degree of crush injury and may be at high risk of infection, including tetanus. Puncture wounds around the parotid and pre auricular region have been reported to result in salivary and arterio–venous fistula formation.
D. Lacerations. These are torn and often ragged wound that result from contact with a sharp instrument. They are often deep and involve multiple tissue layers. They can take various forms and orientations, making repair technically difficult. Depending on the mechanism of injury these may also be associated with crushed tissues and risks of infection. With very irregular wound ages, the tissues may become friable and necrotic, increasing the risks of infection and unsightly scarring.
E. Avulsion defects. This occurs when there has been forcible tearing or separation of a structure, notably the ears, nose and scalp. Eyelid avulsion has also been reported. Not surprisingly, these can result in significant blood loss, major defects and are a major reconstructive challenge.

Fig. 3.50 Multiple foreign bodies

Classification of facial bite injuries

- Type I Superficial injury without muscle involvement
- Type IIA Deep injury with muscle involvement
- Type IIB Full-thickness injury of the cheek or lip with oral mucosal involvement (through and through wound)
- Type IIIA Deep injury with tissue defect (complete avulsion)
- Type IIIB Deep avulsive injury exposing nasal or auricular cartilage
- Type IVA Deep injury with severed facial nerve and/or parotid duct
- Type IVB Deep injury with concomitant bone fracture

3.4.2.1 Management of Soft Tissue Injuries

Extensive soft tissue injuries and uncooperative children usually require repair under general anaesthesia. Details of management will vary depending upon the site, type and extent of injury. In general terms, main aim of treatment is to reduce the risk of infection and restore function and aesthetics. Early closure of a defect, even if temporary, seals off access to infecting organisms, encourages earlier healing and minimises scar contraction. An open raw wound will quickly begin to granulate, becoming friable and difficult to repair. It is very easy to become distracted about how to get a good result and this indecision can lead to delay in providing basic wound care. Therefore, refer complex cases early. Clean wounds should ideally be closed as soon as possible (within 12 h, if not sooner). If a delay is likely to occur, gently clean the wound and loosely close it, or alternatively apply an appropriate dressing. Never allow a wound to become dry or ischaemic. Delayed primary closure may be necessary in large and cosmetically unimportant regions that are not suitable for primary repair. The may be necessary in wounds that are grossly contaminated and in puncture or bite wounds. All patients should be warned about the risk of scarring. Once the dermis is breached this is inevitable. Whilst there is ongoing research into 'scarless' wound closure, currently this is not possible. Healing can be unpredictable and whilst an initial good result may be encouraging, this is no guarantee of a final aesthetic result.

Suturing of the wound should be performed in layers, not just the skin. Most injuries can be repaired under local anaesthesia [lidocaine 1 or 2% with epinephrine (1:80,000)]—the same local anaesthetic solution used by dentists ('dental local'). The vasoconstrictive effects of adrenaline is very helpful in providing haemostasis and prolonging the effect of anaesthesia. However following placement of the local anaesthetic requires patience, it takes around 5–10 min for the vasoconstrictive effects to occur. Contrary to popular belief this solution can be used on the nose and ears. The concentration of adrenaline is insufficient to result in tissue necrosis.

Initially the deeper tissues are aligned to support the weight of the tissue and eliminate any "dead space". Closing the skin only, leaving this potential space can predispose to fluid collection, infection, abscess formation and ultimately result in poor healing. When closing the skin the aim is to produce a neatly opposed and slightly everted edge. This small amount of eversion is said to compensate for depression of the scar during wound contraction. Various methods may be used for repair. For meticulous repair suturing is necessary. Wound staples, provide rapid placement but do not allow a precise repair. Tissue adhesives such as 2-octylcyanoacrylate, are less painful and can be applied quickly. This is suitable for small lacerations that are not subject to large degrees of tension. Similarly, tissue tapes may be used for superficial or partial-thickness lacerations but are not suitable for lacerations under tension. Nevertheless, adhesive tapes and glues are especially useful in children and patients who will not cooperate. Care is required in both patient and wound selection. Only superficial and hairless wounds and those that are not under tension (such as lower border of the mandible or under the chin), should be closed by these techniques. The final cosmetic results are less predictable with these techniques compared to carefully placed sutures, as the unsupported deep tissues may still gape. Glues also act to seal the wound and protect it from ingress of contaminants. Minor tension across the wound can be held by steri-strips. Although simpler, gluing can still be quite difficult—take care not to allow glue to enter the patient's eyes, ears or mouth and be careful not to glue your glove to the patient.

Wounds in the head and neck area take 5–7 days to heal. The patient should be instructed to keep the wound dry for this period. At day 7 they can then wash the wound. This will cause the steri-strip to fall off and enable excess glue to be removed.

If the wound edges are ragged, careful trimming may convert this into a neat edge which can then be closed more easily. Trimming should be reserved for dead or obviously damaged tissues, and should be kept to a minimum, to avoid tension across the wound. Wide excision of tissue from the face may lead to difficulties in achieving a cosmetic closure, especially around the eyes, nose and mouth where tension can distort these sites. There should ideally be no tension across the wound. In cases where tension is a problem, undermining the skin, a local flap, or skin grafts may be required. If doubt exists about the viability of a piece of tissue, this can often be left in place and inspected later. These are difficult and time consuming cases and often need to be referred. Remember to document your findings and treatment carefully. Ideally, photograph the wound. Note any tissue loss, the patients tetanus status, and if necessary take a wound swab for culture. Antibiotics are not always necessary and should be prescribed in accordance with local protocols.

3.4.2.2 Scalp Injuries

Haemostasis can be difficult. The blood vessels run within the aponeurotic layer and can contract making them difficult to find. Ideally bipolar diathermy should be used, as this minimises thermal damage to the hair follicles. If diathermy is not available, sutures may be passed through the bleeding area in an attempt to ligate the vessel. Remember to check both sides of the wound. Although the opposite side may not be bleeding as much, this will require careful haemostasis as well. Shaving the hair at the edge of the wound should be avoided because this follicles help accurate repair. If the hair is long and getting caught up in the wound, just cut it short (Fig. 3.51).

Fig. 3.51 Crush injury to scalp

3.4.2.3 Scalp Avulsion

Avulsion of the scalp most commonly results when long hair is trapped industrial high-speed rotary machines. This tends to produce similar injuries in patients as the tissues tear along planes of least resistance between the insertion of the frontalis, temporalis and occipitalis muscles. Occasionally tearing occurs through the skin beyond these insertions and can include the eyebrows and ears. The deeper plane of separation is through the loose connective tissue (between the galea aponeurotica and the periosteum). Before the advent of microsurgical techniques, management of an avulsed scalp usually involved replacing the avulsed tissue as a free graft and suturing it back in place. Not surprisingly this had poor outcomes. Microvascular techniques using a variable number of arteries and veins have now improved the chances of survival in both partial and complete avulsions. Postoperatively congestion of the flap can occur, occasionally requiring the use of leeches. Close monitoring is therefore required. The reported ischaemic time of an avulsed flap is variable but some scalps can withstand up to 17 h of warm ischaemia and up to 24 h of cold ischaemia.

3.4.2.4 Eyelid Injuries

If eyelid function is compromised, corneal ulceration and other complications can occur. Injuries to the tarsal plate, canthi, lacrimal system or lid margin may be better managed by an oculoplastic surgeon, or other specialist. Eyelids are both delicate and complex structures and a poor repair can result in significant functional problems. Superficial lacerations can often be managed with simple sutures, either 6–0 resorbable sutures, or fine sutures which are removed after a few days. Keep these to a minimum. A watertight closure is not essential, rather tissue approximation.

With medially sited injuries, both the upper and lower canaliculi must be examined carefully to determine whether they are involved. Complete transections may require repair over a fine catheter, although some specialists prefer to manage these secondarily. Complications include epiphora and dacryocystitis.

3.4.2.5 Eyebrow Injuries

Poorly aligned eyebrows result in significant cosmetic deformity. It is important to remember that the hair of the eye brow exits obliquely to the skin and not at 90°. Never shave the eyebrow, contrary to popular belief they do regrow, but this is slow. Shaving the eyebrow will result in loss of anatomical landmarks. Remember to assess forehead sensation beforehand. Blunt impacts to the brow area that result in numbness may indicate crush injury to the supraorbital and supratrochlear nerves. This should be noted before repair is attempted.

3.4.2.6 Ear Injuries

These injuries can be difficult to repair, due to the complex geometry of the underlying cartilage. Wounds should be carefully cleaned and debrided as there is a risk of perichondritis. Simple linear lacerations may be closed in layers. More complex lacerations require the placement of key sutures at the helix and other anatomical landmarks. Small avulsed fragments may be reattached, but the likelihood of

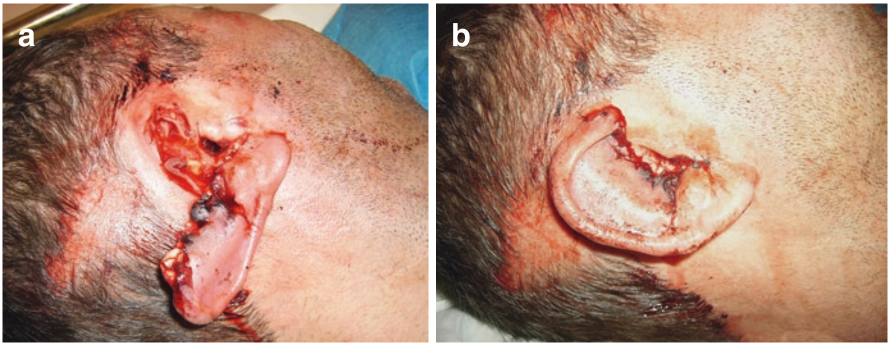

Fig. 3.52 Tacking sutures for partial avulsion injury. Before (**a**) and after (**b**) suturing

success is low. However as the ear is highly vascular, partial avulsions may do surprisingly well, even if attached by a small pedicle. Following repair prescribe antibiotics and place a light pressure dressing to prevent subperichondrial haematoma (Figs. 3.52, 3.53 and 3.54).

3.4.2.7 Nasal Injuries

Depending on the mechanism of injury, lacerations often those following blunt impacts are often associated with underlying fractures. These complex injuries are probably best referred where they can be managed comprehensively in one procedure. Superficial lacerations through the skin only, can usually be repaired using fine non absorbable sutures. Lower down, near the tip of the nose, lacerations and bites frequently involve the cartridges, which also need to be carefully repaired. Full-thickness lacerations must be carefully closed in layers, including the nasal lining. If the laceration involves a key landmark (such as the rim) realign this first and place a suture (Fig. 3.55).

3.4.2.8 Cheek Injuries

These injuries require careful assessment, due to the risks of injury to the facial nerve, parotid gland and parotid duct. Mucosal injuries can be simply closed, making sure not to suture through the parotid duct. Cutaneous lacerations need careful assessment and if in doubt, exploration and repair under general anaesthesia. With superficial lacerations the branches of the facial nerve are rarely injured. However, wounds can be deceptive and may be deeper than initially appreciated. Since the arterial vessels in the gland are more superficial than the nerve, if there is significant arterial bleeding always assume a nerve may be divided. Anteriorly sited lacerations (anterior to a perpendicular line passing through the lateral canthus) generally do not require nerve repair. Lacerations passing along the lower border of the mandible may involve the mandibular branch of the facial nerve. If there are any signs of facial weakness, always assume the possibility of nerve injury.

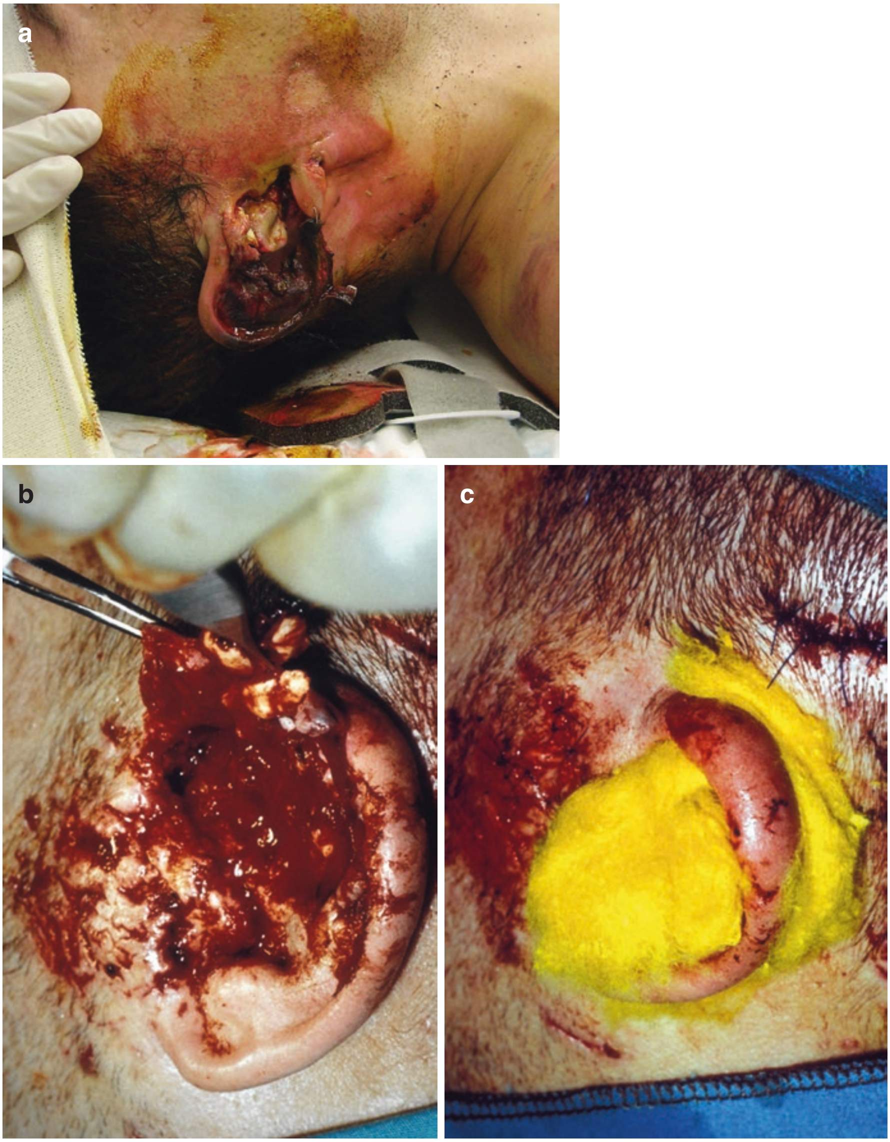

Fig. 3.53 Always try to preserve tissues, rather than extensively debride. Realign and gently support if unable to suture

3.4.2.9 Lip Injuries

Laceration of the lip should always be repaired with careful attention to the vermilion border, sometimes referred to as the red or white roll. These should be identified prior to placement of local anaesthetic, as the tissues will swell and blanche. Steps

Fig. 3.54 Antiseptic dressings help to maintain shape of the pinna and prevent haematoma. The proflavin dressing used here was following evacuation of a haematoma (delayed presentation with early signs of infection)

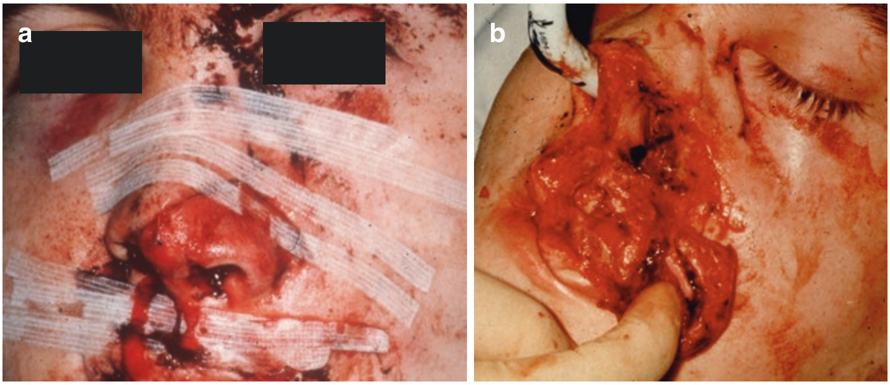

Fig. 3.55 A well-positioned flap (**a**). Examination under general anaesthesia was required to show the true extent of the injury (**b**)

in the vermilion border are a frequent source of dissatisfaction and sometimes litigation. The lips should be repaired in layers, commencing with the muscle, followed by the mucosa and then the skin. If possible the first suture should precisely align the vermillion. Tissue defects of the lower lips less than one third of the length of the lip can often be trimmed and closed directly. However this is not possible with upper lip defects, where symmetry of the philtrum and Cupid's bow will be lost. Tissue loss in the upper lip requires more complex reconstruction.

3.4.2.10 Intraoral Injuries

The intra-oral tissues are lined with mucosa that heals much faster than skin. Even loss of large portions of mucosa, for example following removal of a tumour, can be quickly replaced by epithelium from the surrounding tissues. Saliva contains a number of growth factors which help fight infection and accelerate healing. This is why many animals lick their wounds. Consequently many mucosal lacerations do not require closure. Nevertheless, it is important to be aware of dirty and contaminated wounds that will need cleaning and debridement. Many can be kept clean with regular mouth washing.

Wounds that result in exposure of bone will need to be closed in order to cover the bone and prevent contamination from food. Through and through wounds that result in communication between the skin and intra-oral mucosa will also require a layered closure. This is to prevent leakage of saliva and fistula formation.

Children often present with lacerations to the soft palate. This is commonly as a result of falling whilst running with an object such as pen in the mouth. In most cases this can be allowed to heal. If there is suspicion of communication with the nasal cavity, a layered closure may be indicated to prevent fistula formation. Beware also of the possibility of injury to the internal carotid artery, which lies deep at the lateral margins of the soft palate. There have been reports of occult injury to the internal carotid and delayed onset of stroke. Large soft palate lacerations will also need a careful closure to prevent problems with speech or swallowing. These will require a general anaesthetic and an appropriately skilled surgeon with intra-oral experience. The soft palate is a difficult site to repair.

The vermillion border is the junction of the lip mucosa with the skin. It is an area of high aesthetic importance. Effort must be taken to keep the edges in line and reduce any step discrepancy in the lip margin. However very small lacerations across the vermillion border in children can be allowed to heal with glue and steri-strips to avoid general anaesthetic. Patients and family must be warned that this may lead to a step deformity. This may require revision at a later date.

3.4.2.11 Devitalised Tissue and Foreign Bodies

Tattooing can occur when grit or debris is not completely removed from a wound. Healing occurs with visible particles under the skin surface. Pigments can also leak out into the surrounding tissues. A common example of this is the 'amalgam tattoo' seen in patients who have large 'metal' (amalgam) fillings. All foreign material must therefore be removed. This may require prolonged, but gentle scrubbing of the wound (scrubbing in itself is additional trauma). Regional nerve blocks or general anaesthesia may be necessary. However it is important not to scrub too aggressively. This will cause further trauma and can extend zones of ischaemia, with further devitalisation of tissue. If scrubbing is required a small toothbrush is often helpful. Be patient—removal of all the grit may take time. For tiny pieces of grit, the tip of a pointed scalpel or a sterile needle may be the best way to remove it. Copious but gentle irrigation is usually necessary. Although a number of antiseptics are

Fig. 3.56 Patient was struck by an object resulting in a "shelving type" laceration and injury to the upper branch of the facial nerve

available, some have been shown to impair healing. The agent of choice is not as important as the volume of irrigation used. The old adage of 'dilution is the solution to pollution' should be remembered. Sterile saline solution or water are currently recommended by many authorities. If using irrigation fluids other than these, be careful to avoid sensitive sites such as eyes. Solutions such as chlorhexidine have been known to cause chemical burns to the cornea if left to pool. If used, remember to protect the patient's eyes (Figs. 3.56 and 3.57).

3.4.2.12 Bites and Scratches

These injuries should be considered as potentially serious and managed expeditiously. The nose and lips are injured the most often. Injuries can rapidly become infected if not treated properly. Dog bites can range from simple puncture wounds, to lacerations, tears and avulsions of the scalp face and neck. Teeth can penetrate deeply, taking bacteria deep into the wound. As animal saliva harbours numerous virulent microorganisms, the main concern is wound infection. Pasteurella species are the most common isolates, with *Pasteurella canis* predominating among the dog bites and *Pasteurella multocida* in cat bites. *Capnocytophaga canimorsus* is particularly worrying in dogs bites and has been implicated in a variety of clinical conditions such as septicemia, purpura fulminans, peripheral gangrene, endocarditis and meningitis. Cats are the main reservoir of *Bartonella henselae*, the causative agent of cat scratch disease. Canine saliva also contains a necrotising factor. Depending on the patient (and the animal) the force and relative bluntness of the teeth also increases the possibility of a crush injury with devitalised tissue. The force delivered by a dog's jaws has been reported to be as high as 200–450 psi—sufficient enough to perforate sheet metal. Human bites, although often appearing more

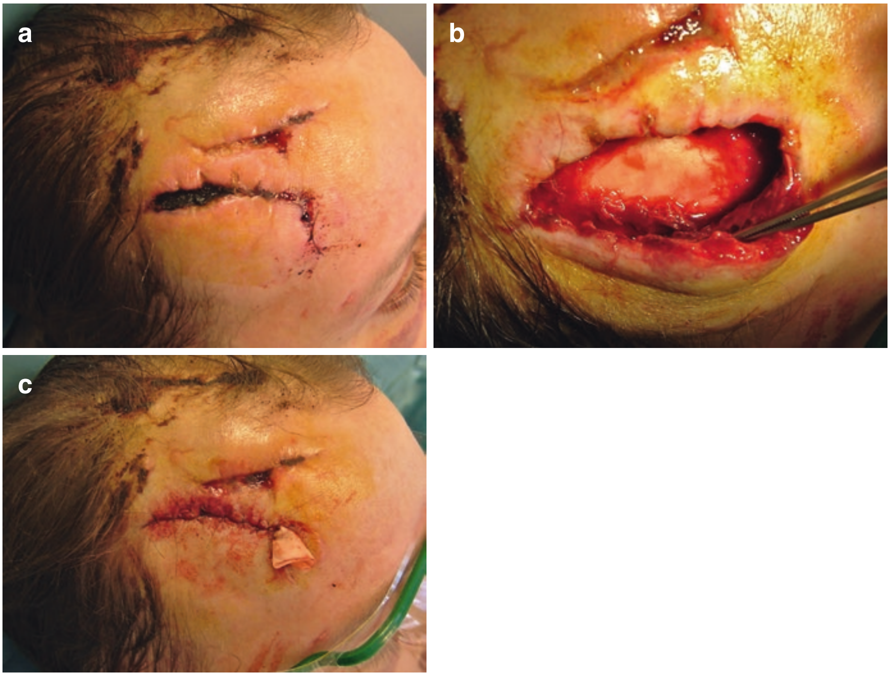

Fig. 3.57 Delayed presentation of a scalp wound (hit by a brick). Patient did not seek medical attention until it became infected. Exploration revealed a full-thickness wound with infected haematoma and multiple small FBs. The wound was loosely closed and a drain placed for 48 h

innocuous and considered less serious, are actually more likely to result in significant infection. Human oral flora is different from animals and is more virulent. a-streptococci and *Staphylococcus aureus* are usually the most frequent pathogens. Candida species has also been found and human bites can be a source of the hepatitis B and C virus and possibly, HIV transmission, as well as syphilis. More unusual bites (e.g., farmyard animals, snakes, spiders) require specialist knowledge as they may contain exotic organisms or even venom. Pig bites are not uncommon in farmers and can be severe with a high risk of infection from multiple organisms. Bites from aquatic animals have a bacteriology that is reflective of their water environment (Figs. 3.58, 3.59, 3.60 and 3.61).

Close attention should also be paid to scalp lacerations in infants and young children because their thin and incompletely mineralised skulls are susceptible to puncture-type fractures, with intracranial injury. Management of animal bites is an evidence poor area. Most recommendations are based on small case series, microbiological data and expert opinion. The main controversies focus on whether wounds should or should not undergo primary closure and the use of prophylactic antimicrobials. However many specialist consider that unlike elsewhere, bites and scratches in the head, neck and face can often be closed immediately. This is because of the excellent blood supply. By contrast, deep puncture wounds should be left

Fig. 3.58 Dog bites result in deep penetrating and crush injuries, often heavily contaminated

Fig. 3.59 Animal scratches are also similarly at high risk of infection

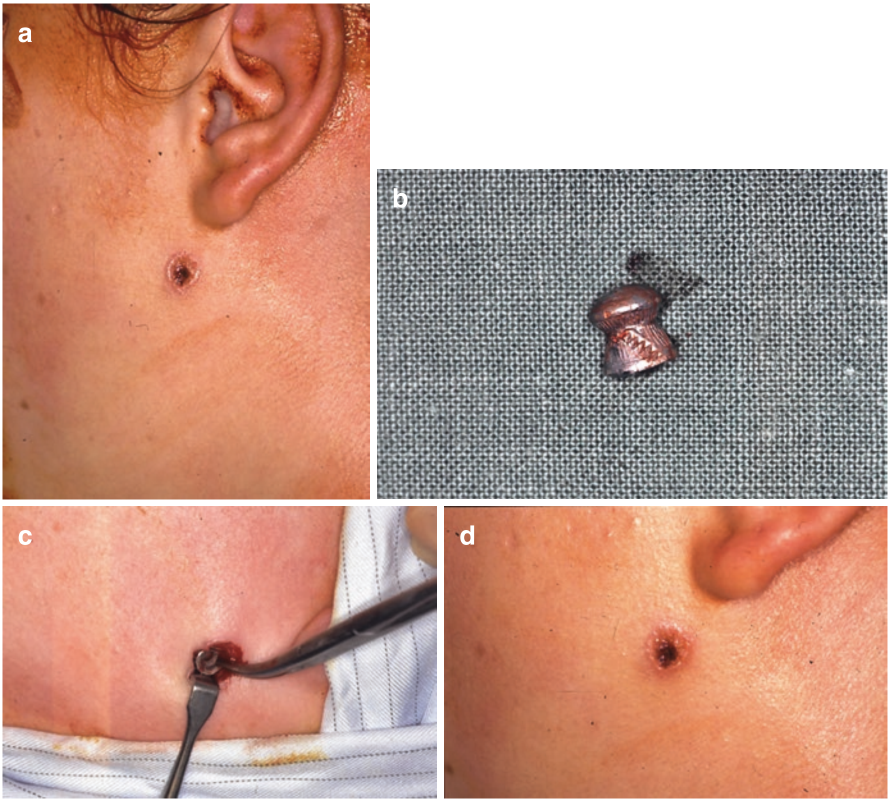

Fig. 3.60 Removal of airgun pellet

open, particularly when inflicted by cats. Treatment involves copious irrigation of the wound with isotonic saline or anti septic solution (such as 1% providone–iodine solution), followed by judicious excision of any necrotic tissue. If the wound is less than 6 h old it can be closed with fine interrupted sutures. Management after 6 h is difficult as these wounds are at high risk of infection. Closure may still be possible, but should be loose. Needless to say, these are at high risk scarring. Antibiotics should be given in all cases of bites. The decision whether to administer rabies vaccine depends on the animal (domesticated and immunised or wild). If this is not known, seek advice or follow local protocol.

3.4.2.13 Suturing

Whilst many suture techniques are described, most traumatic wounds are closed using simple interrupted sutures. The benefits are multiple. Interrupted sutures allows even spread of tension across the wound. If a stitch becomes loose, it does not compromise the integrity of the rest of the closure. The small gap between sutures allows drainage of exudate. If the wound becomes infected, pus can drain through this space and be diagnosed early. However, in certain circumstances the

Fig. 3.61 The airgun pellet was clearly visible on X-ray

wound may require more support. This may be the case if there is tissue skin loss. Here the use of vertical or horizontal mattress sutures may be more appropriate. Other, long straight wounds may be closed using a subcuticular suture. This has the advantage of being able to remain in place for many weeks, thereby providing long term support. This is particularly useful in unfavourably orientated incised wounds. However, whenever possible skin edges should not be closed under tension.

Suture materials can be classified according to their stability—absorbable and non-absorbable sutures. With each type these can be either monofilament and braided. Absorbable sutures will disintegrate over time. The time to absorption depends on the suture material and can usually be found on the manufacturers website. It is also dependent on the caliber of the suture material and conditions of the wound. The life expectancy of a suture material should be slightly longer than the time needed for the wound to heal. Suture materials that linger in the tissues for too long can become a nidus for infection, especially if braided. Braided sutures are theoretically more vulnerable to biofilm infestation. However they have the advantage of higher tensile strength and are better suited for closure of highly mobile tissues such as mucosa and deep structures in the face. Evidence suggests that non-absorbable monofilament sutures have better outcomes for skin closure.

All non-absorbable sutures will need to be removed. This should be taken into account when placing the sutures, by leaving the suture ends long. However, children and uncooperative patients may not allow suture removal. Consideration can then be given to the use absorbable sutures for the skin. As a guide, children who require GA for suture placement will be difficult to ensure cooperation with suture removal. Aesthetic outcome can be improved in these cases by using small caliber suture such as 6.0.

The key steps in suturing include

A. Following skin preparation local anaesthetic is infiltrated around the margins of the wound.
B. Explore all wounds carefully and thoroughly—they are often deeper than they initially appear to be.
C. Thoroughly but gently clean the wound (irrigate copiously, and gently scrub the tissue). Use the tip of a pointed scalpel blade to remove grit.
D. Remove only dead tissue. Carefully excise wound edges. Try to ensure there is sufficient tissue to allow tension free closure.
E. Ensure meticulous haemostasis.
F. Remove the suture from the packet with the needle holder. Never use your fingers to hold the needle. Never hold the tip of the needle with the holder—this will damage it
G. Place the needle holder two-thirds along the circumference of the needle from the tip.
H. Insert the needle at 90° to the tissue using counter pressure from the forceps. Pull the suture through to the other side and tie a knot.
I. Avoid pinching the skin with the forceps. This can crush the tissue leading to necrosis.
J. As a guide, the distance from the edge of the wound should correspond to the thickness of the tissues being sutured. Each subsequent suture should be placed approximately twice this distance apart.
K. Start by aligning key anatomical landmarks first (vermillion border, eyebrow, eyelids, etc.). A temporary suture to approximate these landmarks may be helpful.
L. Close in layers (mucosa to mucosa, muscle to muscle and skin to skin). Skin sutures should not be relied upon to hold the wound closed in the presence of tension.
M. Once the wound is closed, ensure none of the knots on the skin lie over the suture line.

N. According to local protocol a topical antibacterial ointment (e.g. chloramphenicol) or adhesive strips (steri-strips) may be applied to the skin wound until the sutures are removed.
O. Ensure follow up is arranged for skin suture (Figs. 3.62, 3.63, 3.64, 3.65, 3.66 and 3.67).

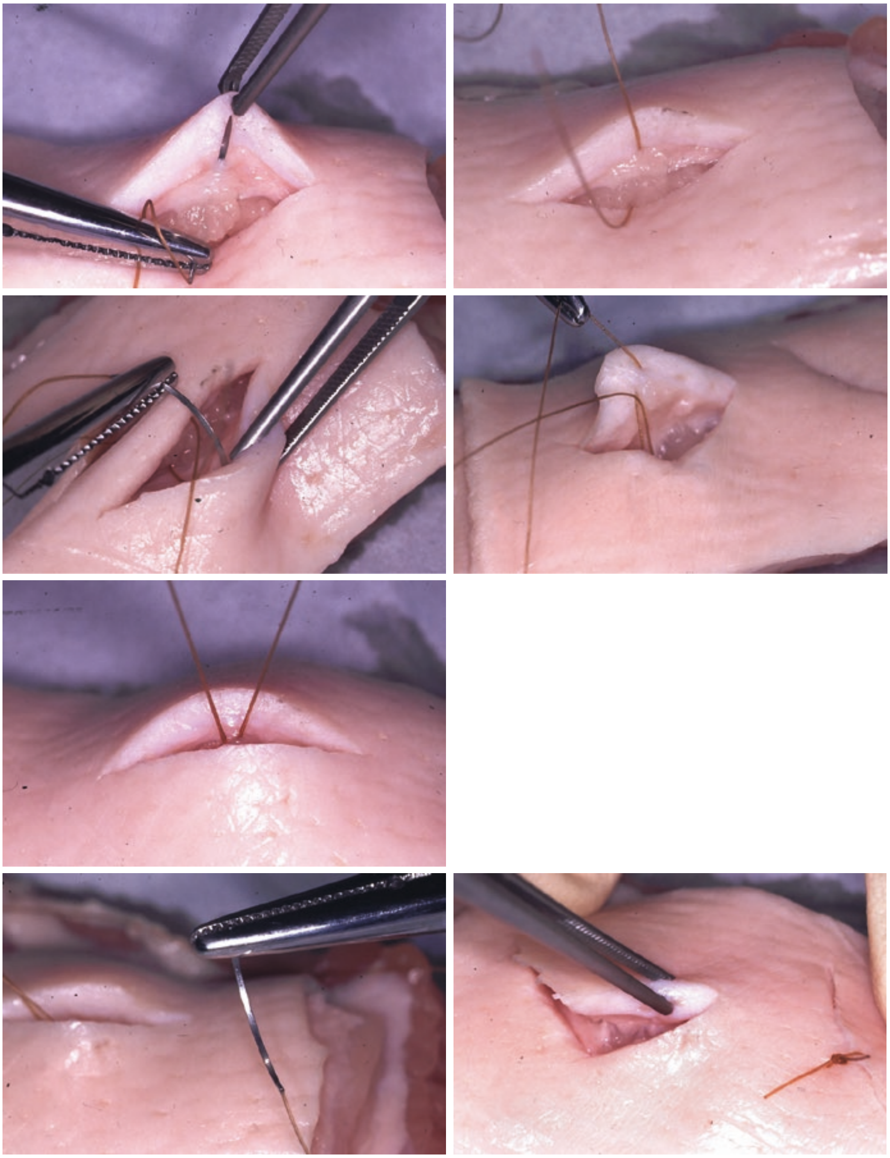

Fig. 3.62 Suture technique, step by step (see also text)

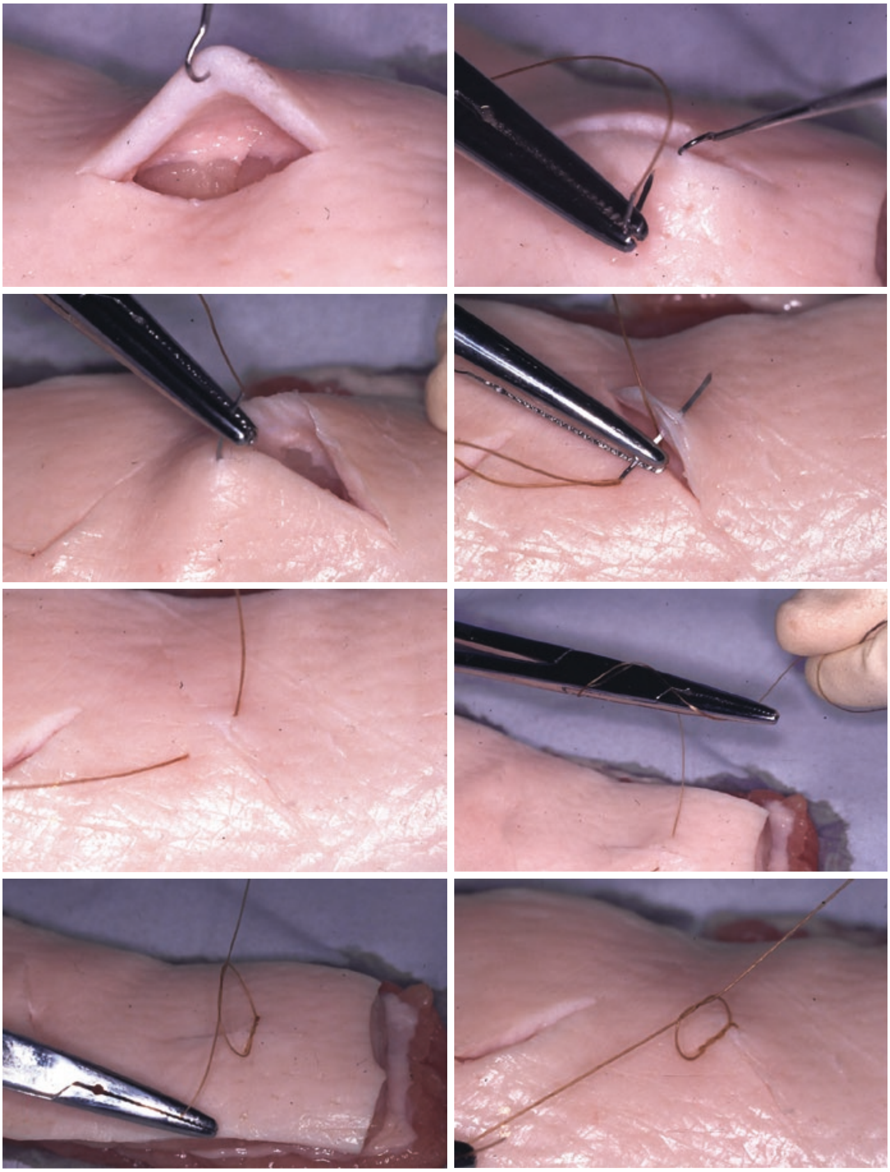

Fig. 3.62 (continued)

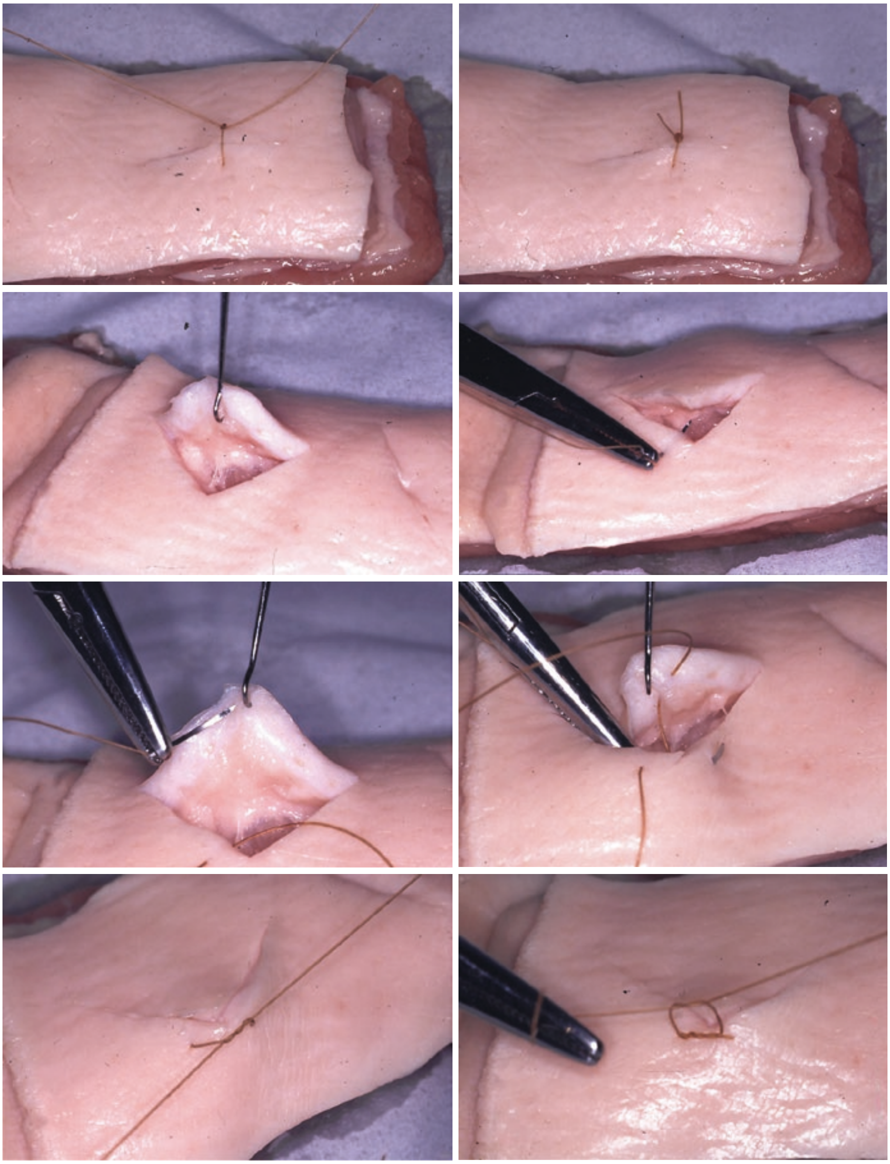

Fig. 3.62 (continued)

Sutures need to be removed at the appropriate time. Sutures that remain in the skin past the time of healing can cause a chronic inflammatory reaction and a 'divet' scar. In the head and neck, sutures should be removed between days 5–7. Older patients with co-morbidities or previous radiotherapy will require sutures to be left longer and removed after day 10. Scalp clips may be left for up to 2 weeks in

Fig. 3.63 Primary closure of an irregular wound following a dog bite

extensive lacerations. These are just guides, some flexibility in these times is usually acceptable.

Staples may be used in the scalp and neck. However the aesthetic results of staples is poor on the face. They are a quick and clean way of closing wounds in an emergency. Areas of low aesthetic importance such as scalp can usually be closed satisfactorily with staples. The skill required to place staples is much less than for sutures and they are usually quicker to place. Placement can be done by

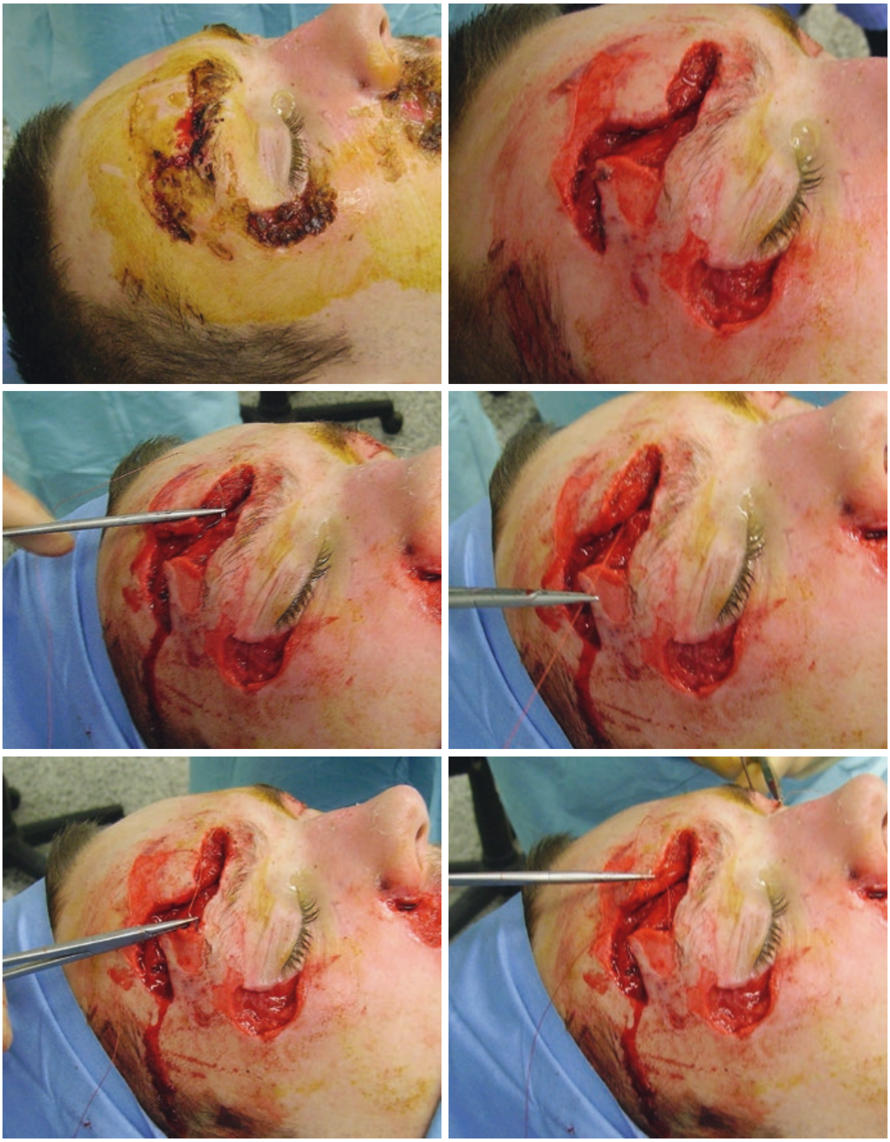

Fig. 3.64 Delayed primary closure, step by step

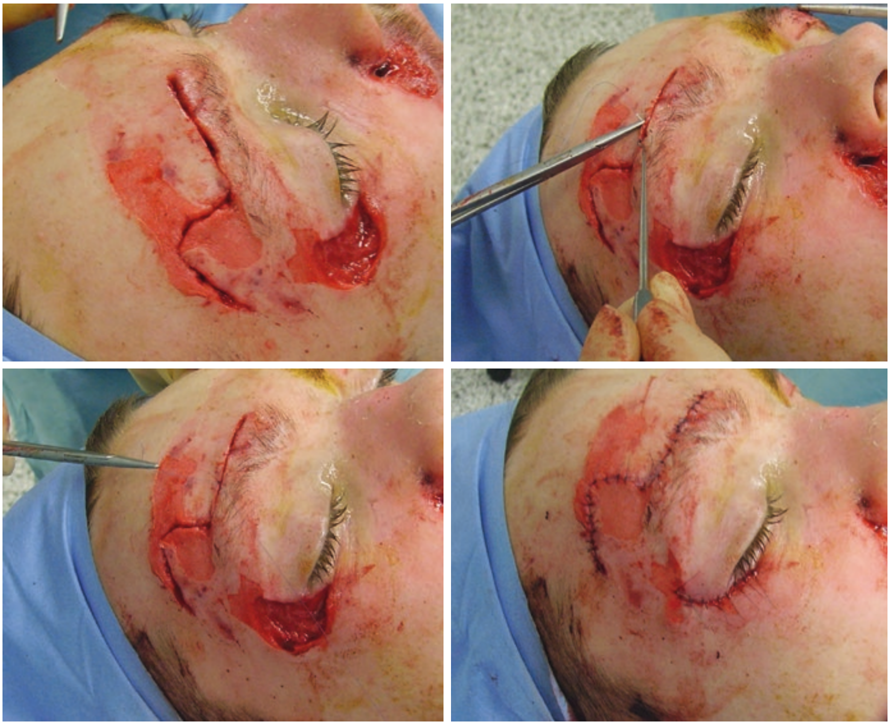

Fig. 3.64 (continued)

appropriately trained non-medical staff often without the use of local anaesthetic. However they do need to be placed carefully. Otherwise in scalp wounds, bleeding may continue from the subgaleal vessels. Staples must also be removed in a timely fashion similar to sutures.

3.4.2.14 Referring Soft Tissue Wounds: Which to Refer

Generally, follow your local referral guidelines. Indications for referral may include:

1. Involvement of key landmark sites such as the vermillion border, eyelids, eyebrow, ala of the nose and ears
2. Deep facial wounds particularly with clinical evidence of damage to the bones, nerves (e.g. facial nerve) or other structures (e.g. parotid duct)
3. Animal/human bites
4. Oral lacerations
5. Burns
6. Wounds with associated tissue loss
7. Any penetrating neck wounds
8. Lack of resources (time, equipment, skills) to do a good job

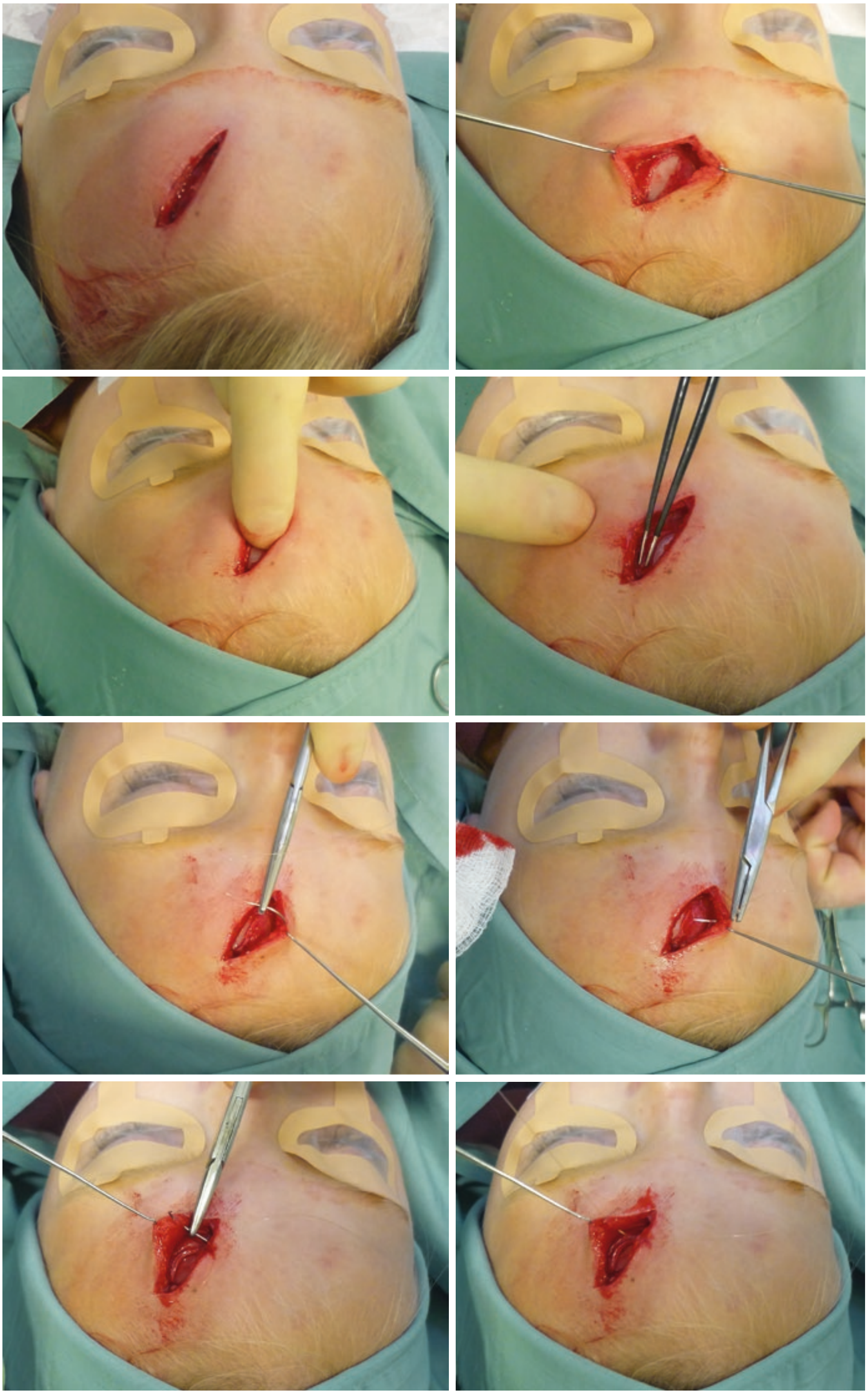

Fig. 3.65 Paediatric laceration

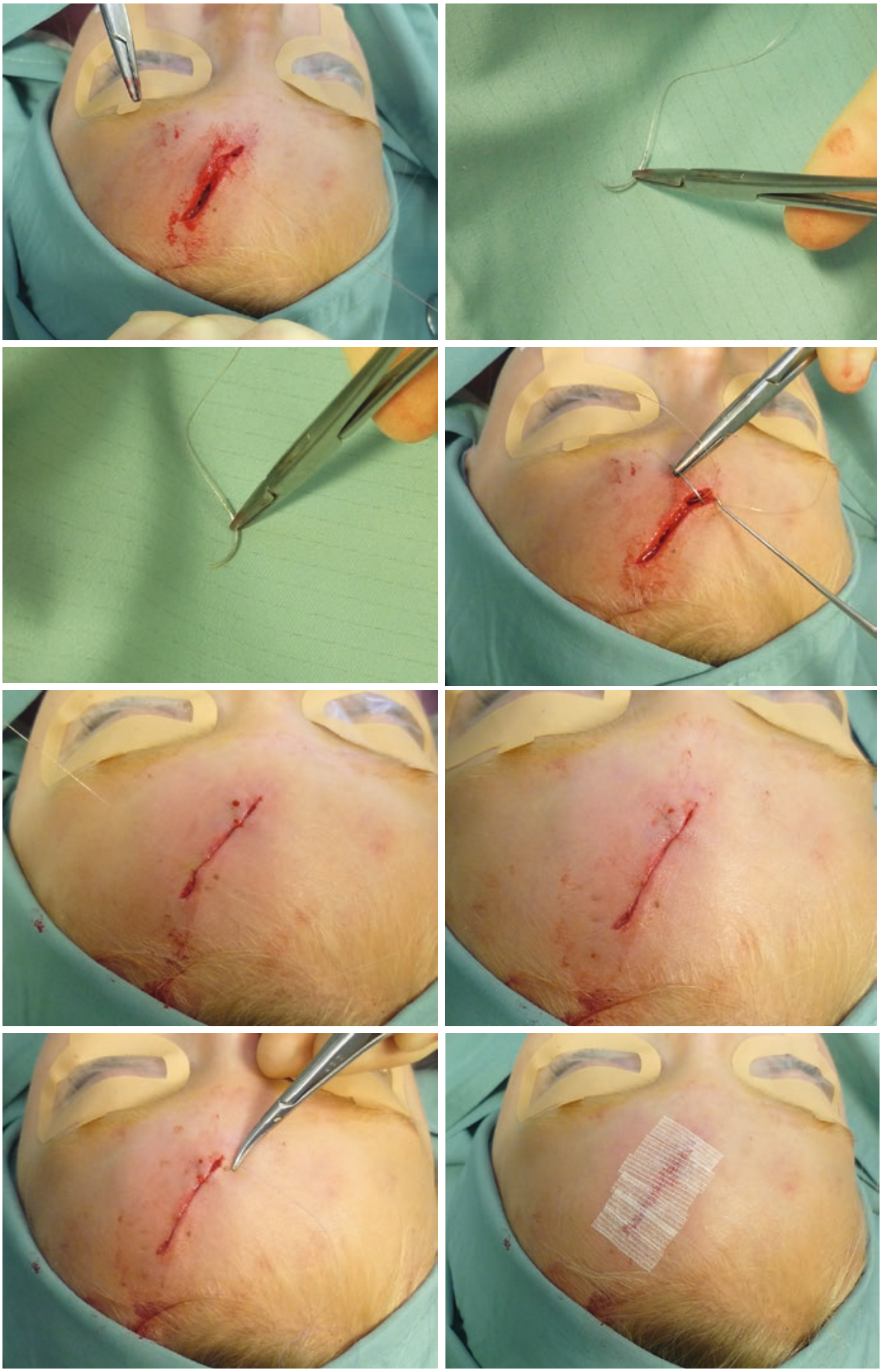

Fig. 3.65 (continued)

Fig. 3.66 Wound support using steristrips

Fig. 3.67 Trimming may be necessary, but should be kept to a minimum

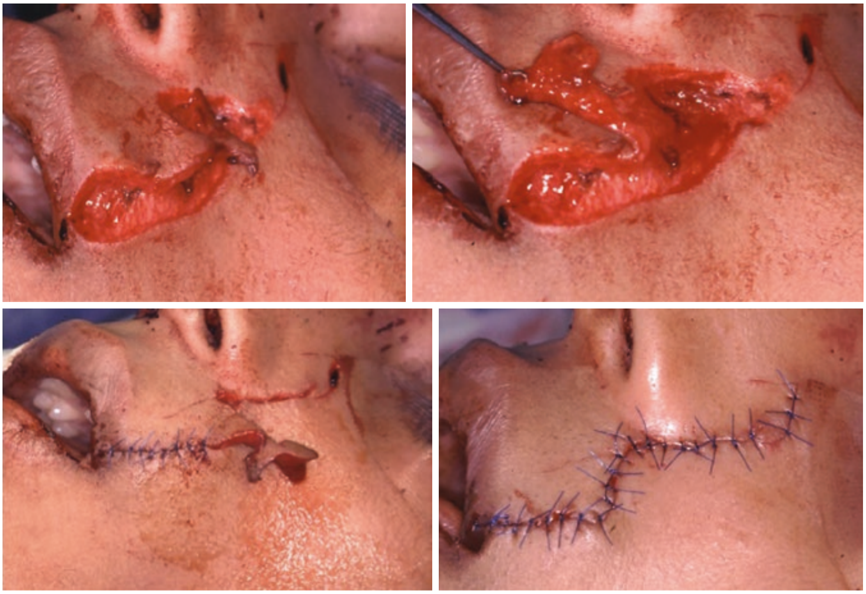

Fig. 3.67 (continued)

3.4.3 Facial Fractures: An Overview

3.4.3.1 Applied Anatomy

In many patients following trauma to the head and neck, the relatively rigid skull vault provides a degree of protection to the brain. The brain does not rest directly on the skull base, but is supported and cushioned by the surrounding CSF. Some mobility of the brain within the skull is possible, which accounts for the phenomena of contrecoup injuries—discussed further in the chapter on the head. However the brain is largely tethered by the spinal-cord, cranial nerves and vessels entering and leaving its structure. Sudden and severe movements can therefore result in shearing forces within the brainstem—diffuse axonal injury. The arrangement of the brain and skull is commonly referred to as the "neurocranium."

Suspended from the front of the skull is the facial skeleton. This is divided vertically into three main areas, or thirds.

A. The upper third of the facial skeleton (forehead) is that part of cranial vault and comprising of frontal bone. It contains the frontal sinus, a variably sized structure which drains into the ethmoid region. In contrast to the frontal bone itself, the bones comprising the front and back walls of the frontal sinus are of variable thickness and are often thin. Direct impacts to the anterior wall of the frontal sinus can result in collapse and an obvious depression in the forehead.

B. The middle third, is that part of the face between the supraorbital ridges (brow) and the upper teeth. This is subdivided into a central midface (maxilla, nasal, ethmoid, vomer and lacrimal) and the lateral midface either side (zygoma). The bones here are particularly thin in certain places, notably the ethmoids, orbital walls and anterior wall of the maxilla. The frontal sinus drains into the ethmoid sinuses and therefore impacts to the central midface can affect drainage of the frontal sinus, even in the absence of an injury to the forehead.
C. The lower third of the face is comprised of the mandible. This articulates with the base of the skull at the temporomandibular joint and is therefore highly mobile. It is commonly fractured during trauma.

The bones of the face, often referred to as the "viscerocranium", provide support and enable important physiologic functions, including support of the nasal airway and olfaction, support and protection of the globes and visual function, and support for the teeth and masticatory function. Embryologically, they are derived from multiple sources and are therefore highly variable in size and thickness. Some of them (notably the ethmoid and orbital roof) are extremely delicate. This can be verified on a real skull, in which light can be seen to easily pass. In addition there exist multiple forminae, through which pass sensory and motor branches of the cranial nerves and blood vessels. These form natural sites of weakness, through which fractures frequently propagate. Fractures through the anterior and posterior ethmoid foraminae are commonly associated with profuse epistaxis following tears in their associated vessels. The remaining bones vary in thickness but are still quite delicate and commonly fractured (e.g. nasal and zygoma). The mandible is the strongest of all the facial bones.

The bones of the face can be conceptualised as a system of vertical and horizontal struts or buttresses. These are separated by weaker areas or sheets of bone that enclose important structures, such as the nasal cavity, eyes and brain. The buttresses resist masticatory and other forces applied to the face. Three vertical buttresses consist of the paired nasomaxillary (NM), zygomaticomaxillary (ZM) and pterygomaxillary (PM) midfacial buttresses (as well as the ramus of the mandible). These define the vertical height of the face and provide the bony resistance to mastication, transferred forces to the skull base. The ZM buttress transfers the majority of the masticatory force. It has been suggested that from an evolutionary standpoint, the presence of the sinuses improves survival. During an impact the facial bones collapse, thereby minimising the transfer of energy to the brain and cervical cord.

3.4.4 Forehead Injuries

Impacts to this area can involve the cranial vault, skull base and frontal sinus. Not surprisingly traumatic brain injury is frequently associated. Occasionally, an isolated impact to the central forehead can result in collapse of the anterior wall of the frontal sinus only. In such cases the frontal sinus has effectively acted as a 'crumple zone' protecting the brain from injury. This phenomenon varies widely as focal sinuses can vary significantly in size. Clinically the patient may appear well although examination will reveal a depression in the forehead. This may initially be masked from swelling. The patient may present with epistaxis. Whilst these are technically skull fractures, those that are confined entirely to the anterior wall of the sinus are not clinically significant. The main issues related to cosmesis. Nevertheless this may not be apparent until the patient has had a CT scan. Clinical examination should include an assessment of any contour deformity over the frontal bone along with any lacerations or sensory deficit in the forehead. Fractures that extend over the supraorbital ridges can damage the supraorbital and supratrochlear nerves. The orbits may also need to be carefully assessed. Management of frontal sinus injuries is discussed elsewhere in this book. During the initial stages of assessment the most important distinction to make is between isolated anterior wall fractures and fractures that involve the posterior wall, which may result in CSF leaks. If the face is also involved in an injury, these injuries are often referred to as 'craniofacial' injuries. Whilst both head and facial injuries often associated with raised alcohol levels, it is important to remember that confusion may be secondary to brain injury and/or hypoxia. Do not assume a patient is drowsy because of alcohol. Initial clinical assessment therefore involves evaluation of the Glasgow coma scale (GCS) and a thorough inspection of the skull for evidence of any skull fracture or scalp laceration. If available, blood alcohol levels can also be measured. These injuries frequently require CT imaging to assess the cranial vault, skull base, orbits, sinuses, and temporal bone. Fractures at this site require early discussion with the Neurosurgical team (Fig. 3.68).

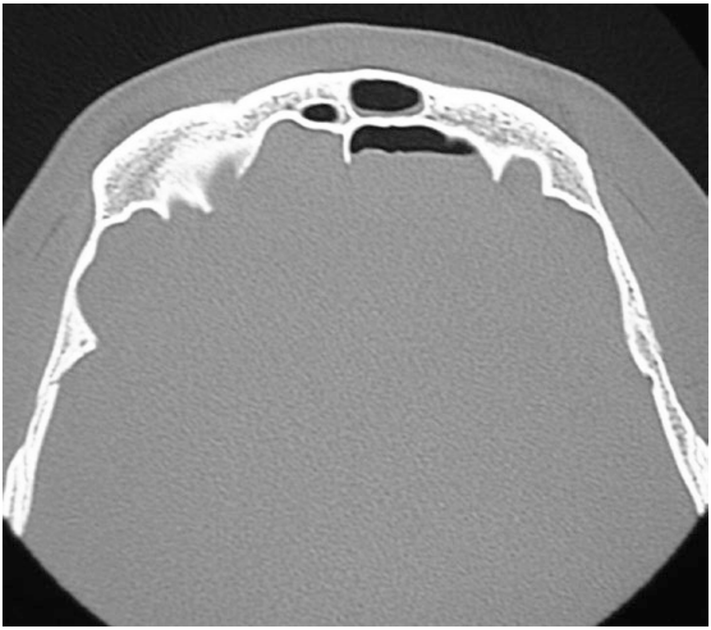

Fig. 3.68 Intracranial air following forehead trauma

3.4.4.1 Skull Fractures

Most fractures of the skull occur in either the frontal or parietal bone. These represent significant injuries. Skull fractures are discussed in the chapter on the head. Whilst fractures of the calvarium can occur following relatively low level impacts, skull base fractures represent high energy injuries and are frequently associated with significant brain, or neurovascular injury. The anterior cranial fossa is relatively thin and can be fractured in association with upper central midface injuries (nasoethmoid fractures). However fractures involving the middle and posterior cranial fossa or those that cross the midline, require significant amounts of energy to occur. Occipital condylar fractures are very rare, but serious injuries. Most patients with these are unconscious and have associated cervical spine injuries. They may also have lower cranial nerve injuries, hemiplegia or quadriplegia. Initial assessment involves evaluation of the Glasgow coma scale (as part of ATLS). Detailed neurological examination should then be performed looking specifically for.

A. CSF rhinorrhea/otorrhoea.
B. Battles sign: ecchymosis in the mastoid region.
C. Haemotympanum
D. Bilateral periorbital ecchymosis (panda eyes).
E. Vernet syndrome (or jugular foramen syndrome) is involvement of the IX, X, and XI cranial nerves with the fracture. Patients have difficulty in phonation and aspiration with ipsilateral motor paralysis of the vocal cord, soft palate (curtain sign), superior pharyngeal constrictor, sternocleidomastoid, and trapezius.
F. Collet-Sicard syndrome is occipital condylar fracture with IX, X, XI, and XII cranial nerve involvement.
G. Signs of spinal cord injury.

3.4.5 Midface Injuries

The term “midface” is often used to refer to those structures situated between the brow and the ‘occlusal plane’ (an imaginary horizontal plane where the upper and lower teeth meet). Depending upon the direction of force, energy transferred and the site of impact, injuries can vary widely, each with its own structural, aesthetic, and functional characteristics. Trauma of the midface regularly lead to lesions of soft tissue, teeth, and bony structures of the skull including the maxilla, the zygomatic bone, the naso-orbital and naso-ethmoid (NOE) complex as well as supraorbital structures. Fractures here can be easy to miss as not all are mobile. Not surprisingly, injuries here have significant cosmetic implications. Injuries of the lateral midface (zygomaticomaxillary) occur more frequently than central ones. Complex fractures are often described as nasorbitoethmoidal and Le Fort I, II and III. While numerous classification systems have been proposed, they are not necessarily precise. Although the term “middle third” is commonly used to denote LeFort fractures, injuries to this region are often much more widespread and complex. Often many bones are involved, commonly the nasal, lacrimal, vomer, maxillary, ethmoidal and frontal bones. Common fracture patterns include nasal, nasoorbitoethmoid (NOE) and zygomaticomaxillary. Whilst these often occur in isolation they may also extend upwards to involve the anterior cranial fossa (craniofacial fractures). Effectively, the face either collapses along, or is sheared off the skull base to varying extents. Clinical signs associated with middle third fractures include

A. Facial swelling/deformity
B. Subconjunctival bleeding
C. Oronasal bleeding
D. Palpable step deformity in the periorbital region
E. Displacement or impaired movement of the globe, with diplopia
F. Displacement of the medial canthal tendon (nasoethmoidal fractures)
G. Sensory impairment (infraorbital division of trigeminal nerve)
H. A change in the occlusion (bite).
I. A horizontal line drawn between the medial canthi bilaterally should pass through the centre of each pupil. If one pupil is below to this plane, this is known as hypoglobus)

To accurately assess a midface fracture, CT is required. For any patient that has suffered significant periorbital trauma, referral to an ophthalmologist at an early stage is also important. Examination of the injured midface should proceed in a sequential fashion following examination of the upper third of the facial skeleton. The neck should ideally have been "cleared" first. This is discussed in the relevant chapter. It is important to be methodical, as useful signs can be easily overlooked. Lengthening of the face, or a "Dishface" deformity are very useful visual clues, but may be obscured by swelling. Examination should include the following (Figs. 3.69 and 3.70).

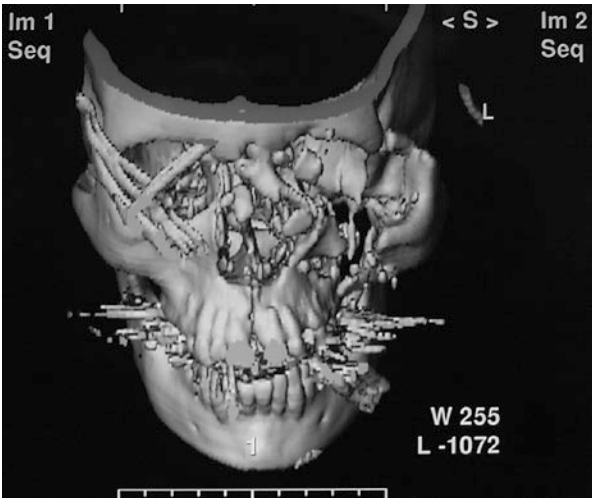

Fig. 3.69 Complex midface fractures

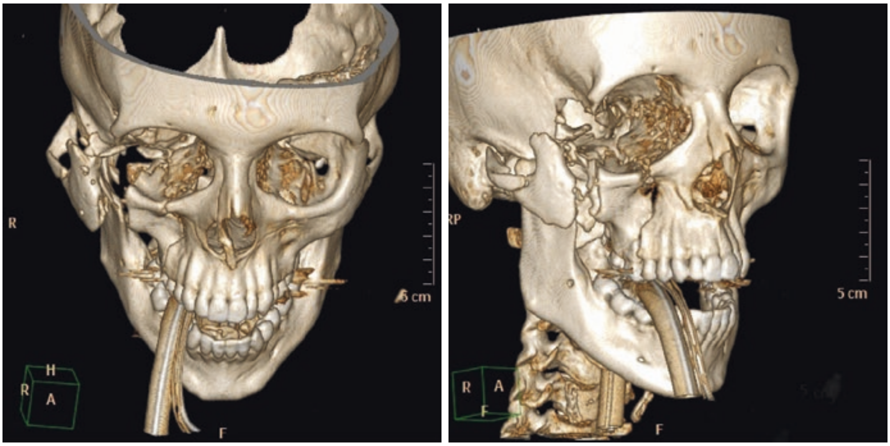

Fig. 3.70 Complex midface fractures

3.4.6 Lower Third Injuries

The mandible is the largest and main bone of the lower part of the face. In about 60% of cases it breaks in two places. By far, the two most common symptoms described are pain and the feeling that teeth no longer correctly meet (traumatic dysocclusion). Examination of the lower third of the facial skeleton is usually performed together with assessment of the midface.

3.5 Examination of the Injured Face

Detailed examination of each of the anatomical areas that comprise the face is discussed in their respective chapters. However when faced with a patient with widespread injuries a methodical approach is required in order not to miss less obvious injuries.

3.5.1 Extraoral Examination

Often signs of swelling, bruising and deformity can all be seen. However condylar fractures are deep and so external signs may be less obvious. Fractures here can disrupt the bone in the anterior external auditory meatus with visible bruising in or around the ear canal. Mouth opening can also be diminished. Numbness or altered sensation (anesthesia/paraesthesia in the chin and lower lip (the distribution of the mental nerve) is an important sign. Assess for tenderness particularly around the chin and over the angles of the mandible on palpation. Look for swelling/bruising over the submandibular region.

3.5.2 Palpation of the Bones

Clinical assessment is always necessary, despite the ready availability of computed tomography (CT) scans. Palpate the midface skeleton at the following sites for tenderness, step deformities or mobility. While this will provide an indication of the fractures present, there is also the more important need to assess areas of function.

1. Palpate the lateral and inferior rim of the orbit to assess the presence of pain or a step deformity; this may be difficult to appreciate when swollen.
2. Nose
3. Zygomatic complex and zygomatic arch. A flat malar arch is best assessed standing above the seated patient's head. Compare symmetry with the opposite side.
4. Intraorally assess the malar buttress (bony curve in buccal sulcus above the first and second molar teeth) for
5. Tenderness or a step in the curvature again comparing with the opposite side.
6. Grasp the maxilla and feel for movement (described below).
7. The patient's range of mouth opening should be greater than 30 mm. If this or lateral excursions of the mandible are restricted or cause localised pain, a malar fracture should be suspected.

3.5.3 Examination of the Eyes

Since ocular injury is very common in midface trauma, a thorough ophthalmological examination is essential in all suspected malar and midface fractures. Examination of the eye is discussed in further detail in the chapter on the eye. Note any lacerations, puncture wounds and assess visual acuity, visual fields, extraoccular motility and the pupillary light reflex. Consider hypoglobus (lowered pupillary level), enopthalmos (sunken eye), hypertelorism, ptosis and proptosis. Optic nerve function must be established even if the eye is closed by soft tissue swelling. This is accomplished by shining a light over the closed eye and getting the patient to confirm the presence or absence of light.

1. Visual acuity
2. Visual fields
3. Ocular movement
4. Globe position/proptosis/exophthalmos
5. Pupillary/relative afferent pupillary defect

3.5.4 Examination of the Ears

1. Examine the pinna, looking particularly for haematoma of the auricular cartilage. If extensive this might require drainage.
2. Using an auroscope, examine the external auditory can and tympanic membrane, looking for evidence of blood/CSF leaks. If present, fracture of the middle cranial fossa should be considered.

3.5.5 Examination of the Nose

Establish presence of deformity, ideally comparing to preinjury photos (e.g., driver's license). Palpate for mobility, crepitus, bony steps and displacements. Note any soft tissue lacerations avulsions etc. Anterior rhinoscopy is then undertaken to look for septal deformities, haematoma, perforations, mucosal lacerations and overall patency of the nose. Bleeding points should be controlled. With high energy impacts consider also the possibility of CSF leaks.

3.5.6 Sensory and Motor Nerve Examination

These should be assessed, notably the all divisions of the trigeminal nerve and facial nerve function. Occasionally decompression or peripheral repair may be indicated.

1. Sensory nerves of the face (supraorbital, infraorbital division)
2. Motor nerve (facial nerve)

3.5.7 Intraoral Examination

Sometimes, if a fracture occurs in the tooth bearing area, a step or gap may seen between the teeth on either side of the fracture. This is often mistaken for a lost tooth. Assess the occlusion (bite). Look for bruising, particularly in the floor of mouth and the buccal sulcus. Check for tenderness/mobility of the dentoalveolar segments. Specifically note the following

1. Posterior oropharyngeal collapse. Whilst this is commonly listed as part of an intraoral examination, extensive collapse is usually uncommon and if present is usually associated with high energy impacts to the face and a highly mobile midface. Collapse is not seen in isolation, but rather the entire midface and oropharyngeal region is usually very swollen and bleeding. These injuries are an immediate threat to the airway, especially in supine patients.
2. Placing a finger in the upper sulcus and palpating along the maxillary buttress mate sometimes revealed tenderness and steps suggestive of fractures. This can be seeing in fractures of the zygoma as well as central midface fractures.
3. Palatal haematoma/lacerations. These may indicate a split palate. This does not occur in isolation (unless from and intra oral penetrating injury), but rather occurs following a high energy impact to the central part of the face. Usually there are other midface fractures, together with significant swelling and bleeding. Diagnosis of the presence of a split palate is very important when it comes to surgical repair. Failure to recognise this can result in significant derangement of the patients occlusion and increased facial widening following healing.
4. Change in the occlusion (bite)—the key here is that the bite has changed, rather than it appears to be abnormal. Traumatic disturbances in the occlusion can take

many forms, such as premature contact on one side, failure for the front teeth to meet (anterior open bite) and other shifts in the alignments of the upper and lower teeth. Changes in the bite can occur as a result of either maxillary or mandibular fractures.

5. Apparent trismus—occasionally following frontal impacts to the midface, the central portion is displaced posteriorly. As the midface collapses it slides down the obliquely orientated skull base, resulting in premature contacts between the upper and lower back teeth. This forces the lower jaw open and can result in an anterior open bite. Patients may complain of an inability to open their mouth, although the mouth is already propped open. This can result in diagnostic confusion.
6. Mobile dentoalveolar segments/missing teeth. These need careful assessment. Occasionally large dentoalveolar fragments can be confused with Le Fort fractures (see below).
7. Dentures—be careful. Loose fitting dentures can confuse even an experienced clinician. If broken, check all the pieces are present. If not consider the possibility of aspiration.

3.5.8 Abnormal Mobility of the Midface

Le Fort and other midface fractures are generally evaluated by assessing movement of the tooth-bearing maxilla relative to the skull, making sure that the teeth themselves are not moving separately from the bone. This can be detected by grasping the anterior maxillary bone just above the teeth, and gently rocking the maxilla. At the same time the other hand palpates the sites of suspected fractures (nasal bridge, inferior orbital margins, or frontozygomatic sutures). Care is required if the neck has not been “cleared”. If concerns exist about the neck this part of the examination is best deferred. Alternatively, the head must be fully supported. Only attempted to move the bones gently. This may be quite painful for the patient and overzealous manipulation may cause further bleeding.

A. If the teeth and palate move but the nasal bones are stable, a Le Fort I fracture is present (or it is a denture).
B. If the teeth, palate, and nasal bones move but the lateral orbital rims are stable, it is a Le Fort II fracture.
C. If the whole midface feels unstable, it is probably a Le Fort III, or a complex midface fracture pattern.

Sometimes the level of a Le Fort fracture can be determined by this examination, but this is not important. In practice “pure” fractures are uncommon. The classic Le Fort fracture patterns are rarely seen in isolation today. Maxillary fracture patterns are more commonly asymmetric and frequently occur at multiple sites, reflecting the high-energy injuries more commonly seen in today’s society. Consequently other fractures often coexist. This is not a major concern however, since these injuries will require a CT scan to define the fracture pattern and plan surgery.

3.6 Useful Signs and Their Significance

There is potentially a huge number of clinical signs that can be determined following careful examination of the patient. Some of these are very reliable, others less so. Since many of these patients will undergo imaging (CT) the usefulness of the signs is more in determining the degree of urgency, rather than the presence of an injury. Whilst a sign may be highly suggestive of an injury, it may not necessarily give a good indication of the extent of the injury. Nevertheless, as a general guide the usefulness of these clinical signs can vary from those which only suggest an underlying injury (*) to those which are almost pathognomonic (***). Their interpretation must always be taken in conjunction with the history and likelihood of the condition being present.

3.6.1 General Inspection

*Facial Burns****

When associated with soot in the nose and mouth, singeing of the nasal vibrissae and sooty sputum this represents a potential airway problem. There is also the risk of and inhalation of carbon monoxide and other toxins.

*Facial Nerve Palsy***

Following head injury—fracture of the middle cranial fossa (petrosal bone).

*Horse voice/ineffective cough***

Following direct blow to the anterior neck may indicate disruption of the larynx. The term 'bovine cough' is sometimes used when the vocal cords do not meet prior to the normally explosive expulsion of air. As a result the cough is relatively weak and ineffectual.

*Wry Neck (Torticollis)**

Following trauma is due to muscle spasm. May occasionally be associated with dislocation of the posterior facet joints.

3.6.2 The Face

*Intercanthal distance***

This refers to the separation of the inner corners of the eyes. If greater than 30–33 mm (female) or 32–35 mm (male) the patient may have detached canthi secondary to an underlying nasoethmoidal fracture. These numbers are not absolute, but rather a guide. Alternatively various proportions can be applied (such as the 'rule of fifths'). As well as an increased intercanthal distance the medial canthus loses its pointed shape becoming rounded. This can occur unilaterally, or bilaterally. If unilateral, the distance from the midline to canthus will be greater on one side. The interpupillary distance should be within normal limits. There may also be depression of the root of the nose.

*Anterior open bite and elongated face***

If not preexisting, is suggestive of posterior and inferior displacement of the maxilla following a Le Fort fracture. This results in posterior gagging of the molar teeth—An anterior open bite (AOB).

*Septal haematoma****

Seen as a blue/reddened swelling on the septum on direct examination. Needs drainage as failure to do so can result in septal perforation, abscesses and intracranial infection.

*Numbness of the cheek**

Suggests a cheek or blowout fracture.

*Numbness of the lower lip**

Suggests a mandibular fracture.

*Anosmia**

Loss of smell due to tearing of olfactory nerves secondary to an underlying anterior cranial fossa floor fracture. Not reliably detectable in the acute phase of injury.

*"Bow-string" test****

This assesses for medial canthal detachment in nasothmoid injuries—the lateral canthus is pulled laterally and the medial canthus observed. If this is detached it will also move laterally.

3.6.3 Within the Mouth

*Dysphagia**

Many causes. When related to submandibular, pharyngeal or other posterior oral swellings it is a significant finding often requiring admission. Is often painful (odynophagia).

*Inability to protrude the tongue***

When related to submandibular, sublingual or other oral swellings it is a significant finding often requiring admission.

*Trismus***

Limitation of mouth opening due to muscle spasm (usually masseter or medial pterygoid). May be seen following a direct blow. When related to submandibular, pharyngeal or other posterior oral swellings it is a significant finding often requiring admission.

*Guerins sign****

Palatal bruising of the hard palate—underlying fracture involving palatine foramen.

*Upper Buccal Sulcus Bruising***

Fractured zygoma or unilateral LeFort I or II.

*Sublingual Haematoma****

Bruising/bleeding under the tongue—Fractured mandible (body/symphysis/parasymphysis.

*Bleeding gums***

May indicate an associated fracture of the tooth or bone.

*Change in the patients bite****

If the occlusion has changed it is likely that there is an underlying fracture of maxilla, mandible or alveolar bone. Displacement of the zygoma may also flex the maxilla. This can sometimes result in diagnostic confusion. Subluxation of teeth may also produce a malocclusion although usually much more minor. If none of the above are present a malocclusion may be a result of a TMJ effusion/haemarthrosis.

*"Cracked cup note"**

When percussing the maxillary teeth suggests a fracture.

3.6.4 The Eyes

*Visual acuity****

This is the single most sensitive indicator of visual impairment. It must be recorded in all patients with midface trauma. In patients who wear spectacles to correct short sight the recording must be done with the spectacles on or through a pinhole. If the patient is unconscious pupillary responses to light must be checked.

All patients must have a documented visual acuity. Any decrease in visual acuity requires an ophthalmic opinion.

*Pupillary responses***

Check direct response to light and consensual response. Responses should be equal on both sides and to direct and consensual stimulation. A pupil that reacts poorly to direct stimulation but briskly to consensual has an afferent pupillary defect.

*Swinging flashlight test****

Detects subtle defects to the optic nerve. Light is shone in one eye then swung to the other and back and forth. If the right eye has a problem, on shining the light in the right eye both pupils will constrict as the light moves to the left they will constrict further. As the light is brought back to the right the pupils will not respond or dilate a little.

*Periorbital Haematoma****

If the margins of this are well defined, this represents a fracture involving the orbit. Usually this means a fractured zygoma but can also include a blowout fracture, fractured base of skull (anterior cranial fossa), unilateral nasoethmoidal or nasal bones.

*Racoon (Panda) eyes****

Bilateral well defined "black eyes"—fractured base of skull (anterior cranial fossa), LeFort III or nasoethmoid fracture.

*Lateral subconjunctival haemorrhage***

This indicates a fracture involving the orbit, usually the cheek or nasoethmoid region. There is no posterior limit to the haemorrhage.

*Chemosis**

Swelling of conjunctiva is often seen in significant trauma. It looks a bit like frogs spawn. If no tear of conjunctiva is present it will resolve. If a tear is present it is important to rule out globe injury.

*Hyphema***

Blood in anterior chamber seen as fluid level when patient is standing. Needs ophthalmic assessment probably require admission and observation.

*Iridodialysis**

The iris is detached from its root leading to a distorted pupil shape.

*Dilated pupil (Traumatic mydriasis)**

Spasm of the dilator pupillae. Can be seen following a direct blow to the eye. Not to be confused with a third nerve palsy.

*Diplopia**

Double vision may be neurogenic, myogenic or bony in origin. It may be temporary or permanent and should be reviewed. Depending on possible cause refer to ophthalmics or maxillofacial.

*Unilateral Restricted upward gaze***

Often a sign of a "blowout" fracture, occasionally due to injury to ocular muscle or its nerve. Painful diplopia from a blowout may require urgent release.

*Retraction sign****

When looking from the side of the patient, as they look upward the globe is seen to move posteriorly. This is a good sign for a blowout fracture. Entrapment of the fat and restriction of the inferior rectus muscle results in a shift of the axis of rotation of the globe from its centre to the point of entrapment. Thus the pull of the superior rectus results in a backward rotation of the globe.

*Hypoglobus**

Inferior displacement of the globe seen in cheek complex fractures, where the bone and Lockwoods ligament drop down. May also be seen in large blow out fractures.

*Enophthalmos**

Posterior displacement of the globe due to increased orbital volume. Seen in blow out fractures of the orbit and cheek fractures. Globe appears "sunken in" with a deep supra tarsal groove.

*Third Nerve palsy****

Dilated pupil, the eye looks down and out, and ptosis. In severe head injuries this represents third nerve compression from an expanding intracranial lesion. The patient has a reduced GCS.

*Aqueous leakage****

A penetrating injury of the cornea.

*Superior Orbital Fissure (SOF) Syndrome***

Ophthalmoplegia, Fixed Dilated Pupil and Ipsilateral Forehead Numbness—fracture extending into the SOF, or possible carotid aneurysm. This is usually part of a significant injury.

*Orbital Apex Syndrome***

As in the SOF but here the patient has reduced visual acuity.

*Periobital oedema**

When infective in origin represents significant spread of infection. If the eye is closing the patient may probably need admission.

3.6.5 The Ears

*Haemotympanum***

Blood visualised behind the ear drum. Indicative of a fracture of the middle cranial fossa.

*Battles sign****

Bruising around the mastoid region—fractured base of skull (middle cranial fossa).

*CSF Rhinorrhoea/Otorrhoea****

"Tramlining"—Fractured base of skull. Blood mixes with CSF and leaks out. Along the edges the blood clots while centrally the CSF leak washes it away to form two parallel lines (like tramlines). Several methods for detecting B2-transferrin have been developed (isoelectric focusing, staining with alkaline silver nitrate, radioimmunoassay, chromatofocusing and high resolution immunofixation).

*Bleeding from the ear***

May indicate a fractured base of skull or mandibular condyle. If the tympanic membrane is intact the bleeding is local to the meatus, usually the anterior wall. This is often secondary to an associated condylar fracture. If the tympanic membrane is perforated the blood may be from a middle cranial fossa fracture.