2 The symptoms, signs and emergency management of major injuries

This is the only chapter in this book that contains advice about management. To describe the relatively small number of symptoms and signs that accompany the failure of the body's life-supporting systems without describing how, in emergency circumstances, these system failures should be treated from the moment the signs of failure are observed would be pointless. Furthermore, medical students, even in their early years of learning the basic clinical symptoms and signs of disease, are expected by the general public to know how to administer emergency first-aid measures to an injured patient.

The physical signs produced by injury are usually more evident and immediately significant than their history, *especially if the patient is unconscious*. Obtaining the history of the type of injury and the possible forces involved, including information on the injured person's habits, such as drug or alcohol addictions, from the patient, family members, friends, onlookers or first-aiders who witnessed the event is always helpful but must not interfere with the initial rapid clinical assessment and resuscitation.

Worldwide adoption of the principles enunciated in the Advanced Trauma Life Support course (ATLS) has established the value of a standardized approach to trauma assessment and management, especially in patients who have sustained injuries to more than one of their systems. This chapter follows the ATLS approach.

Some injured patients are brought directly to the accident and emergency department by ambulance, some severely injured patients may be brought in by private vehicles, or even walk into hospital, others may be given treatment at the site of the event. Even when an initial assessment has been made at the site of the event, it must be repeated in the hospital. When ambulance staff are involved, they may radio ahead and warn of their casualty's likely injuries, a measure that allows the trauma team to be alerted and immediately available. Patients presumed to have sustained major injuries should be taken straight to the resuscitation area for their primary hospital survey.

Even patients thought to have minor injuries should be carefully assessed by an experienced nurse or doctor as soon as possible, as apparently stable patients may have sustained serious injuries, which may have passed undetected during the initial assessment, especially when an influx of many injured patients overwhelms local resources.

THE PRIMARY SURVEY AND MANAGEMENT AT THE SITE OF THE EVENT: FIRST-AID

This is carried out under the three easily remembered headings of **A**, **B**, **C**, i.e.:

- **A**irway
- **B**reathing
- **C**irculation.

This approach is particularly important when assessing patients with multiple injuries.

Airway

The signs of an obstructed airway are **cyanosis** (blue), **apnoea** (not breathing) and **stridor** (a rasping noise on respiration).

It is essential to protect and secure an adequate airway. The lungs cannot oxygenate the blood if the airway is obstructed by the jaw and tongue falling back, swollen soft tissues, direct damage to the upper airway, false teeth, vomitus or blood.

The airway of unconscious patients lying on their back often becomes obstructed by their own intra-oral soft tissues, but before they are rolled into the supine or semi-prone position, or the neck extended, always consider, and if possible exclude, an associated cervical spinal injury

All patients found to be unconscious after an injury must be assumed to have an associated injury of their cervical spine because abrupt or careless turning may further dislocate or sublux a cervical vertebra and injure the spinal cord when no injury existed, or turn partial cord damage into a complete transection. The neck should therefore be immobilized in all unconscious injured patients by longitudinal, manual support, the application of a hard collar and the use of stabilizing sand bags and tape before turning the patient onto their side, until clinical examination and radiographs have excluded unstable fractures of the cervical spine.

Compromises are inevitable if an immobilizing collar is not available at the site of injury. The presence of two first-aiders may allow one to support the neck while the other assesses and manually clears the airway, feels the neck and jaws, and assesses the respiratory effort by palpating the chest during respiration.

Airway obstruction is often relieved by lifting the jaw upwards, but may only be relieved by inserting a finger in the mouth and pulling the jaw or palate forward, especially when the obstruction is associated with a fractured maxilla or mandible.

An oropharyngeal or nasopharyngeal airway should be inserted as soon as possible, and then, in an unconscious patient, replaced by an endotracheal tube, inserted by an experience anaesthetist, because the absence of a gag reflex in an unconscious patient makes aspiration of saliva, vomitus or blood into the lungs a major hazard.

Breathing

If the patient remains cyanosed or apnoeic after the airway has been cleared, mouth-to-mouth resuscitation should be started immediately. This is easier and safer (from risks of cross-infections) if a Brook's airway, a facemask, an Ambu bag and oxygen are available. Mouth-to-mouth ventilation combined with external cardiac massage may, however, be life saving in patients who have undergone a short period of respiratory arrest.

There are few indications for heroic attempts at inserting home-made 'tracheostomy' devices at the scene of the accident. The patients are probably better served by a rapid transfer to hospital by experienced ambulance staff who have been trained in resuscitation techniques.

Circulation

It is absurd to concentrate on the detailed drills of assessment of the airway and breathing if the patient obviously has a normal airway and no neck injuries but is losing vast amounts of blood – even to the point of literally bleeding to death. Severe external bleeding at the scene of the accident requires manual compression directly over the wound or pressure proximal to the point of bleeding, where the feeding artery can be compressed against an underlying bony point.

Tourniquets should only be used to stop distal limb bleeding. They rarely work efficiently and often exacerbate bleeding by obstructing the venous outflow, while failing to occlude the arterial inflow.

An effective tourniquet makes the whole limb ischaemic and will cause permanent muscle and nerve damage if it is kept in place for more than 1.5 to 2 hours. Tourniquets can also theoretically cause re-perfusion problems when released – metabolic acidosis, myoglobulinuria and hypercalcaemia. Nevertheless a tourniquet can sometimes be life saving if it is applied at the correct pressure to a mangled bleeding limb for a short period. **The time of application must be carefully recorded and passed on to ambulance and medical staff.**

Direct manual pressure, provided it is achieving its desired effect (i.e. stopping or reducing the blood loss), is usually preferable to a tourniquet. This can be very tiring because it must be maintained until the patient reaches the hospital's accident and emergency department.

General first-aid advice

First-aiders should ensure that there is no immediate danger to themselves before approaching a casualty.

Many injured patients are best served by leaving them where they are until experienced help arrives, provided the environment is not continuing to damage or threaten them. Provided the injured patient has a strong pulse, is breathing normally and is not overtly bleeding, this is invariably the correct course of action. Patients should only be moved if there is a risk of further injury from leaving them where they are, e.g. inside a burning car.

It is, of course, important to obtain help as soon as possible so that there is always someone available to stay with the patient to monitor their pulse and breathing and provide moral support. The widespread availability of mobile phones has improved the first-aider's ability to summon help.

Under no circumstances should an injured patient be given anything to eat or drink.

THE PRIMARY SURVEY IN THE ACCIDENT AND EMERGENCY DEPARTMENT

All patients who are unconscious or suspected of having multiple or serious injuries should be admitted directly to the resuscitation area of the accident and emergency department. While medical students are rarely required to have an active role in the management of acute trauma, the opportunity to witness assessment and resuscitation in this setting is extremely valuable, as the principles of the process are relevant to many other areas of medical practice.

The clinical assessment (history and examination) and resuscitation must occur simultaneously if lives are to be saved, hence the inclusion of treatment in this chapter.

The routine A, B, C assessment must be repeated whatever happened before the hospital admission.

Airway

The neck must be protected by a collar and immobilized fully using sand bags and tape. An anaesthetist should assess the need for better control of the airway.

Look for the signs of inadequate oxygenation

Respiratory distress, apnoea, cyanosis, loss of consciousness and the presence of **major facial, neck or chest injuries that might obstruct the airway** may all indicate the need for endotracheal or naso-gastric intubation once the neck has been stabilized.

Look for the signs of inadequate ventilation

The chest should be uncovered and palpated to assess **respiratory movements**. Confirm the presence of **air entry** into the lungs with a stethoscope.

The neck and jaws should be palpated to check for deformity. Insert a finger into the mouth to extract any foreign bodies and to check for jaw fractures. Occasionally severe damage to the upper airways or trachea makes intubation impossible. An emergency tracheostomy is indicated if the patient is deeply cyanosed or apnoeic and an endotracheal tube cannot be inserted safely.

Breathing

Assess the condition and function of the thoracic cage

Once you are certain that the airway is patent, assess the adequacy of ventilation by inspecting, palpating, percussing and listening to the chest for **symmetry, movement, dullness** and **breath sounds**. Patients with multiple injuries or chest problems causing hypoxia should be given high-flow oxygen through a closed circuit oxygen mask from the moment of their arrival in the accident and emergency department. An oxygen saturation monitor placed on an extremity is a valuable means of assessing the effectiveness of the patient's ventilation.

Inspection and palpation

The presence of **open wounds** or **flail segments** in the chest indicates the need for a chest drain and positive-pressure ventilation. A flail segment occurs when several ribs are fractured in two places. The flail segments sink inwards during inspiration. **Bruising** over the chest indicates that rib fractures are likely, and the presence of **surgical emphysema** suggests that the pleura has been breached. Surgical emphysema presents as a crackling sensation in the subcutaneous tissues. A 'sucking' chest wound may be present.

Percussion

A **tension pneumothorax** must be suspected if breathing is difficult, the **trachea is deviated** to the contralateral side and if there is decreased air entry over the affected lung. Although the clinical diagnosis

will have to be confirmed with a chest radiograph, a chest drain should be inserted on the evidence of the clinical signs if the patient is unstable. **Bilateral tension pneumothoraces** are very rare, but cause severe cardiac and respiratory compromise, manifest as **cyanosis, severe air hunger, a weak pulse** and **hypotension**.

Remember that, with bilateral pneumothoraces, the trachea remains central but air entry is poor into both lungs. The rapid insertion of chest drains which are connected to under-water seal drainage bottles relieves the situation.

A large **haemothorax** also causes respiratory and circulatory problems, manifest as **reduced breath sounds** and a **dull percussion** note combined with **reduced vocal fremitus** and **vocal resonance**. The diagnosis should be confirmed with an erect or decubitus chest radiograph, but a chest drain may occasionally have to be inserted as an emergency measure on the basis of the clinical signs.

A large amount of blood draining from a chest may destabilize the patient and need urgent replacement into the circulation (see below), so intravenous lines should be inserted into both antecubital fossae before a haemothorax is drained. The chest drain may occasionally need to be clamped to prevent massive continuing blood loss. Lost blood should be replaced with a crystalloid solution at first, but subsequently with blood as soon as this is available (see below).

The blood pressure must be carefully and continuously monitored to confirm the adequacy of any blood volume replacement.

Flail segments rarely cause major problems initially but are indicative of a severe **underlying lung injury**. Both these problems are treated by endotracheal incubation and positive-pressure ventilation, but it must be remembered that this can cause a tension pneumothorax and may also make an existing tension pneumothorax worse. This complication should be suspected if the anaesthetist notices an increasing resistance to ventilation, a decreasing oxygen saturation and signs of circulatory embarrassment. Decreasing air entry and breath sounds indicate the need for chest drainage.

Circulation

Restoration of the circulation may take precedence over the airway and ventilation if the patient is breathing satisfactorily. It can be assessed simultaneously with the airway and breathing if an experienced anaesthetist is available to manage ventilation.

There are two major causes of circulatory embarrassment – cardiac damage/tamponade and haemorrhage. The former is rare but life threatening and easily missed. It must therefore be briefly considered in all patients with major injuries, especially in those with penetrating injuries of the chest.

Cardiac tamponade

Cardiac tamponade occurs when large quantities of blood collect within the pericardial cavity, around the heart, and embarrass its action. This reduces the cardiac output, producing a **weak pulse** and **hypotension**. The condition should be suspected if the **jugular venous pressure is markedly elevated and rises rather than falls with inspiration** (*Kussmaul's sign*); however, jugular venous distention may not occur in a patient who has lost a large quantity of blood.

Pulsus paradoxus, when the pulse volume decreases on inspiration rather than increasing, may be present. The heart sounds are usually muffled and poorly heard.

Chest radiographs may show an enlarged cardiac shadow. An echocardiogram will confirm the diagnosis.

The patient's condition may be stabilized by aspirating the blood from the pericardial sac using echocardiography and electrocardiography to ensure correct placement of the needle and catheter before definitive surgery is undertaken.

Revealed haemorrhage

Visible arterial bleeding presents as **a pulsating stream of bright red blood** coming from an open wound, whereas **venous bleeding is dark and continuous**. Arterial haemorrhage from an open wound can usually be controlled by direct digital pressure or proximal arterial compression. Sterile vascular clamps can be applied directly to bleeding arteries for temporary control before definitive surgery if these simple measures fail.

Venous bleeding always responds to simple pressure and may be made worse by the application of a tourniquet.

Revealed bleeding should always be assessed and controlled as soon as possible. There is no point in pouring fluid and blood into the circulation through

intravenous catheters when an equal amount is rapidly escaping.

Concealed (internal) haemorrhage

Concealed haemorrhage is much harder to diagnose and therefore must be suspected in all patients with multiple or serious injuries. It always accompanies major fractures of long bones and fractures of the pelvis. It must, if possible, be rapidly diagnosed and treated, as it is an important, potentially irreversible, cause of death in an injured patient.

Clinical signs of haemorrhage

The diagnosis is based on finding the signs of hypovolaemic shock – **a pale, anxious, sweaty patient** with **cold extremities**, a **rapid, thready pulse, tachypnoea** and **hypotension**. These signs occur when the body redistributes the circulation in an attempt to maintain the blood flow to the vital organs (heart and brain). Other organs, such as the skin, intestine and kidneys, become inadequately perfused and poorly oxygenated. This homeostatic response is brought about by the sympathetic nervous system causing a tachycardia and vasoconstriction in the extremities. The skin becomes cool and clammy. The systolic blood pressure is usually maintained at first, but the pulse pressure (the pressure difference between systolic and diastolic pressures) may be reduced by a rise in the diastolic pressure. The rate of respiration increases to try to improve oxygenation.

Patients who arrive in the accident and emergency department without overt haemorrhage but who exhibit these signs have almost certainly lost 1–2 litres of blood. It is important to remember that young, fit patients can often tolerate considerable blood loss before they develop, often very suddenly, any signs of hypovolaemic shock, whereas elderly patients, especially those on beta-blockers or digitalis, tolerate quite small amounts of blood loss less well.

All seriously injured patients must have their pulse rate, blood pressure, respiratory rate, level of consciousness and tissue oxygenation monitored continuously. Patients with an associated head injury must be monitored using the Glasgow Coma Scale (see Revision panel 1.3, page 12). A urinary catheter and the measurement of central venous pressure provide additional valuable information for monitoring resuscitation when there are signs of hypovolaemia. An intra-arterial pressure line is also very useful for continuously monitoring the blood pressure, and allows easy sampling of arterial blood for blood gas and acid/base measurement.

Once blood loss is suspected, the patient must be given immediate fluid replacement through two wide-bore cannulae inserted into the veins of the cubital fossae. Fluid can be given faster through a central venous catheter if this has been inserted for monitoring purposes and is not contra-indicated by the presence of neck and chest injuries. One to two litres of crystalloid (normal saline) or colloid should be given *after* sending a sample of the patient's blood for grouping and cross-matching. For patients with clear signs of shock, request at least 4 units of blood.

Patients who fail to respond to the rapid restoration of their blood volume in the absence of cardiac or major respiratory problems, e.g. tamponade or tension pneumothorax, probably have severe continuing blood loss. In these circumstances the blood transfusion should be started while making a rapid assessment of the potential sites of concealed blood loss. The most common are the pleural or abdominal cavities. Fractures of the pelvis can also cause catastrophic blood loss.

The retroperitoneum can contain litres of blood with few external physical signs.

A rapid clinical examination looking for chest dullness, abdominal distension and abdominal tenderness (if the patient is conscious) should be followed by chest radiography, insertion of chest drains and computerized tomography (CT) scanning of the torso or peritoneal lavage where indicated. Properly warmed Group O Rh-negative blood or, as a last resort, uncross-matched blood can be given if the situation is dire. The patient should be transferred to an operating suite once the site of blood loss has been established.

Echocardiographs and electrocardiographs (ECGs) can be helpful if cardiac injury or coincidental cardiac disease is suspected. The ECG leads should be kept connected to a monitor for the detection of any dysrhythmias. A cardiac contusional injury should be suspected if there is widespread ST segment elevation or depression. Very occasionally, an emergency thoracotomy in the accident and emergency department may be required to

relieve a tamponade, to suture a penetrating wound of the heart or to clamp the hilum of the lung or the descending aorta to prevent massive blood loss.

These heroic attempts are seldom successful. Rapid transfer to an operating theatre with trained staff, proper instruments and adequate lighting increases the chances of success.

THE SECONDARY SURVEY

Many injured patients do not deteriorate catastrophically. The majority stabilize rapidly after being resuscitated with intravenous fluids. This favourable response provides time to carry out a full secondary survey to assess other systems and body parts which may have been injured and to assess the general fitness of the patient. It is important to continue monitoring the patient while the secondary survey is being carried out to detect any further or new bleeding or chest problems.

The whole patient must be examined from the top of the head to the toes. Other blood tests, investigations and diagnostic procedures should be undertaken as necessary after the secondary survey is complete. Adequate analgesia may be needed before beginning the secondary survey, especially in fully conscious patients in whom the primary survey and resuscitation have been quickly completed.

History

A detailed history should be taken from a stable, conscious patient at this stage. It is helpful to ask the patient what they remember of the accident and useful if they can describe what happened. The mechanism of the injury and the possible physical forces involved often give a useful indication of the site and severity of the damage. Knowledge about the height of a fall, the speed of a car, the use of guns or knives, the presence of an explosion or fire and the use of protection devices such as seat belts or airbags is often helpful. If the patient is unconscious, obtain the observations and views of family, friends, bystanders or paramedics.

Pain, dysfunction and malfunction

The conscious patient should be asked if they have any localized areas of pain or malfunction, which may indicate particular areas or systems that require more detailed examination.

Conscious patients must also be asked if they had experienced any loss of consciousness during or after the injurious event. Their cognitive function should be quickly tested by asking a few questions about who they are, where they live and their occupation. The history from a third party of a lucid interval is also helpful if the patient is unconscious.

General and previous history

Take a full history of previous illnesses, operations, drugs and allergies (see Chapter 1). The patient's general fitness, occupation, tobacco and alcohol usage should be recorded following a full systematic enquiry.

Record the time that the patient last ate or drank. This is very important if the patient is to have a general anaesthetic.

General examination of a conscious patient

The head

Scalp The scalp must be inspected and palpated for lacerations, swellings, bony depression and distortion.

Orbits Palpate the margins of the orbits for depressions or irregularities.

Eyes Examine the eyes for pupil size, reaction and red-reflex. Test the eye movements and visual acuity (see Chapter 1).

Occasionally a corneal injury may lead to loss of the anterior chamber and prolapse of the iris, with an obvious collection of blood behind the cornea.

The presence of a large **subconjunctival haemorrhage** (see Fig. 8.17, page 229) that spreads to the full extent of the conjunctival attachment suggests that there is a fracture of the base of the skull. **Panda eyes** (black circumorbital haematomata around one or both eyes) (see Figs 2.1 and 8.17, pages 42 and 229) also suggest the presence of a skull base fracture or a fracture of the upper jaw. **Diplopia**, especially on looking up, is indicative of a blow-out fracture of the floor of the orbit, which often allows the eyeball to sink inwards, giving the upper face an asymmetrical appearance.

Signs of intracranial haemorrhage

A **fixed dilated pupil** which fails to respond to light indicates third nerve compression, by a contralateral

FIG 2.1 'Panda eyes'. Extensive peri-orbital extravasation of blood from a fracture of the base of the skull.

extradural haemorrhage or a direct injury to the optic nerve. Deterioration of the patient's score on the Glasgow Coma Scale – which quantifies eye opening, verbal response and motor response – and/or agitation indicate increasing cerebral compression. The patient is in 'coma' if their Glasgow Coma Score is less than 8.

Loss of upwards gaze, other cranial nerve pareses or developing contralateral hemiplegia are indicative of a cerebral haemorrhage.

Observations should also be made on the patient's mental state, including whether they are agitated or confused. A rising blood pressure, a falling pulse and slowing of respiration suggest **coning**, a condition in which the swollen brain is forced down through the medullary foramen, with subsequent loss of all vital functions. An urgent CT scan should be obtained.

The face Major facial injuries often cause considerable orbital oedema, but it is very important to retract the lids carefully, using two people if necessary, to look for any of the features described above. The cheek bones should also be palpated for a **'step'** and any asymmetry noted. Fractures of the zygoma and blow-out fractures of the orbit have to be confirmed by radiographs, but loss of sensation over the cheek from damage to the infra-orbital nerve strongly suggests a fracture of the cheek bones. Instability of the maxillary zygomatic process (a LeFort-type fracture) is tested by inserting a gloved finger or thumb into the mouth and attempting to pull the upper jaw complex forward from the base of the skull. A fracture is present if rocking occurs. This needs to be done with care, as forceful rocking may cause a massive pharyngeal bleed, which can only be controlled by pushing the whole bony facial complex backwards to compress the bleeding vessels.

The lower jaw and its stability on the temperomandibular joints must also be assessed. Malocclusion and an open-bite deformity suggest a fractured jaw, as does numbness of the lower lip.

Carefully palpate and inspect the mouth, teeth and gums and record the number of missing or damaged teeth. Missing teeth indicate the need for a chest X-ray, if this has not already been performed, to exclude the possibility that they have been inhaled and are lodged in the lung.

The nose, face and ears The nose should be palpated to exclude a fracture and detect the presence of any bloody or clear fluid discharge of cerebrospinal fluid which would suggest the presence of a fracture in the anterior cranial fossa (often associated with panda eyes and an extensive subconjunctival haemorrhage).

The facial muscles (VIIth cranial nerve) and auditory acuity should be tested.

Blood or fluid coming from the ear suggests the presence of a posterior fossa fracture. The tympanic membrane must be examined with an auroscope. Bruising behind the ear (*Battle's sign*) (see Fig. 2.2) suggests a fracture in the posterior cranial fossa. Skull radiographs, specific facial views and CT scans are usually required to assess these injuries.

The neck The importance of not causing or exacerbating any spinal cord damage, especially during airway assessment, endotracheal incubation or moving the patient, is now well recognized. A full radiological assessment of the cervical spine should be carried out as soon as the patient is relatively stable if there are any concerns that the spine may have been damaged.

Pain and **local tenderness** are suggestive of a cervical fracture, but there may be few, if any, physical signs, and further assessment may have to be delayed until the condition of the cervical spine has been established. If the spine is normal, the neck can be carefully palpated for bruising and deformity

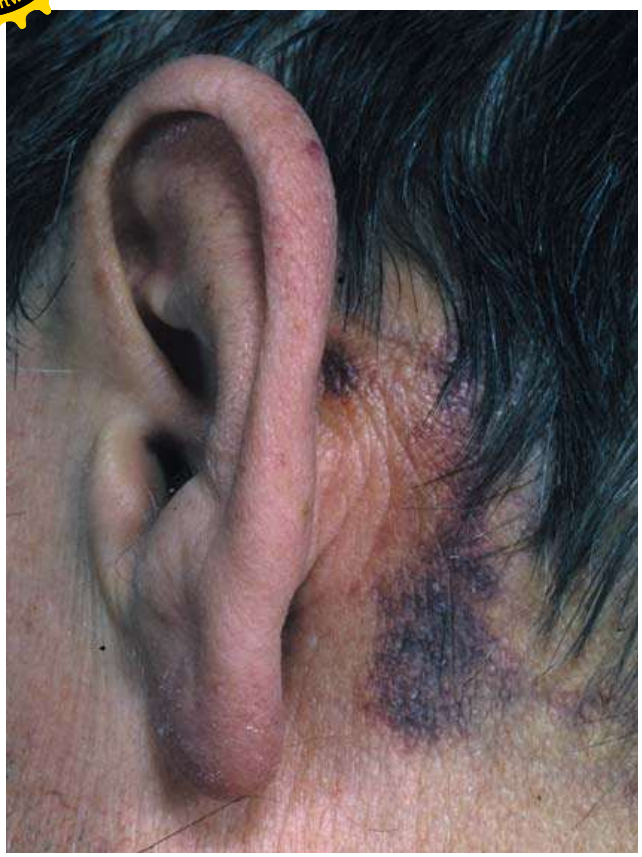

FIG 2.2 Battle's sign. Bruising behind the ear suggests a fracture in the posterior cranial fossa.

and inspected for any penetrating wounds. The position of the trachea in relation to the manubriosternal notch should be assessed to see if it is central.

Gentle palpation should detect the presence of any subcutaneous **surgical emphysema** in the neck or supraclavicular fossae.

Penetrating descending wounds of the root of the neck can be very dangerous, as they may cause damage to the supra-aortic blood vessels – the carotid, vertebral and subclavian arteries – as well as to the trachea, larynx, pharynx and oesophagus. Major structures within the upper chest can also be damaged. The presence of neurological signs or ischaemia of the upper limb suggests a major arterial injury, as does a rapidly expanding haematoma or a machinery murmur. Neck wounds should be explored in the operating theatre.

The clavicle should be palpated along its course. Severe **compound clavicular injuries** are often associated with injuries to the subclavian or axillary vessels, the brachial plexus and the apex of the lung.

Examine the vascular supply and peripheral nerves of both upper limbs to exclude these possibilities.

The chest Although the chest was quickly assessed as part of the primary survey, it should now be carefully re-examined by inspection, palpation, percussion and auscultation to detect any minor signs that may have been missed at the time of the initial examination and treatment when speedy resuscitation was essential. New signs may have developed and subtle signs may have been missed.

Test again for rib fractures. A careful inspection may detect a small flail segment. The chest should be 'sprung' by compressing it with both hands, anteroposteriorly and from side to side, and then quickly releasing. Pain on compression or release indicates the likelihood of rib fractures or costal cartilage separation from the ribs or sternum. Both can then be more accurately localized by detailed palpation. It should be remembered that rib fractures are often associated with injuries to the great vessels, lungs, spleen or liver.

The sternum must also be inspected and palpated. Sternal fractures are often associated with cardiac injuries.

Check again for the presence of a **haemothorax, pneumothorax** and **cardiac tamponade**, taking particular care to look for small pneumothoraces and an increase in the width of the mediastinum, which may be the only indication of an aortic dissection. A chest radiograph should always be obtained if there is any question of a chest injury. CT chest scans are even more accurate in detecting minor abnormalities and rib fractures.

The abdomen The primary survey of the abdomen usually detects the signs of major intra-abdominal haemorrhage, but a secondary survey is essential to pick up continuing severe haemorrhage or further bleeding following the restoration of a normal blood pressure.

Increasing **abdominal distension, tenderness** and **guarding** are all significant signs, especially when associated with a rising pulse and other signs of hypovolaemia.

The bowel sounds may or may not be abolished by free blood or bowel contents in the peritoneal cavity.

Skin bruising over the abdomen, penetrating wounds and associated rib fractures all indicate the possibility of abdominal organ damage. When doubt

persists, ultrasound, CT scanning or peritoneal lavage may be indicated. A CT scan is very useful if there is an associated pelvic fracture.

Blood coming from the external urethral meatus or frank haematuria suggests kidney, bladder or urethral damage. Rectal and vaginal examination can confirm a high-riding and boggy prostate or associated vaginal injuries. The presence of these injuries must always be excluded before allowing catheterization by inexperienced junior staff or nurses. It may be preferable to insert a suprapubic catheter if palpation or percussion detects a large bladder, especially if the prostate feels abnormal or blood has been seen coming from the urethra.

Pelvic fractures are commonly associated with severe shock and with tenderness on springing the pelvis by pressing back on both iliac crests and releasing.

The upper and lower limbs All surfaces of the limbs must be fully inspected and the presence of bruising, lacerations, instability and deformity carefully noted. All the major bones should be carefully palpated along their full length to detect any bony deformity and swelling that were not appreciated by the inspection. The only indication of an undiagnosed, undisplaced fracture may be the detection of a localized point of tenderness. Major fractures are almost always associated with some deformity together with swelling from the associated bleeding.

The circulation Signs of hypovolaemic shock are common. The radial and pedal pulses should be felt and compared. The presence of equal symmetrical pulses indicates that a major vascular injury in the limbs is unlikely (see Chapter 7). Unfortunately, the peripheral pulses are often difficult to feel in a shocked, cold patient with severe limb bruising and concomitant fractures. When the pulses cannot be felt in an adequately resuscitated patient, it is helpful to measure the arterial pressure with a Doppler flow detector (see Chapter 7). Persisting pallor, especially if it only affects one limb, is a sign of severe ischaemia. The presence of a compartment syndrome must always be considered when there are combined bony and vascular injuries. This condition may also follow the successful surgical re-vascularization of an injured limb. Compartment syndromes begin with pain, tenderness and swelling over the anterior shin or calf muscles. The swelling can exacerbate the ischaemia, obliterate the pulses and lead to muscle and nerve death if left untreated.

The nerves The peripheral nerves must be fully examined in both the upper and lower limbs if the patient is conscious. Test power, tone, coordination, sensation and the reflexes. Test the movement of joints controlled by the major muscle groups. Test sensation by the response to light touch and pinprick. Always test and document the peripheral nerves beyond any laceration. A more detailed neurological examination should be carried out if abnormal neurological signs are detected, or if the patient is unconscious (see below).

The back (thoraco-lumbar spine) The discovery of paralysis or weakness of several muscles may be the first indication of a spinal cord injury. The patient must then be carefully immobilized and 'log rolled' by a team of staff to allow examination of the spine. Log rolling allows turning of the patient in a coordinated manner that keeps the spine immobilized at all times. Detailed radiographs and even CT scans may be required if a spinal fracture or spinal cord injury is suspected. Palpation down the back over the spinous processes may detect a boggy swelling, deformity or a 'step' in the regularity of the spinous processes. While the patient is on their side, take the opportunity to inspect and palpate the back of the head, neck, torso and limbs to exclude any major injuries to this surface of the body which may have passed unnoticed at the initial survey. A rectal examination should be performed at this stage and peri-anal sensation, motor function and sphincter tone and the bulbo-cavernosus reflex tested.

The secondary survey in the unconscious patient

The secondary survey in an unconscious patient should begin with a reappraisal of the Glasgow Coma Scale to discover if the level of consciousness has changed from the initial assessment. This is important, as the whole purpose of resuscitation and assessment is to rectify factors such as hypotension or hypoxia that could cause neurological deterioration while trying to detect the presence of an intracranial haemorrhage, which can usually be treated effectively. Any suggestion of a 'lucid interval' – a period of consciousness after the injury before the patient became

unconscious – is an important sign of a developing intracranial haematoma. Monitoring of the Glasgow Coma Scale must be carried out at frequent intervals in comatosed patients with a score of 8 or less. Patients must be frequently asked to open their eyes and move their limbs. If they do not respond, apply a painful stimulus by pressing hard on the bone of the upper orbit or the manubrium sterni. An ability to **localize pain** is accepted if the patient moves one or other hand to try to push away the painful stimulus, whereas flexion or, worse still, extension of the upper limbs indicates a severe brain injury.

Verbal responses are impossible to assess in patients who are anaesthetized, intubated or have suffered severe facial injuries. It must also be remembered that some head-injured patients may be mentally defective, some may have taken an overdose of drugs or alcohol, and some be unable to understand your language.

A detailed neurological examination should be carried out to discover if there are any focal neurological signs indicative of brain injury or an expanding intracranial haematoma. This should start with the examination of the size, symmetry and reaction to light of the pupils. If the brain is shifted to one side by an expanding haematoma, the **ipsilateral third nerve** becomes compressed against the rigid free edge of the tentorium cerebelli. At first this causes slight **constriction of the pupil**, but then, later, **dilatation** and eventually a **failure to respond to a bright light** being shone directly into it.

If left untreated, the haematoma will continue to expand and force the brain down through the tentorium and into the foramen magnum. The **contralateral pupil** then becomes **dilated** and **unreactive**. Eventually compression of the medulla causes **bradycardia**, a **rising blood pressure** and **depressed respiration**.

Do not forget that optic nerve injuries, previous eye disorders and drugs can also cause the pupil to be unresponsive.

Neurological examination of the limb should concentrate on detecting any evidence of hemiplegia. Unilateral paralysis, increased muscle tone, brisk reflexes and upgoing plantar reflexes on the contralateral side of the injury all indicate that a haematoma is present.

Intracranial haematomata outside of the substance of the brain develop in two sites.

- **Extradural haematomata** are usually the result of haemorrhage from the middle meningeal artery. This is often caused by a linear temporoparietal fracture of the skull. Patients are often briefly knocked unconscious or dazed by the initial injury, but then regain consciousness (the lucid interval) before becoming drowsy and eventually losing consciousness. As the intracranial pressure rises, patients may complain of a **headache**, **blurred vision** and **vomiting**. At this time, the localizing signs described above begin to develop.

  It must be remembered that some patients develop an extradural haematoma without a lucid interval and without the classic progression of neurological signs. The certain indicator of deterioration is a progressive reduction of their Glasgow Coma Scale score. A CT scan will confirm the diagnosis.
- **Subdural haematomata** can be classified as either acute or chronic.

Acute subdural haematomata are invariable associated with major brain injury when torn vessels on the surface of the brain continue to bleed into the subdural space. Patients are usually deeply unconscious and develop neurological localizing signs. It is very difficult to differentiate an acute subdural haematoma from an intracerebral haemorrhage, cerebral oedema or diffuse axonic injury. A CT scan of the head is essential.

Chronic subdural haematomata usually occur in elderly patients after a minor injury which tears a vein on the surface of the brain that bleeds slowly but persistently for days or weeks. They are also common in alcoholics and patients on anti-coagulants. Patients often present with fluctuating levels of consciousness, worsening over several days or weeks. The raised intracranial pressure may cause **headache**, **vomiting**, **blurred vision** (papilloedema) (Fig. 2.3), **personality change** and **drowsiness**. Pupil changes and some neurological localizing signs are usually present. The diagnosis is confirmed by a CT scan of the brain.

Brain death

A number of patients with severe head injuries develop brain death or a persistent vegetative state. In brain death the brain stem is irreversibly damaged.

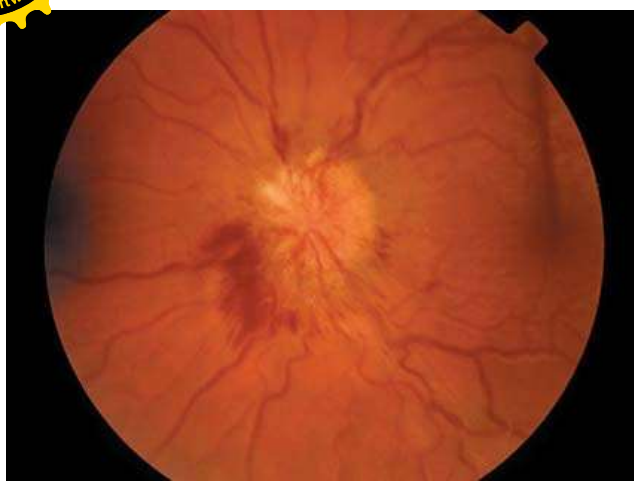

FIG 2.3 Papilloedema, a diagnostic sign of a chronically raised intracranial pressure most often caused by a space-occupying intracranial tumour or a chronic subdural haematoma. (Courtesy of Dr E Graham.)

In a vegetative state the brain survives but there is severe cortical damage. Patients with a persistent vegetative state can survive on or off a ventilator for many years. Recovery can occur after several months, but becomes increasingly unlikely as the months pass, especially if there are localizing or generalized signs of brain injury.

A number of criteria must be fulfilled to confirm brain death. Patients must be normothermic and off all drugs. Brain-dead patients are apnoeic and deeply comatosed. They have no pupillary response to light and the corneal reflexes are absent. They have no response to pain or to movement of the endotracheal tube when off all sedation. The final test is to look for the presence of a caloric vestibulo-ocular response. The external auditory meatus is syringed with ice-cold water, which normally causes nystagmus. When this does not occur, brain death is confirmed and relatives must be appropriately counselled. Brain-dead patients are the main source of organs for transplantation.

Assessment of multiple casualties

All hospitals should have a major accident plan in which the roles of accident and emergency doctors, other medical staff, nurses, theatres, telephone staff, managers and press liaison officers are all clearly defined. These plans should be tested from time to time to assess their effectiveness and encourage familiarity. Each patient must be carefully assessed by the techniques described above into dead, immediate life-threatening injuries, those with major injuries and those who can be called the 'walking wounded'.

Scoring systems

There are a number of scoring systems which have been developed to try to improve management and outcome of patients who have been injured. These allow the results of individual centres to be compared against one and other. The **Revised Trauma Score** is probably the best measure. It allows an audit of outcome against expected recovery or likely death. Any variation from the expected outcome should be critically examined to discover if earlier diagnosis or more efficient resuscitation or treatment would have achieved a better result.