4

TRAUMA, SHOCK, HEAD INJURIES AND BURNS*

TRAUMA

Imagine yourself being faced with a multiply injured patient with trauma to the head, chest, abdomen and limbs. Where would you start? What if there were several injured patients, which would take priority?

The Advanced Trauma and Life Support (ATLS®) course was developed following a tragedy. In 1976 an orthopaedic surgeon who was piloting his own plane over rural Nebraska crashed in a cornfield. His wife died instantly and three of his four children sustained critical injuries. They were taken to the nearest medical facility, the surgeon was appalled at the poor quality of care that he and his family received and felt that a system was needed to improve the care of trauma patients.

Causes of Death in Trauma

There is a trimodal distribution of death following injury. The *first peak* occurs at the time of the injury, usually due to severe lacerations of the brain, heart or large blood vessels, and the patient is usually dead before arrival at casualty. Prevention by methods such as seat belts, crash helmets and speed limits is the only effective way of reducing these deaths.

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The *second peak* occurs within minutes to hours of the injury. Injuries such as a tension pneumothorax, blood loss and intracranial bleeds account for this peak. These deaths are potentially reversible with immediate medical management.

The *third peak* of deaths occurs several days to weeks after the incident, due to sepsis and multiorgan failure. The care provided during the initial resuscitation and subsequent period directly affects the outcome of this group.

The concept behind ATLS® is to treat life-threatening injuries first and all other injuries in order of priority, and since a blocked airway kills within seconds this clearly should have first priority; likewise, a tension pneumothorax will kill before bleeding from a wound.

The ATLS® approach is divided into a *primary* and a *secondary survey.* In the *primary survey*, life-threatening injuries are identified. In this chapter we study *assessment* and *resuscitation* separately, although in reality they take place simultaneously (i.e. life-threatening injuries are treated as soon as they are identified). The *secondary survey* is a more thorough head-to-toe examination.

The patient is continuously *re-evaluated* until they are stable and a definitive care pathway can be instituted.

Primary Survey

As the patient arrives there is usually some history available — if not from the patient, then from witnesses or the ambulance crew. Their vital signs from when first seen by the paramedics until the time of arrival in the A & E department should be noted.

The primary survey is a rapid evaluation; the mnemonic ABCDE is used to allow one to think in an ordered and prioritised manner.

A — Airway with cervical spine control
B — Breathing and ventilation
C — Circulation with haemorrhage control
D — Disability
E — Exposure and environment

Airway with Cervical Spine Control

In anyone with an altered level of consciousness or injuries above the clavicles, suspect a cervical spine injury. The patient's head should be supported by a hand on either side to prevent any movement (in-line manual immobilisation), and when possible a semirigid collar should be applied with two sandbags on either side of the head with tape across them to hold them in place.

The airway should be checked to see if it is patent or if there are signs of airway obstruction. Listen for noisy breathing, look for obvious facial trauma, and inspect for foreign bodies.

Breathing

Assess the respiratory function. Inspect and palpate for tracheal deviation, expansion of the lungs and for any lacerations, rib fractures or flail segments. A flail chest, commonly asked about in exams, is a segment of the chest wall that, owing to multiple fractures, has no bony continuity with the rest of the thoracic cage. The flail segment moves paradoxically with the rest of the chest (i.e. it moves in on inspiration and out on expiration). The hypoxia that results is usually not due to the flail segment alone but more to the underlying contusion to the lung and hence mismatches between ventilation and perfusion.

Circulation with Haemorrhage Control

Assess the level of consciousness, pulse, blood pressure, respiratory rate, skin colour and capillary refill time (see page 55). Hypotension following injury must be assumed to be due to hypovolaemia until proved otherwise.

During the primary survey any external severe bleeding points should be controlled by applying a sterile pressure dressing or a pneumatic splint. Tourniquets are usually avoided, as they cause crush injuries and distal ischaemia.

Internal bleeding should be suspected and you should examine systematically for all of the common causes, such as an intrathoracic or intra-abdominal bleed or a fractured pelvis and/or femur. A bleed into the cranial cavity will by itself not cause hypovolaemia.

Disability

This is a rapid neurological evaluation assessing the patient's level of consciousness and the pupil size and response to light. The mnemonic AVPU is used as a quick assessment of the patient's level of consciousness. If, for example, the patient responds only to pain, then his AVPU score is P.

A — Alert
V — responds to Verbal stimuli
P — responds to Painful stimuli
U — Unresponsive

The Glasgow Coma Score (GCS) is a more detailed neurological evaluation that can be done during the primary survey although it takes a little longer, and because the life-threatening A, B and C take precedence in the primary survey the GCS may be performed in the secondary survey (see section on head injury for details).

A decreased level of consciousness may be due to many factors, including cerebral injury, hypoxia and shock. It may also be secondary to alcohol and drugs, although head injury, hypoxia and shock must be excluded first.

Exposure

Completely undress the patient (cut off the clothes as appropriate), inspect the entire skin surface for evidence of injury, such as bruising, abrasions or lacerations. A log roll should be performed with in-line cervical spine immobilisation (i.e. the head is supported and turned in line with the patient to prevent any displacement of the cervical spine). The entire vertebral column is palpated down to the coccyx for tenderness and a rectal examination is performed.

During the primary survey a series of X-rays are taken, called the 'Trauma Series', which include a lateral C-spine, chest and pelvic X-rays. An ECG is usually taken.

A nasogastric tube should be considered (note: contraindicated if a cribiform plate fracture is suspected as the tube could enter the cranial vault and an orogastric tube may be used instead) and urinary catheter should also be considered (note: during the rectal examination, a high-riding prostate or any sharp bony pelvic fragments might indicate a urethral transection which would mean trans-urethral catherisation is contraindicated). Other signs to suggest a urethral injury: blood at the urethral meatus or a scrotal haematoma. If a urethral transection is suspected then a retrograde urethrogram can be performed and a supra-pubic catheter might be needed.

RESUSCITATION

As mentioned above, this is carried out simultaneously during the primary survey.

Airway

Every injured patient should receive supplemental oxygen; however, the airway must be patent and protected in all patients. There are five things you can do to ensure a patent airway; always start with simple measures, such as the chin lift, and progress through the following list until oxygenation is adequate. Apply an oxygen mask with a reservoir (to allow about 85% oxygen).

1. *Chin lift or jaw thrust*. In the supine position the tongue naturally falls back, obstructing the hypopharynx. These procedures bring the tongue forward, opening up the airway. In the chin lift the chin is grasped between the first finger and the thumb. The chin is then lifted gently

and brought anteriorly (being careful not to hyperextend the neck). In the jaw thrust manoeuvre the angles of the mandible are grasped by hand on each side and the lower jaw is brought forward.

2. *Guedel airway*. If breathing is still noisy, you can maintain the airway by inserting an oropharyngeal airway, such as a Guedel airway (an S-shaped plastic tube). The size should correspond to the distance from the centre of the patient's mouth to the angle of the jaw. It is sometimes put in upside down and rotated when it is past the tongue.
3. *Nasopharyngeal tube.* If the patient is conscious and has a gag reflex, they will be unlikely to tolerate an oropharyngeal airway. In this case a nasopharyngeal airway can be tried, as it is better tolerated and less likely to induce vomiting, although many conscious patients will not tolerate either and may need to be anaesthetised and intubated.
4. *Intubation.* This is called a definitive airway, which means a tube is inserted into the trachea with a cuff inflated to prevent aspiration; the whole thing is secured with tape and oxygen is connected. A definitive airway can be an orotracheal tube, a nasotracheal tube or a surgical airway (see below). A definitive airway is needed if the patient is not breathing, or is unable to maintain an airway with the above measures, or if there is impending airway compromise (as in inhalation injuries) or in a head injury requiring hyperventilation. Since CO_2 is produced in the lungs you can confirm that the tube is in the trachea by measuring the end tidal CO_2 tension. If the tube was mistakenly placed into the oesophagus then the CO_2 gas pattern would be absent. Proper placement of the tube is also checked by listening for bilateral air entry (i.e. if the tube is in the right main bronchus, then no air entry will be heard on the left).
5. *Surgical airway.* If you are unable to intubate (for example, in severe facial trauma) then a surgical airway is indicated. A tracheostomy is difficult to perform and is time-consuming, and so a needle cricothyroidotomy can be performed [a large-caliber cannula is inserted through the cricothyroid membrane into the trachea (feel for Adam's apple, and move your finger downwards till you come to the first gap between the thyroid and cricoid cartilages)]. Oxygen is then connected to the airway.

A needle cricothyroidotomy will only buy a short amount of time and must be converted to a surgical cricothyroidotomy by widening the incision and placing a cuffed endotracheal tube into the space between the thyroid and cricoid cartilages (if you are ever asked about the difference between tracheostomy and a surgical airway, note that a tracheosttomy is placed into the trachea at about the level of the second or third tracheal ring and is a much longer procedure as the thyroid gland has to be divided and is therefore performed in theatre when the patient is stable).

Breathing

The mnemonic 'ATOMIC' has been used to list life-threatening chest injuries, which should be identified in the primary survey:

*A*irway obstruction
*T*ension pneumothorax
*O*pen pneumothorax
*M*assive haemothorax (greater than 1500 ml)
*I*ntercostal disruption (some people modify the mnemonic to ATOM FC, where *F* stands for 'Flail chest')
*C*ardiac tamponade

A *tension pneumothorax* occurs when air enters the pleural space either from outside or from inside the lung. A one-way valve is formed by the pleura, which allows air to enter the pleural space during inspiration, but does not allow it to escape during expiration. The lung collapses, and the mediastinum and the trachea are deviated away from the affected side. The patient becomes very short of breath and cyanotic. The venous return to the heart is impaired and the signs are similar to those of cardiac tamponade (i.e. raised JVP and falling BP, but they can be differentiated by listening for breath sounds). The diagnosis is made clinically — a distressed, tachycardic patient with a deviated trachea, hyper-resonance to percussion and absent breath sounds on the affected side. You should never see a chest X-ray on patients with a tension pneumothorax, as they should have been treated immediately before waiting for an X-ray to be taken. Treatment is by placing a cannula (venflon) into the second intercostal space, midclavicular line, and hearing a hiss as the air escapes. Once this is performed the tension pneumothorax will be converted to a simple pneumothorax and the immediate threat to life is over. A chest drain should be inserted as soon as possible.

Insertion of a Chest Drain

A chest drain is inserted under aseptic technique anterior to the midaxillary line, in the fifth intercostal space. If possible (provided no cervical spine injury is suspected) the patient is sat up at 45° and the hand is placed behind their neck on the affected side to expose the field and open up the intercostal space.

If sitting up is not possible, then the procedure should be performed with the patient supine and again the arm on the affected side is placed behind the patient's neck. The area is prepared with antiseptic (e.g. betadine) and draped. Local anaesthetic is infiltrated into the skin, subcutaneous tissues and down to the pleura. A 2 cm transverse incision is made in the fifth intercostal space (aiming above the rib as the intercostal bundle sits in the groove just below the rib). Blunt dissection is then performed down to the pleura with a pair of forceps which then are pushed through the pleura into the pleural space.

A finger is placed in the hole and swept around to free any adhesions and create the space for the tube. A chest drain is inserted using a pair of forceps, usually French gauge 24–28 (if a haemopneumothorax exists a larger tube size, Fr. 38, is usually used). The drain is fixed with a stitch and a purse-string or mattress suture is placed in the wound (to allow it to be closed when the drain is removed). The chest drain is connected to an underwater seal (this allows air to escape during expiration, but no air to enter on inspiration). Ensure that the underwater seal is below the level of the patient, otherwise the water will enter the chest. Re-X-ray the patient after the procedure to ensure correct positioning of the tube.

If you are ever asked how you can check if a chest drain is blocked, a top tip is to ask the patient to cough and you will see bubbles escaping if it is patent and no bubbles if it is blocked.

In an open pneumothorax, if the opening is approximately two-thirds of the diameter of the trachea, then air passes through the wound in preference to the airway during inspiration (taking the route of least resistance). This is also called a 'sucking chest wound'. The management is to close the wound with a sterile dressing taped on three sides to form a flap valve.

Circulation (see page 55)

Two large-bore cannulae should be inserted, one into each antecubital fossa of all patients exposed to major trauma. Blood should be taken for a cross-match, a full blood count and urea and electrolytes.

The ATLS® system recommends giving two litres of warmed physiological fluids (Hartmann's or Ringer's lactate) immediately, although some surgeons in the UK often start colloids (such as haemaccel) if there is definite blood loss. Obviously, it is important to get the blood as soon as possible. O negative blood is used if necessary (the universal donor), whilst awaiting the X-match.

Recognise the signs of shock, and look for a cause. The chest, abdomen and pelvis are the likely causes if there is no obvious haemorrhage from a wound. A bleed into the abdomen causes distention and signs on examination, such as tenderness, guarding and perhaps absent bowel sounds. If intraperitoneal bleeding is suspected (say, in a stab wound) and the patient is shocked despite immediate resuscitation, then no time should be wasted and the patient should be taken straight to theatre for a laparotomy to 'turn off the tap'. If the findings on examination are equivocal and the patient is not unstable, then a diagnostic peritoneal lavage (DPL), ultrasound or CT scan can be performed (in the USA an ultrasound is often available in the emergency room).

Diagnostic Peritoneal Lavage

For finals you probably just need to know that this involves an incision in the midline, below the umbilicus, and dissection down to the peritoneum, into which a catheter is placed.

A litre of normal saline is run into the peritoneal cavity. The bag is then placed on the floor and allowed to fill. If there is no obvious blood, then a sample of fluid is sent for microscopy to count the red blood cells.

A urinary catheter and nasogastric tube must be inserted prior to the DPL in order to avoid damage to the stomach and bladder during the procedure. The findings of this procedure, however, are often equivocal.

An unstable fractured pelvis can cause profuse blood loss and stage IV shock. The cause is usually venous bleeding. During the primary survey the chest and abdomen will have been examined to look for other causes of the shock. An orthopaedic surgeon can place an external fixator onto the pelvis, and this usually stops the rapid blood loss (by tamponade, and also stops any shearing forces on the vessels).

Disability

See section on head injury (page 59).

Exposure/Environment

The patient is completely exposed so that a full examination can be performed. In order to protect them from heat loss, both the patient and the resuscitation room should be heated. Methods for heating the patient include the use of warmed fluids and blood and the use of blankets. A *log roll* may be performed here or it may be performed in the secondary survey.

In this procedure one person holds and turns the head and neck and three people roll the body. This allows the patient to be turned with in-line cervical spine immobilisation to examine the back of the body for any signs of trauma (stab wounds, bruising, abrasions), palpating for any tenderness, and a rectal examination is performed.

Secondary Survey

A quick history should be ascertained, from witnesses, family or the ambulance men. The mnemonic AMPLE is used for the following vital questions:

*A*llergies
*M*edication

*P*ast medical history
*L*ast ate or drank
*E*vents prior to the accident

The secondary survey is the head-to-toe or full examination. Check the head (eyes, ears, scalp — run your fingers through the hair), cervical spine, chest, abdomen, limbs and perform a full neurological examination.

If the log roll has not been performed in the primary survey, it should be performed here. At the end of the secondary survey the patient should be re-evaluated by starting again at the ABCs. Once you are sure they are fully stabilised you can begin to make arrangements for definitive care (this usually means an admission).

Cervical Spine — X-Rays and Management

A cervical spine injury is almost always accompanied by pain in the neck; however, it is important to know that the absence of a neurological deficit does not rule out a fracture of the cervical spine. Under A for 'airway' with cervical spine control, the neck should be immobilised and a lateral 'shoot through' X-ray should be taken. If a motorcycle helmet needs to be removed or intubation is required, these should be performed with in-line manual immobilisation.

Assessment of the Cervical Spine X-Ray

Yet again, think of the mnemonic ABCs — *A*dequacy and Alignment, *B*ones, *C*artilages and *S*oft tissues.

Adequacy. An adequate C-Spine X-ray is one in which you can see the junction between the body of C7 and T1. If given a cervical spine X-ray in an exam and all you can see is C1-6, tell the examiner that this is not acceptable and you would like a further view. If they tell you that this is the best they could get and asks you what other methods you could use to improve the view, then say that you would like to repeat the X-ray with someone pulling down on the arms from the end of the bed or would like a swimmer's view (where the arm is abducted fully).

Alignment. Assess four lines — the line that runs down the anterior vertebral bodies, the anterior vertebral canal, the posterior vertebral canal and the tips of the spinous processes. These should be curved with a slight lordosis. A step along this line or a loss of the lordosis is abnormal (note: whether the X-ray was taken with a hard collar on, because that can often be a cause for loss of lordosis). If the anteroposterior spinal canal space is narrowed, there is possibly spinal cord compression.

Bones. Look at the shape of the individual vertebral bodies (which should be rectangular), the lateral mass (the pedicles, facets, laminae and transvere processes) and the spinous processes.

Cartilages. Assess the intervertebral discs (should be of equal height) and facet joints.

Soft tissues. Just anterior to the vertebral bodies are the soft tissues of the pharynx. If there is damage to the cervical spine, there is likely to be associated soft tissue swelling (haemorrhage). Look at the shadow of the prevertebral space for any swelling. In front of the upper cervical vertebrae its normal width is about half that of the vertebral body (or less than 5 mm). At about C4 the soft tissues take up more space with a width about equal to that of the vertebral body (as the larynx and oesophagus are here). If the space between the spinous processes is widened, this implies a torn interspinous ligament.

SHOCK

Shock is defined as an inadequate perfusion and tissue oxygenation of the vital organs (brain, heart, kidneys and skin). There are several causes of shock and they can be divided into haemorrhagic and nonhaemorrhagic.

The nonhaemorrhagic causes include cardiogenic, anaphylactic and septic shock (they should be known about but are not covered here).

Tension pneumothorax is another cause of shock due to mediastinal shift and impairment of the venous return.

Haemorrhagic Shock

Haemorrhage is the commonest cause of shock after injury. The most important step is to recognise and treat shock early even if the blood pressure is normal. As a rule, any patient who is cool and tachycardic should be assumed to be shocked until proven otherwise.

The normal adult blood volume is 7% of body weight (about 5 l for a 70 kg man), whereas in a child it is about 9% of body weight, or 80 ml/kg. The body has excellent compensatory mechanisms to deal with volume loss (although as age increases these mechanisms become less efficient) and there may be no changes in the blood pressure until the loss is considerable. On examination you should assess the appearance of the patient, the pulse, blood pressure, pulse pressure (the difference between the systolic and the diastolic blood pressure), respiratory rate, capillary refill time (normally less than 2 s), mental status and urine output.

There are four stages of shock based on the percentage of blood loss. If you play tennis you will have no problem in recalling the percentages, as they are the same as in the tennis scoring system.

Stage I Shock (0–15%)

This is up to 750 ml blood loss (based on a 70 kg man). This is the group that catches people out, as signs of shock are minimal. The patient is usually a little anxious; however, the pulse rate is usually less than 100 and the blood pressure and pulse pressure are normal.

Stage II Shock (15–30%)

This is 750–1500 ml volume loss. Again, the patient is anxious and the pulse is now above 100, with an increased respiratory rate. The systolic blood pressure is still usually maintained (by vasoconstriction and increased cardiac output); however, the pulse pressure is now decreased, mainly because of a rise in the diastolic pressure.

Stage III Shock (30–40%)

Up to 2000 ml. Now you see all the classic signs of inadequate perfusion, including a marked tachycardia and tachypnoea and a drop in the systolic blood pressure. There may be evidence of CNS impairment, such as confusion. It is therefore important to recognise shock in stages I and II in order to prevent the patient from going into stage III shock.

Stage IV Shock (Greater than 40%)

With a loss of greater than 2 l the condition is immediately life threatening. The pulse is weak and thready, there is a significant drop in the systolic blood pressure (the diastolic blood pressure may be unrecordable), and the patient is pale, cold and clammy, with a depressed consciousness level.

Stage	*Stage I*	*Stage II*	*Stage III*	*Stage IV*
Blood loss (%)	<15	15–30	30–40	>40
Blood loss (ml)	<750	750–1500	1500–2000	>2000
Consciousness	Slightly anxious	Agitated	Confused	Depressed
Pulse rate	<100	>100	>120	>140
Blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure	Normal	Decreased	Decreased	Decreased
Respiratory rate	14–20	20–30	30–40	>35
Urine output (ml/h)	>30	20–30	5–15	Negligible
Replacement	Crystalloid	Colloid	Colloid + blood	Colloid + blood

Management

Under C for 'circulation', insert two large-bore cannulae (brown or grey), preferably one into each antecubital fossa. According to Poiseuille's law, flow is proportional to the fourth power of the internal radius of the tube and inversely proportional to the length, and so a short fat tube is essential. Note that a central line, although important for monitoring, is usually long and very thin and hence not effective for fluid resuscitation. If IV access is difficult in the antecubital fossae, then a femoral approach or a cut-down on to the saphenous vein can be attempted (this is 2 cm above and anterior to the medial malleolus). In a child less than 6 years old, an interosseous needle can be used (this is a needle inserted directly into the tibia (just below the knee), allowing access to the vascular marrow, and can be used to replace blood and fluids in the same way as a venous cannula inserted into any other site).

Blood should be taken for laboratory analysis, including a cross-match, FBC, U & Es, glucose, toxicology studies and a pregnancy test in females of childbearing age. Blood gases are often useful at this stage. A central line (a catheter in a large central vein) may be inserted to help monitor fluid replacement or if cardiogenic shock is suspected.

Insertion of a Central Line

There are in use two approaches. The first is known as the infraclavicular approach into the subclavian vein and the second into the internal jugular vein. A guide wire based on the Seldinger technique is employed. In the infraclavicular approach the patient is supine with the head down (about 15° — this helps distend the neck veins and prevents an air embolism). The head should be supported by another helper if a cervical spine injury is suspected. An aseptic technique is used. Some local anaesthetic is infiltrated into the skin. A needle attached to a saline-filled syringe is introduced 1cm below the junction of the middle and inner thirds of the clavicle. The needle is advanced medially and slightly upwards behind the clavicle (aiming for the sternal notch) as the plunger is slowly withdrawn. When venous blood enters the syringe, the syringe is removed leaving the needle in the vein. A guide wire is inserted through the needle into the vein. The needle is removed, leaving the guide wire in the vein. The central line is then inserted over the guide wire and into the vein. The central line is fixed to the skin with a suture and is dressed. If necessary, the central line is then connected to a manometer to measure the central venous pressure.

The internal jugular approach is similar but via a different vein. The carotid pulse is felt just anterior to the midpoint of the sternocleidomastoid muscle (the high approach) and a needle is inserted lateral to this, aiming posteroinferiorly and towards the nipple on that side (the internal jugular vein lies posterior to the carotid artery at the base of the skull; the vein then twists around the carotid and lies lateral to it half-way down the neck and in front of it just below the clavicle).

In the low approach the needle is inserted between the two heads of sternocleidomastoid just above the clavicle.

After the central line has been inserted it is important to get a check X-ray to confirm the position of the line and rule out a pneumothorax.

Complications of central line insertion include

- Pneumothorax and haemopneumothorax (especially in the subclavian approach)
- Arterial puncture (it is easier to apply pressure to the internal jugular if it is hit by mistake, than it is to the subclavian artery which is hidden deeply)
- Haematoma formation
- Infection

Recent evidence has suggested that real-time ultrasound guidance for central line insertion, with or without Doppler assistance, improves catheter insertion success rates, reduces the number of venepuncture attempts prior to successful placement, and reduces the number of complications.

The ATLS® system recommends starting two litres of crystalloid fluids as the initial resuscitation for every major trauma patient. The response to volume expansion is monitored by the same signs and symptoms that are used to diagnose it. The urine output is the best indicator of the adequacy of resuscitation.

There are three types of response to the initial fluid resuscitation:

1. *Rapid response.* Here, the patients respond rapidly to the fluids and remain haemodynamically stable once the fluids are stopped or slowed. These patients have usually lost minimal blood volume ($<20\%$) and

can be observed but do not necessarily need any further intravenous fluids.

2. *Transient response*. There is an initial response with a rise in the blood pressure and a fall in the pulse rate; however, as the fluids are slowed down, the indices used to measure shock start to deteriorate again, indicating that the blood loss is ongoing or resuscitation has been inadequate. The response to the fluid will indicate those patients who are still slowly bleeding (as may other clinical findings).
3. *No response*. This could be exsanguinating haemorrhage and blood is needed rapidly. Type-specific blood (where the ABO and Rhesus groups are compatible, but there may be some minor antibodies that are incompatible) takes about 10 min to process and should be given initially in life-threatening bleeding whilst waiting for the full cross-match, which may take as long as 40 min. As a last resort, Group O negative blood can be given, which is the universal donor.

Failure to respond to the fluid resuscitation and the blood indicate the need for immediate surgical intervention to control the haemorrhage ('turn off the tap'). Less commonly, a failure of response may be due to the fact that there is a nonhaemorrhagic cause for the shock, such as myocardial contusion or tamponade, and a CVP measurement may help differentiate the causes. If blood is given (usually packed red cells without plasma) it should be warmed to prevent hypothermia and, after a large transfusion, platelets and fresh frozen plasma may be needed to correct the lack of clotting factors. The main aim of transfusion is to correct the oxygen-carrying capacity, since crystalloids and colloids can both correct the lack of intravascular volume but have no oxygen-carrying capacity.

HEAD INJURIES

Introduction

Head injuries are common and range from the minor bump on the head that usually warrants simple advice but no investigation or treatment, through to the multiply injured patient with an associated head injury and a depressed level of consciousness. The majority of head injuries fall somewhere between these two extremes, and the difficulty for the doctor is in deciding who needs to be admitted for observation and who can be sent home. Questions on head injuries are common in the finals.

Anatomy

The scalp has five layers, described by the mnemonic SCALP — Skin, Connective tissue, Aponeurosis, Loose connective tissue and Periosteum (pericranium). It is highly vascular and can lead to large blood losses. Beneath the scalp is the skull, which contains the meninges, and then the brain. In a head injury any of these structures can be damaged.

Intracranial Pressure

The pressure within the skull is known as the intracranial pressure (ICP) and is actually the pressure which the subarachnoid space is under. Normally, the ICP is less than 10 mmHg.

There is a simple, yet vitally important, concept relating to ICP dynamics, which is that the total volume of the intracranial contents must remain constant (known as the Monroe–Kellie Doctrine), which should be obvious since the skull in an adult is essentially a rigid structure that cannot expand.

The skull contains cerebrospinal fluid (CSF), blood and the brain. If the volume of one of these components increases, then the other two must decrease to compensate or the ICP will rise (Figure 4.1).

The ICP is usually maintained at a constant level by excellent autoregulatory mechanisms that can accommodate changes in the blood flow and so a normal ICP should not exclude a mass lesion.

We can accommodate a mass of about 50–100 ml without a significant rise of ICP. However, as the mass expands further, the autoregulatory mechanisms fail and the rise in ICP is rapid (as is the patient's deterioration) and can lead to brain herniation.

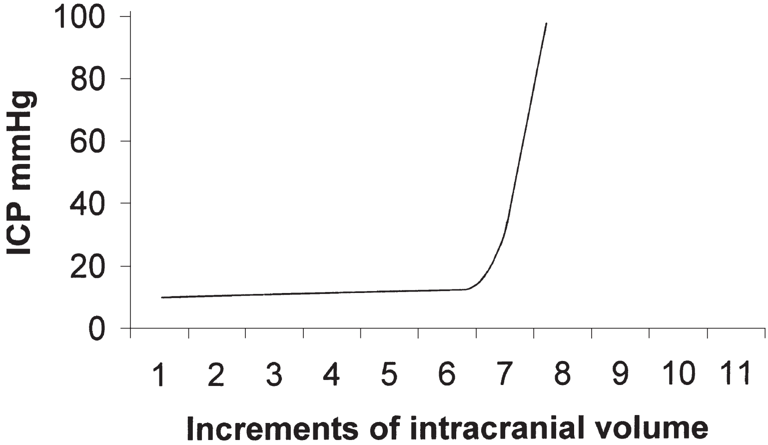

Figure 4.1. Graph of intracranial volume against intracranial pressure. Note that an expanding mass can initially be compensated as blood and CSFs are squeezed out. However, the ICP rises rapidly after the period of compensation.

Cerebral Perfusion Pressure

The cerebral perfusion pressure (CPP) is just as important as ICP as it is a measure of the amount of oxygenated blood reaching the brain:

$$\text{CPP} = \text{mean arterial BP} - \text{ICP}.$$

Large increases in the ICP lead to a decrease in the CPP.

As the CPP falls there is initially electrical followed by structural brain damage and a prolonged CPP of less than 70 mmHg is usually associated with a poor outcome following head injury.

Cerebral blood flow is dependent on both the arterial PCO_2 and the systemic blood pressure. As the arterial PCO_2 rises, cerebrovasodilatation occurs, worsening the raised ICP. In reverse, reducing the arterial PCO_2 reduces the cerebral blood volume and hence the intracranial pressure. Therefore, in cases of raised ICP the patient should be hyperventilated to keep the PCO_2 low.

Maintenance of CPP is one of the priorities of management of a patient with a severe head injury.

Types of Injury

Scalp Laceration

Lacerations of the scalp can bleed profusely and lead to major blood loss, especially in children.

Skull Fracture

Skull fractures are common. It is possible to have one without severe brain injury, and likewise, you can have an intracranial injury without accompanying skull fracture, especially in children, whose bones and joints are more supple. The only significance of X-raying head injury patients and looking for a skull fracture is that such patients have a statistically higher probability of developing a bleed into the brain, and hence they get admitted for observation. The types of fracture are:

- *Linear (nondepressed) fracture.* This appears as a lucent line.
- *Depressed skull fracture.* Management will depend on the underlying brain injury. The fragment may need to be elevated if depressed more than the thickness of the skull or if there are focal signs.
- *Open skull fracture.* This usually requires operative intervention. A broad-spectrum antibiotic should be started, the patient taken to theatre for wound debridement and the fracture dealt with.
- *Basal skull fracture.* This fracture cannot usually be seen on a plain X-ray of the skull, although it should be suspected if there are fluid levels in the sphenoidal sinuses. The diagnosis is made on clinical findings of the CSF leaking from the nose (rhinorrhoea) or the ears (otorrhoea). The CSF is usually crystal clear, unless it is blood-stained. It can be tested for by allowing a drop to fall onto a piece of filter paper. The blood remains at the centre and the CSF soaks around it in concentric rings of clear fluid, called the 'halo sign'. Other clinical signs of a basal skull fracture include the *battle sign* (bruising around the mastoid region due to tracking of blood under the skin) and *haemotympanum* (blood behind the tympanic membrane), which together with

CSF otorrhoea are indicative of a middle fossa fracture through the petrous temporal bone. The *badger sign* (bruising around both orbits), together with rhinorrhoea, is associated with a fracture of the cribriform plate. The badger and battle signs may, however, take several hours to develop.

Brain Injury

Injuries to the brain can be primary, occurring at the time of impact, or secondary to hypovolaemia, hypoxia, hypo-glycaemia and raised intracranial pressure. Prevention of primary brain injury can only be brought about by measures to stop the accident happening in the first place, such as having road speed limits and the wearing of motorcycle helmets, etc. The main aim in the management of a head injury is, therefore, to prevent or limit the damage that occurs due to secondary injury.

Primary brain damage can be diffuse or focal.

Diffuse Injuries

- *Concussion.* This is a brain injury accompanied by a temporary loss of neurological function. The changes are reversible and are often resolved by the time the patient arrives in hospital. They may have just been confused or dazed at the scene or may have lost consciousness. Afterwards they may complain of a headache, feel dizzy, be amnesic or nauseous, and generally if the patient has been unconscious for more than 5 min it is probably best to admit them to hospital for observation.
- *Diffuse axonal injury.* This is a more severe injury, with microscopic structural damage throughout the brain tissue. It is often characterised by prolonged coma and can last from days to weeks. Such patients can develop autonomic dysfunction and hence have high fevers, hypertension and sweating. The mortality is high.

Focal Injuries

- *Contusions.* These are focal areas of brain injury. They can be *coup* injuries, where the brain is damaged directly by the skull at the point of impact, or *contre coup* injuries, where the brain is squashed by the skull at a remote point from the impact.

  The patient may have a focal neurological deficit, depending on the site of the contusion. Oedema may develop at the site of damage and cause a neurological deterioration. The patient is usually managed conservatively; however, due to the risk of delayed bleeding into the contusion, careful observation is needed to observe for deterioration (especially in alcoholics).
- *Intracranial haemorrhage.* This can be meningeal or into the brain tissue.
  - *Acute extradural/epidural haemorrhage.* This is due to a bleed from the arteries that supply the skull and dura — usually the middle meningeal artery, which sits just under the skull in a region called the pterion (or temple). This type of bleed is quite rare, accounting for less than 1% of coma-producing head injuries; however, it can be rapidly fatal. There is usually an associated skull fracture of the parietal or temporal bone, often caused by a direct blow — for example, being hit over the side of the head by a baseball bat.

    The typical picture is loss of consciousness (concussion), followed by a lucid interval. During this lucid interval the haematoma is expanding into the extradural space and compressing the brain inwards, stripping the dura off the skull as it expands (hence the convex appearance of the clot on the CT). As mentioned before, the ICP does not rise initially as the mass is accommodated; however, once the clot reaches a critical volume the ICP increases rapidly.

    The rapid rise in the ICP causes a secondary lapse in the consciousness level. As the ICP rises further, the uncus (the medial aspect of the temporal lobe) herniates through the tentorium (the layer that divides the cerebral hemispheres from the brain stem and cerebellum). The third nerve passes through this opening and can be compressed at this point. The patient initially develops a constriction of the pupil on the affected side, which then begins to dilate up (Hutchinson's pupil). The fixed dilated pupil on the affected side is usually accompanied by a hemiparesis on the opposite side (remember the corticospinal fibres cross over). As the pressure continues to increase, the opposite pupil dilates up and eventually the brain stem 'cones' through the foramen magnum.

This injury requires immediate surgical intervention. The patient should have a CT as early as possible if this type of injury is suspected. Neurosurgical advice should be sought and the patient transferred if necessary for surgical evacuation of the clot. If the injury is treated, early the prognosis is excellent.

- *Acute subdural haemorrhage.* This is much more common than an extradural haemorrhage, and occurs in about 30% of severe head injuries. It is usually due to rupture of a bridging vein between the cerebral cortex and the dura (but it can also be due to laceration of the cerebral cortex), and is often caused by a rotational injury. The elderly are more susceptible, as their brains are often shrunken and hence the bridging veins are put under tension. The bleeding is typically less brisk than an extradural haemorrhage, but clinically it can present with symptoms of an expanding mass as above. The prognosis is much worse and the mortality high.
- *Subarachnoid haemorrhage.* This can be associated with trauma, although it is usually due to hypertension and bleeding from berry aneurysms. The symptoms are those of meningeal irritation similar to meningitis.
- *Brain haemorrhages and lacerations.* These are tears to the brain substance with bleeding into them. The deficit will depend on the site of the damage. These injuries are therefore similar to strokes, and surgery cannot help the patient. Rehabilitation can be very slow.

Assessment of Severe Head Injuries

As the patient is brought into casualty you should attempt to get some history, finding out as much as possible about the incident. If they are unconscious, the history is taken from witnesses or the ambulance crew, etc. Perform the primary survey according to ATLS® guidelines — ABCDE.

The *Glasgow Coma Score* (GCS) is a quantitative measure of the patient's level of consciousness. It is divided into three parts: assessing the best motor response, the best eye-opening response and the best verbal response. It was devised to allow comparisons to be made (if necessary by different observers) to see if the patient's consciousness has improved or deteriorated. The minimum score is 3 and the maximum 15.

A GCS of 8 or less implies coma and a severe head injury. If the score is greater than 8, then the patient is not in a coma. A GCS of 9–12 implies a moderate head injury and a GCS of 13–15 shows a minor head injury.

Glasgow Coma Score

	Score
Best Eye Opening	
Spontaneous	4
To voice	3
To pain	2
None	1
Best Verbal Response	
Orientated	5
Confused	4
Inappropriate speech	3
Incomprehensible speech	2
No speech	1
Best Motor Response	
Obeys commands	6
Localises to pain	5
Withdraws from pain	4
Flexes to pain	3
Extends to pain	2
None	1
Total	3–15

The vital signs and the GCS should be repeated at regular intervals, and deterioration by more than two points should be taken very seriously and a neurosurgical consultation sought. Remember that although bleeding from a scalp wound can cause shock, bleeding into the skull cannot, and therefore never assume that hypotension is due to an intracranial bleed or to brain injury (as this is a terminal event on failure of the medullary centres). Look for another cause.

The Cushing response is a combination of progressive hypertension, bradycardia and a decreased respiratory rate (the opposite of hypovolaemic shock). It is due to a lethal rise in the ICP, usually by an intracranial bleed needing urgent decompression. Hypertension alone or with hyperthermia suggests central autonomic dysfunction caused by diffuse brain injury.

Under D for 'disability', document the patient's level of consciousness using the AVPU score. If the airway, breathing and circulation are under control, then the minineurological examination can be performed in the primary survey; otherwise it is performed in the secondary survey.

The mini-neurological examination involves three components:

1. *Level of consciousness.* The GCS.
2. *Pupillary function.* Are the pupils equal and reactive to light?
3. *Lateralising neurology.* Swiftly assess the tone, power and reflexes of all four limbs.

The purpose of this is to detect those with a severe head injury who are likely to need surgery (i.e. those with abnormalities of all three components).

Remember that the initial neurological examination is only a baseline for comparing the results of repeated examinations, in order to determine deterioration or improvement of the patient's condition.

Management of Severe Head Injuries

This involves, first, dealing with the life-threatening injuries (ABC); then, assessing the severity of the head injury, whilst preventing secondary brain damage from occurring, by ensuring optimal cerebral metabolic supplies and preventing intracranial hypertension.

Cerebral Metabolism

The brain requires oxygen and glucose to function, and so adequate substrates must be present in the circulation to meet this requirement. The oxygen content depends on both the arterial haemoglobin and the PO_2.

The PO_2 can be measured by blood gases, and oxygen can be supplemented as necessary. If the haemoglobin is low, a transfusion may be required to improve the oxygen-carrying capacity.

Raised Intracranial Pressure

This may be due to a mass lesion or brain oedema and should be treated.

In cases of raised ICP the patient should be hyperventilated to keep the PCO_2 low (see section on ICP). To do this it is usually necessary to intubate and ventilate the patient and so early involvement of an anaesthetist is essential. Remember that a decrease in the PCO_2 leads to a decrease in the cerebral blood flow and so the PCO_2 must be kept at about 3.5 as a compromise.

Intravenous fluids may be needed in the management of other problems, such as shock, and the risk is that overhydration may make cerebral oedema worse. Therefore, isotonic fluids such as Hartmann's should be administered rather than hyposmolar fluids such as dextrose.

Diuretics such as mannitol are often used to reduce intracranial pressure and are given if a mass lesion is suspected whilst awaiting transfer to a neurosurgical unit, although a neurosurgical consultation should be obtained prior to giving any diuretics (if diuretics are used, a urinary catheter is required to aid fluid balance measurement). Steroids have no place in the acute management of head injury.

Management of Mild to Moderate Head Injuries

The problem for a casualty officer when he sees what appears to be a minor head injury is in deciding who needs admitting for observation. In general, the history is very important.

Falls from a height should be taken very seriously, as they have a much greater risk of an intracranial bleed than road traffic accidents. For a fall, inquire about the height of the fall and whether it was onto concrete or grass, etc. If the patient was driving a car, inquire about the speed of the car and whether a seat-belt was worn, whether any of the other passengers were injured or dead and whether alcohol or drugs were involved. Was consciousness lost and if so for how long? Has the patient regained consciousness since the accident or have they remained unconscious ever since? Has the patient fitted since or complained of visual disturbances, dizziness or a worsening headache?

Document the amnesia, for the events that led up to the incident (retrograde amnesia) or for the events that followed the incident (anterograde amnesia). The length of anterograde amnesia has been shown to be a good indicator of the severity of the head injury (less than 1 h — mild; 1–24 h — moderate; more than 24 h — severe), although this is not much help in the initial assessment, which takes place soon after the incident. With children it is also worth noting whether they cried immediately, as this is a good sign (i.e. normal behaviour), or whether they were limp and unresponsive.

Examination is essentially the same as above; however, in some cases it is difficult to decide what investigations are needed and whether or not you can safely send the patient home. For example, let us say the patient has walked into the department after a head injury sustained in an assault where he was hit over the head by a brick. His speech is slurred from drink and he has a bump on his forehead, but there is no focal neurology to find on examination (within the limits of the cooperation of this patient).

A large proportion of patients present like this. Should you X-ray these patients?

X-rays may help in deciding who will be admitted for observation, but not much else. Statistically, if there is a skull fracture, then the risk of an intracranial bleed is significantly higher.

Rough Risk of Intracranial Haematoma in Adults

	No Skull Fracture	*Skull Fracture*
Fully conscious	$<1/1000$	1/30
Depressed consciousness	1/100	1/4

Indications for performing a skull X-ray include (but do check the protocol at your hospital):

1. Loss of consciousness for more than a few minutes
2. Neurological symptoms or signs (unless a CT is indicated) such as visual disturbances, dizziness, weakness, persistent vomiting, etc.
3. Signs of a basal skull fracture
4. Suspected penetrating injuries (X-rays are essential in this case)
5. Common sense, i.e. history of significant injury or obvious significant scalp wound
6. Difficulty in assessing the patient (young/old, drunk, postepileptic)

The indications for admission are

1. Skull fracture
2. Depressed level of consciousness or confusion when examined
3. Neurological symptoms or signs
4. Difficulty in assessing the patient
5. Social circumstances (e.g. patient lives alone, with no responsible adult to observe)

If the patient is admitted, they are usually given nonopiate analgesia (or codeine phosphate, which is safe to use) and taken to the ward. Regular neurological observations are performed, initially on an hourly basis.

The observations include the vital signs, the GCS, pupils and motor function and are represented schematically on a graph to detect any deterioration.

If the patient is not admitted, they should be sent home with head injury instructions (go to your casualty department and get a copy) and accompanied by a responsible adult who will bring him back should his condition deteriorate.

BURNS

Different types of burns tend to affect different age groups. Toddlers tend to be scalded, for example, by pulling the kettle wire or the pan off the stove, kids tend to set their clothes on fire and the old tend to suffer domestic accidents at home. The majority of adult burns however, are associated with industrial accidents (or are drug- or alcohol-related).

Pathology

The damage is caused by coagulation of proteins with cell death. The burn can affect any depth of skin. The superficial burn causes vasodilatation with diffuse erythema, kinins are released and pain is felt. As the depth increases, the capillaries become damaged and therefore more permeable, leading to blistering and oedema formation. As the dermis becomes involved, the nerve endings which lie here are damaged and sensation is lost. Once the germinal layer is damaged, the skin will never regrow, and these burns heal with fibrosis and contractures. The damaged necrotic tissue lying in a protein-rich exudate is an ideal medium for infection. The increased capillary permeability can lead to the exudation of protein-rich fluid from the surface of the burn and oedema into the surrounding tissues. The patient can very quickly become hypovolaemic.

Types of Burns

1. Thermal — can be dry (fire) or wet (scald)
2. Chemical
3. Electrical
4. Friction

Chemical burns result from exposure to acids, alkalis or petroleum products. In general, alkali burns are more serious than acid burns as they penetrate more deeply. The chemical should be flushed away from the skin with copious amounts of irrigation with water (20–30 min). If dry powder is present, brush it away before irrigating. The neutralising agents are no better than water.

Electrical burns are more serious than they appear. The overlying skin may look normal, but deeper tissue may be damaged. Rhabdomyolysis leads to myoglobin release and the risk of acute renal failure. The patient can also develop cardiac disturbance due to acidosis and changes in potassium concentration. A cardiac monitor and a urinary catheter are therefore necessary. The patient will have dark urine due to the myoglobin and require large amounts of fluids to ensure a high urine output. If necessary, mannitol can be used to maintain a diuresis and flush out the myoglobin.

Management of the Burns Patient

The management of the burns patient, as with any trauma patient, is to exclude any life-threatening injuries first (i.e. ABCDE, according to ATLS® guidelines). The main priorities with burns patients, however, are

1. Securing the airway
2. Management of fluid loss
3. Prevention of infection

Immediate Resuscitation

Secure the airway, and stop the burning process by removing all clothing.

Airway

The supraglottic airway can rapidly become obstructed due to oedema and swelling following a burn injury. It is therefore important to suspect involvement of the airway, even if the patient is breathing normally when first examined. Apart from the obvious signs of airway injury, such as stridor or hoarseness, any of the following should alert the doctor to the likely presence of an acute inhalation injury:

1. Facial burns
2. Singeing of the eyebrows or nasal hairs
3. Carbonaceous sputum
4. Altered consciousness
5. History — such as long exposure to smoke or gases, or an explosion

An anaesthetist must be called immediately. Early endotracheal intubation is better than adopting a wait-and-see policy, as the airway can become obstructed rapidly.

Breathing

Apart from direct thermal injury, which causes upper airway oedema and obstruction, inhalation of toxic fumes and smoke can lead to chemical tracheobronchitis, oedema and pneumonia. You should always assume carbon monoxide (CO) exposure if the patient was confined to an enclosed area. CO has an affinity for haemoglobin that is about 240 times that of oxygen, and hence oxygen is displaced and the oxygen dissociation curve is shifted to the left. The CO dissociates very slowly when the patient is breathing room air (with a half-life of about 6 h). If 100% oxygen is breathed the half-life is shortened to about 40 min. Therefore, the patient should have arterial blood gases taken for assessment of the carboxyhaemoglobin concentration and 100% oxygen should be commenced. Symptoms may include a headache, nausea, vomiting, or confusion at high levels of exposure, but the classic cherry-red skin appearance is rare.

Circulation

It may be difficult to get a reliable blood pressure owing to the burns, and the urine output is probably the best indicator of circulating blood volume.

Establish intravenous access if necessary through the burnt skin, and start two litres of Hartmann's solution immediately. The fluid losses can be huge and a 50% burns patient can lose up to half their plasma volume in about 3–4 h.

A rough guide is to replace 2–4 ml of crystalloid fluid for each kilogram body weight per percent burn in the first 24 h. So a 70 kg man with a 50% burn will require 7–14 l in the first 24 h ($2 \times 70 \times 50 = 7000\,\text{ml} = 7\,\text{l}$). Half the fluid should be given in the first 8 h from the time of the burn (not from the time of arrival to casualty), so if the burn occurred 2 h before arrival, they will need at a very minimum 3.5 l of fluids in the next 6 h.

In some departments the policy is to replace colloids such as human albumin solution (HAS), and in this case the Muir and Barclay formula can be used. This determines how much plasma volume is needed in terms of colloid replacement.

$$\text{Volume of colloid needed (per unit time)} = \text{weight (kg)} \times \text{percent burn}/2$$

So, for a 70 kg man, with a 50% burn this would be 1.75 l of colloid per unit time ($70 \times 50/2 = 1750$ ml). The first amount is given in the first 4 h from the burn, then the same amount in the subsequent 4, 4, 6, 6 and 12 h. This would total about 8.75 l of colloid in the first day and in addition crystalloid maintenance (about 3 l) with, say, normal saline is required.

Remember that these figures are just guides and no matter whether crystalloids or colloids have been administered, the best indicator of sufficient replacement is an adequate urine output of greater than 30–50 ml/h. The haematocrit is also used to guide fluid balance.

Circumferential full thickness burns can impede the blood supply to the limbs owing to oedema in a confined space (a tourniquet effect), and are best treated by escharotomies (an incision through scar tissue). The incision is made along the line of the limb through the entire scar. As this is a full thickness burn, sensation is absent and in theory no anaesthetic is required. In practice, however, the escharotomy tends to be done with the patient anaesthetised (because there are some areas of partial thickness burns adjacent to the full thickness zones which will clearly cause pain). Cross-matched blood must be available, as this procedure can bleed profusely. Circumferential burns of the thorax may cause restriction of chest expansion, and bilateral escharotomies may be needed to improve breathing.

Assessing the Burn (History, Size and Depth of the Burn)

History

Note the cause and exact time of the burn (remember to ask about associated injuries — for example, did the patient jump out of a window to escape the fire?). Try to ascertain some past medical history, such as diabetes, hypertension, heart or lung disease, the medication the patient is on, allergies and tetanus status.

Depth of Burn

Superficial burns (also called first-degree burns) are not life-threatening and are simply painful red areas, such as sunburn. There is no blistering and long term they usually do not scar. In *partial thickness burns* (also called deep dermal or second-degree burns) there is associated swelling and blistering, and the skin is red and may be oozing fluid. These burns are very painful even to air current. Long term most deep dermal burns do not scar but it depends on the patient's skin type and whether or not they need a skin graft (for example, there have been cases of marked keloid scarring following a deep dermal burn in black patients even without surgery). In *full thickness burns* (also called third-degree burns) skin is dry, painless and insensate; it may appear pale, white or charred. Long term these will scar.

Body Surface Area

The 'rule of nines' is a useful way to determine the extent of the burn (Figure 4.2). The adult body is divided into regions that represent 9% of the body area. The genital region is considered to be 1% of the body surface area (BSA). The proportions are different in children whose head contributes more than the legs to the total area (as it does for heat loss). Another good guide is that the *patient's* palm (not your palm and not including the patient's fingers) represents about 1% of the body surface area. You can use these guides to estimate that, in an adult with a burn to one arm and one leg with a small area affected on the torso of about three palm sizes, the percent burn will be about 30 (9 + 18 + 3).

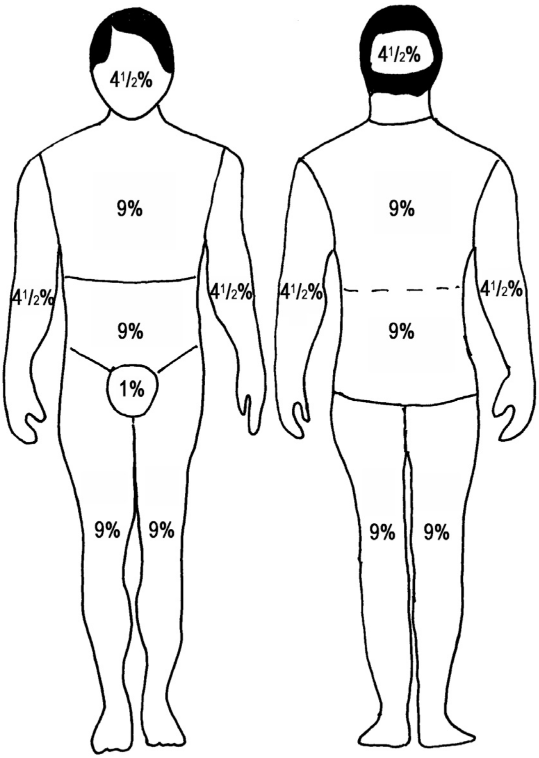

Figure 4.2. The 'rule of nines'.

Summary of Management of the Burns Patient

1. *Airway.* Look for signs of obstruction or signs indicating the risk of obstruction; inform the anaesthetist.
2. *Breathing.* Pulse oximetry; look for signs of CO poisoning, 100% oxygen, arterial blood gas analysis; request a chest X-ray.
3. *Circulation.* IV access × 2 — take blood for FBC, U & Es, glucose, X-match and carboxyhaemoglobin levels; start IV fluids, ECG; catheterise if necessary.
4. Assess the burn depth and BSA, adjust fluid requirements, consider escharotomies.

5. *Analgesia*. Usually opiates, titrated to the patient's pain.
6. Assess for associated injuries; a nasogastric tube may be needed.
7. Cover the burns — partial thickness burns are painful to air current; gently cover them with sterile towels. Do not apply any antiseptic and do not pierce the blisters.
8. Take extra special precautions to avoid infection, which after the initial resuscitation is the main cause of morbidity and mortality. The patient should be transferred to a regional burns unit if necessary, especially if there is
   - A partial thickness burn of greater than 20% BSA (in the very young or old a 10% burn should be referred).
   - A full thickness burn of greater than 5%.
   - Involvement of the face, hands, feet, genitalia or major joints.
   - Significant chemical or electrical burns.
   - An inhalation injury or other serious comorbidity.

The burns should be covered with clingfilm, then warm blankets should be applied before transfer as the use of agents such as sulphasalizine or paraffin gauze interfere with the assessment of the burn when the patient arrives at the burns unit.