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EDITORIAL

Welcome to Update No 6! This edition deals with a common problem facing anaesthetists all over the world - ***Major Trauma***. Patients who are injured need immediate, expert assessment to detect and treat life threatening injuries. Basic care given early following trauma may be life saving as many patients die within the first hour from complications of their injuries such as hypoxia and hypotension.

How to rapidly assess and treat victims of major trauma is discussed in detail in this edition. Although there are differences in facilities from one centre to another much can be achieved by careful attention to a detailed clinical examination and then treatment with the facilities available. In the editors' experience many patients die from hypovolaemia following trauma, in many circumstances this is avoidable.

Many thanks to those who have answered the questionnaire contained in Update 5. We are unable to reply to everyone individually but will attempt to summarise the findings in a future issue of the journal. We would be grateful for as many people as possible to reply to the questionnaire published in the last edition. We are always delighted to receive other letters or suggestions about the journal and will publish a selection if they are likely to appeal to the readership.

Dr Iain Wilson
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THE MANAGEMENT OF MAJOR TRAUMA

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Introduction

Accidental injury is probably the most serious of all the major health problems facing developed countries. In the developing world the impact is just as great but has not been as extensively studied. Head injury was the commonest reason for admission to the Intensive Care Unit at the University Teaching Hospital in Lusaka over a ten year period from 1978-1988 with between 90 and 123 cases per year (approximately 20% of all admissions). In the UK, there are approximately 15000 deaths annually attributable to accidents. One third of these are due to road traffic accidents i.e. almost 100 people per week die in road accidents. For every death, two people suffer permanent disability. In the USA, injuries are the

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leading cause of death up to the age of 44. Many accidents are preventable and this is a major health issue for planners in health economics.

Major Trauma

Patients suffering from multiple injuries are commonly known as **major trauma victims**. Such patients present tremendous demands at all levels within hospitals particularly on those doctors, nurses and clinical officers caring for the patient within the first hours of hospital admission. It is in this context that systems for major trauma care have been developed. In this review we will set out a system for the management of major trauma victims and discuss the principals of anaesthesia for such patients. We will emphasise the importance of recognising mechanisms of injury and thereby identifying those at risk of life-threatening injury. The article will be illustrated by actual case studies.

Trauma Teams

Victims of major trauma are best treated by a well organised and trained team made up of staff competent in assessing and treating the spectrum of life-threatening injuries commonly seen. An experienced physician anaesthetist, possessing airway and resuscitation skills and confidence in dealing with unconscious patients, is a vital member of the team and in many UK hospitals is the team leader. The role of the non-physician anaesthetist is similar using airway skills under the direction of a surgical colleague.

Whenever possible both a general surgeon and an orthopaedic surgeon should be members of the trauma team. Their presence can reduce delays in the accident department, improve the early diagnosis of life threatening injuries and lead to earlier surgery when required. Having both specialists present prevents one doctor becoming overwhelmed by complex problems in an unstable patient. The team should include a radiographer when available. Adequate protection including gowns, gloves and eye protection should be worn by staff. It is often possible for the team to be given prior warning of a casualty arriving, thereby allowing time for preparation. Accident & Emergency departments should have a **resuscitation area** set aside to receive major trauma victims with anaesthetic airway equipment and drugs, intravenous fluids with blood giving sets and blood warmers. Surgical sets should include equipment for the following procedures: urinary catheterisation (including suprapubic), peritoneal lavage, pleural drainage (chest drains sets with underwater seal) and needle and surgical cricothyrotomy. Specific provision should be made for children with appropriate sizes of equipment to deal with all ages and equipment for intraosseous fluid administration (*see Update 5*).

Methods of Managing Trauma

A multidisciplinary approach is required in the management of major trauma and the same technique for assessment and treatment of each patient should be followed. Most modern trauma systems therefore have a fairly rigid protocol to follow, thus reducing the opportunity for misdiagnosis.

The most widely taught system is the Advanced Trauma Life Support (ATLS) Program for Physicians, devised and disseminated by the American College of Surgeons (ACS). This article follows many of their recommendations. The management of major trauma has also been reviewed in the ABC of Major Trauma published by the British Medical Journal, Tavistock Sq. London, WC1H 2JR (ISBN 0-7279-0291-1).

Timing of Death Resulting from Trauma

The mortality due to injury occurs during one of the following time periods:

- The **first peak** of death occurs at the time of the injury. It may be instantaneous or within the first few minutes and is due to overwhelming **primary injury** to major organs or structures such as brain, heart or great vessels. In most situations these injuries are irrecoverable, although rapid treatment and transfer may salvage some patients. Primary prevention has a major role in reducing the incidence of these injuries.

- The **second peak** lasts from the end of this first period to several hours after the injury has taken place. It is during this time that many causes of morbidity and mortality are preventable by avoidance of a **secondary injury** due to hypoxia, haemorrhage or any process that leads to inadequate tissue perfusion. Reversible conditions may include intracranial haematomas, major haemorrhage from viscera, bones and vessels or pneumothoraces. Most trauma care is directed at this period as skilled assessment and treatment should reduce mortality and disability. Even with moderate facilities many lives can be saved by simple measures.

- The **third peak** of death occurs days or weeks after the injury and usually happens in a high dependency area where sepsis and multiple organ failure ensue. Advances in intensive care treatment may reduce these deaths but improvements in initial management on admission will also reduce morbidity and mortality during this period.

Immediate Assessment and Management

The patient suffering multiple trauma must be thoroughly assessed on admission so that life threatening injuries can be corrected. The condition of the patient must be stabilised and plans made for further treatment of their injuries. The team leader is responsible for assessing the patient and co-ordinating the work of the other members of the team, whose role is to treat the injuries as directed by the leader.

All trauma cases should receive:

- *Primary survey (assessment) and resuscitation*
- *Secondary survey*
- *Definitive treatment*

However, any life threatening condition identified during assessment must be treated immediately before proceeding to the next phase. The amount of time taken to proceed from one phase to the next varies.

Primary Survey and Resuscitation

The purpose of the primary survey is to diagnose immediate life threatening conditions. These should be treated as soon as they are discovered before continuing the survey. The survey is planned as follows:

- **A**irway control with cervical spine protection
- **B**reathing
- **C**irculation and control of haemorrhage
- **D**isorders of the central nervous system
- **E**xposure of the whole body

During the course of the primary survey, any deterioration in the patient's clinical condition should be managed by reassessing from the start of the protocol, as a previously undiagnosed injury may become apparent.

Airway control with cervical spine protection: ensure that a clear and unobstructed airway is present. If the patient can answer questions appropriately then it is unlikely that there is any immediate threat to the airway. Noisy or laboured respiration or paradoxical respiratory movements (when movements of the chest and abdomen are out of phase) are evidence of obstruction which must be rectified. Vomit, blood or foreign material in the mouth should be removed manually or with a rigid sucker. Sometimes a simple chin lift will prevent the tongue of an unconscious patient obstructing the airway, but often there will be need for further measures. Performing a jaw thrust (taking care not to disrupt the cervical spine control) will often open the airway. An oropharyngeal airway may also help but must be inserted carefully. It must never be inserted into the pharynx of a patient with an intact gag reflex as it could induce retching or vomiting. In these circumstances a nasopharyngeal airway can be inserted provided there is no suspicion of a basal skull fracture.

Case History

A 12 year old boy fell 30 feet from a tree onto his head. He was initially confused and then became quiet as his parents carried him to a mission hospital 5 miles away which was staffed by clinical officers and one doctor who was on leave. The clinical officer anaesthetist was called to see the boy. He started his assessment with the airway and immediately noted noisy respirations with very little airflow. Recognising that there was a possibility of neck injury he carefully lay the boy on his back, placed the head in the neutral position and performed a jaw thrust manoeuvre whilst holding the head immobilised. The airway obstruction was immediately relieved and he asked a colleague to place an oxygen mask over the face *and to find a semi rigid collar. This was carefully placed round the boy's neck, after which sandbags and tape were applied to ensure immobilisation. Shortly afterwards the patient recovered consciousness and began to breathe well without airway support. Only then did the anaesthetist let go of the child's head. He went on to assess the breathing and circulation. Having excluded other injuries and having stabilised the child's condition the anaesthetist accompanied the child to a district hospital 60 miles away in the back of an ambulance equipped with resuscitation apparatus. Simple airway manoeuvres often lead to an improvement in the head injured patient. It transpired that this child did not have a neck injury but the possibility could not be excluded and the precautions were essential. The boy had cerebral oedema and made a recovery over 10 days. He is now back at school.*

Any patient with a possible cervical spine injury should have their neck immobilised in a neutral position to prevent further damage. Cervical spine damage is likely with deceleration injury, hyperflexion or extension injury or any blunt injury above the clavicles. A fracture of the first rib seen on chest X-ray indicates high energy transfer and should always raise suspicion of cervical injury as well as intrathoracic damage. When available a closely fitting firm cervical collar should be applied and sand bags placed either side of the head to ensure immobility. These are secured with adhesive tape as shown in figure 1.

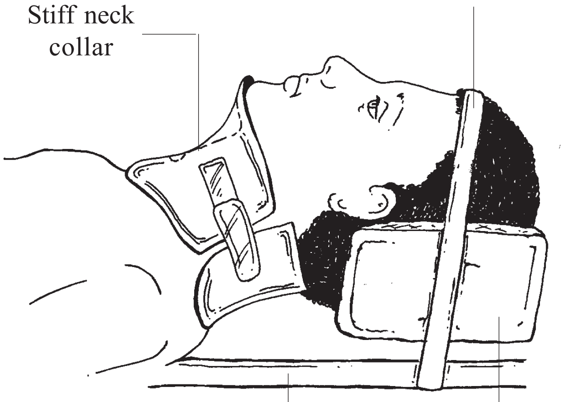


Fig.1.

Endotracheal intubation is indicated if airway patency remains inadequate despite the above measures, or in the presence of apnoea or loss of protective upper airway reflexes. Controversy exists as to the optimal route for intubation. Orotracheal intubation with in line immobilisation (not traction) of the cervical spine and use of a gum elastic bougie is unlikely to cause cervical spine movement (*figure 2*). Intravenous anaesthesia and muscle relaxation to facilitate intubation should only be used by experienced anaesthetists when successful intubation of the trachea with inline stabilisation of the cervical spine can be guaranteed. The combination of intravenous ketamine (or thiopentone in head injured patients) and suxamethonium is ideal. If continued anaesthesia and ventilation are required, a combination of intravenous agents can be used; an opiate, such as morphine in combination with a benzodiazepine such as diazepam and a non-depolarising muscle relaxant such as pancuronium are suitable. If severe facial disruption or anatomical disorders make intubation impossible, then a cricothyrotomy should be performed.

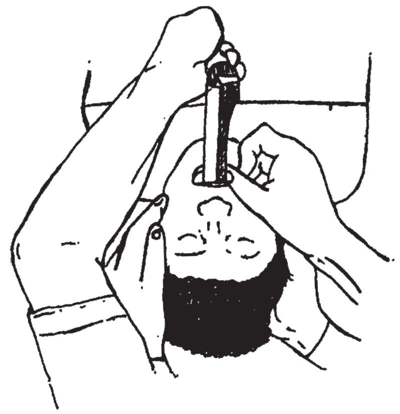


Fig.2. In-line immobilisation during laryngoscopy

Practical procedure- Cricothyrotomy (figure 3a & b). A 12 or 14 gauge cannula with a syringe attached is introduced through the cricothyroid membrane until air can be aspirated. The cannula is then advanced off the needle down the trachea. The hub of the cannula is connected to an oxygen supply. (It is important that all connections are tested beforehand). The patient can be oxygenated in this way, but ventilation to remove CO_2 cannot be achieved and respiratory acidosis will ensue. Spontaneous respiration is impossible through a needle cricothyrotomy.

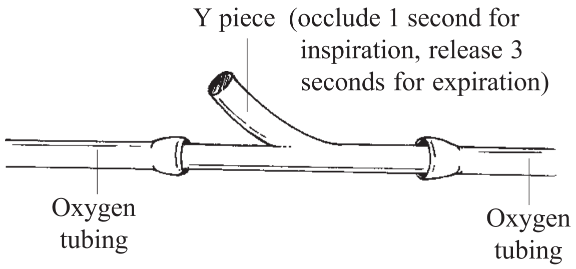


Fig.3a. Cricothyroid tubing set

A needle cricothyrotomy will ensure a supply of oxygen for a maximum of 10 minutes and it should be converted to a surgical cricothyrotomy to allow adequate ventilation. A horizontal incision is made through the membrane and a small (size 5.0-6.5) endotracheal or tracheostomy tube inserted.

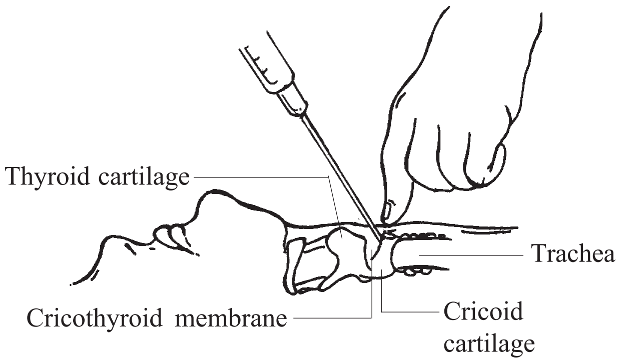


Fig.3b. Needle cricothyroidotomy

A tracheostomy carries a high complication rate in these circumstances, but may be considered if other methods have failed and a skilled surgeon is present.

Breathing: any obvious injuries must be noted, the trachea should be checked for deviation and both sides of the chest for expansion. The thorax must be percussed, and lung apices and the axillae auscultated. If the patient has been intubated but the position of the tube is in doubt, then listening over the stomach may reveal an inadvertent oesophageal intubation. The respiratory rate must be noted. If available, a pulse oximeter is useful as it gives an indication of the adequacy of perfusion as well as arterial oxygen saturation. High concentration oxygen (6-8 litres/minute) should be administered to every patient. The following life threatening conditions need immediate treatment:

- *Tension pneumothorax*
- *Massive haemothorax*
- *Flail chest*
- *Open chest wound*
- *Disruption of the tracheobronchial tree*

A **tension pneumothorax** is suggested by a rapid respiratory rate, mediastinal (and tracheal) shift away from the affected side, and hyper-resonance and reduced breath sounds on the affected side. It should be treated initially by needle decompression of the pleural cavity at the second intercostal space in the mid clavicular line, followed by formal pleural drainage with an underwater seal. It is important to remember that a simple pneumothorax may be converted to a tension pneumothorax when a patient is ventilated and in this situation a chest drain should be inserted prophylactically prior to commencing ventilation.

A **massive haemothorax** is suggested by reduced breath sounds, dullness to percussion and a shift of the mediastinum away from the affected side often accompanied by cardiovascular instability. It should be treated with formal pleural drainage and if the initial volume of blood exceeds 1500mls or bleeding persists at a rate exceeding 200ml/hr thoracotomy is indicated. Before diagnosing either of these conditions in a ventilated patient, it is important to check that the endotracheal tube is in the trachea and that it has not entered the right main bronchus as this may mimic some of the above signs.

Practical procedure - Pleural drainage (*figure 4a,b,c*): This is best performed in the fifth intercostal space at the anterior axillary line. A 32 French gauge or larger tube should be inserted without the use of a trochar, as this can cause significant damage. After skin incision, blunt dissection is performed and the pleura opened (4a). After an exploratory finger examination of the pleural cavity (4b) the tube is inserted in a postero-superior direction (4c), fixed to the skin and connected to a one way valve (for example an underwater drain). If no chest drains are available a nasogastric tube may be used with a drainage bag to drain blood (but not air). It is important that the system is closed to prevent air entering the chest via the drainage tube.

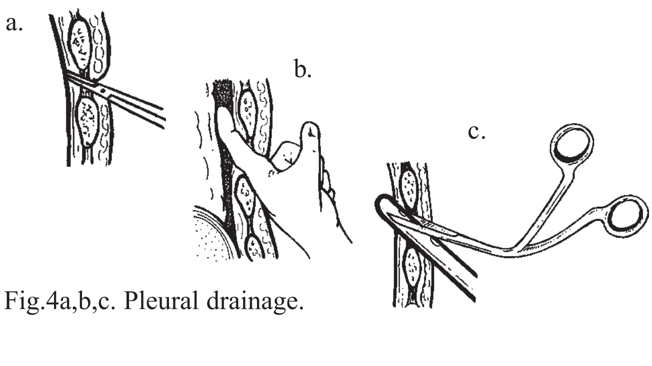


Fig.4a,b,c. Pleural drainage.

Flail chest means that part of the chest wall is able to move independently to the remainder and occurs when ribs are fractured in at least two places. It can be recognised when the flail segment falls during inspiration as the rest of the chest rises. It is always associated with significant pulmonary contusion resulting in hypoxia. If respiratory failure supervenes despite oxygen therapy and adequate analgesia (preferably epidural or intercostal blockade), then ventilation is required.

An **open chest wound** needs covering and sealing on three sides immediately (*figure 5*). A one way valve is formed by the flapping motion of the free edge of the dressing and this prevents air being sucked into the pleural cavity from the outside. This should be followed by formal pleural drainage and possible thoracotomy when the patient's condition has been stabilised. Once the pleural cavity is drained, the wound can be sutured or covered with an occlusive dressing.

Table 1.

Class of hypovolaemia	Class I	Class II	Class III	Class IV
Blood loss:				
% circulating volume	<15	15-30	30 -40	>40
(mls in adults)	<750	750-1500	1500-2000	>2000
Pulse	Normal	100-120bpm	120 bpm Weak	>120bpm Very weak
Blood pressure:				
systolic	Normal	Normal	Low	Very low
diastolic	Normal	High	Low	Very low
Capillary refill	Normal	Slow	Slow	Absent
Mental state	Alert	Anxious	Confused	Lethargic
Respiratory rate	Normal	Normal	Tachypnoeic	Tachypnoeic
Urine output	>30mls/hr	20-30mls/hr	5-20mls/hr	<5mls/hr

Patients with **major disruption of the tracheo-bronchial tree** need immediate endotracheal or endobronchial intubation and thoracotomy (These injuries have a very poor prognosis). The condition is diagnosed most often by the presence of pneumomediastinum, pneumopericardium or air below the deep cervical fascia of the neck in a patient suffering a deceleration injury. Minor tears may sometimes be managed conservatively.

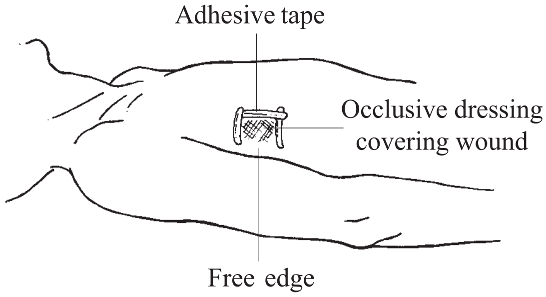


Fig. 5.

Circulation and haemorrhage control: any major haemorrhage that is visible should be controlled by direct pressure. Tourniquets should not be used to prevent bleeding from a limb as they occlude collateral circulation causing tissue destruction. Penetrating wounds should be identified and explored formally by a surgeon. Penetrating implements should be left in situ for formal surgical exploration. A rapid assessment of the cardiovascular system should be made including pulse rate, skin colour, capillary refill (the time taken for colour to return to a finger pad after it has been briefly compressed >2 seconds is abnormal), level of consciousness and blood pressure.

An inadequate circulation is often called shock, and in multiply injured patients the most common cause is haemorrhage. It should be remembered that blood loss from a fractured humerus can be up to 800mls, from a femur up to 2000mls and from a fractured pelvis up to 3000mls. In the early stages, hypovolaemia can often be tolerated without change in the systolic blood pressure due to autonomic nervous system reflexes. To assess the status of the patient the signs of inadequate circulation and the sympathetic response to it must therefore be elicited. Hypovolaemia is often categorised into the 4 classes shown in Table 1 with their appropriate signs. It must be stressed that there is variation from this guide, particularly in the elderly, in those with previous medical conditions or those who are taking cardiovascular medications who all tolerate hypovolaemia poorly, and in fit young patients who often tolerate it well. It should also be remembered that anaesthesia will obtund the signs of sympathetic nervous system activation. The weight of the patient will need to be estimated to calculate fluid requirements.

Management: Throughout the resuscitation period regular reassessment of the patient's condition is required and the treatment should be monitored frequently, preferably by a pulse oximeter or a continuous reading electrocardiograph. Two large (14 gauge) cannulae should be inserted. The antecubital fossae is often the easiest site, but a venous cutdown may be required.

Alternatively, the external jugular vein or the femoral vein can often be cannulated. In patients with suspected thoracic or abdominal trauma, intravenous access both above and below the diaphragm is often recommended. Central venous access is rarely indicated for initial fluid replacement, but may be useful to guide fluid therapy by measuring the right atrial pressure. Blood should be taken at the time of cannulation for crossmatch and in major trauma with shock eight units should be ordered as a priority. In Class III hypovolaemia blood is often needed before a full cross match is possible and in these circumstances blood banks should be able to provide uncrossmatched ABO compatible blood quickly. In patients not responding to volume replacement and those with Class IV hypovolaemia, uncrossmatched O Rhesus negative blood must be used and it is recommended that all Accident & Emergency Departments should have at least 2 units available at all times for immediate use.

Table 2.

Type of blood	Time required for preparation
Full crossmatch	30 - 40 minutes
ABO compatible	10 minutes
Uncrossmatched O Rhesus negative	Available immediately

In a previously fit patient it may be necessary to accept a haemoglobin concentration of 8g/dl (as long as they are not hypovolaemic) due to the shortage of blood in many developing countries and the risks associated with transfusion (including transfusion reactions and HIV and other infections). Oxygen carrying capacity should be adequate at this level. Prompt surgery to prevent blood loss, autotransfusion and transfusion from compatible relatives must be considered. If facilities are available blood should also be taken for full blood count, electrolyte and glucose estimation, and an arterial sample should be taken for analysis of blood gas tensions and acid/base balance.

The type of intravenous fluid administered to a hypovolaemic patient prior to blood transfusion continues to be controversial, and will often depend on local policy and availability. Either crystalloid or colloid can be used as long as the following points are kept in mind:

1. Crystalloid solutions that expand primarily the extracellular fluid should be selected i.e. normal saline or Ringer's lactate. Glucose (dextrose) only fluids should not be used unless there is no alternative.

2. As crystalloids rapidly leave the circulation, 3 times as much crystalloid compared with the volume of blood loss will be required.

3. Colloids remain within the blood vessels for longer and should be administered in volumes equal to the blood loss. However, they are excreted by the body and further infusions should be administered as required.

4. Blood is the best colloid in severe haemorrhagic shock. It should always be warmed if large volumes are administered rapidly.

The amount of fluid given will depend on the type and the extent of the injuries. If colloidal solutions are used, then 10-20mls/kg is an average initial requirement, and 20-30mls/kg if crystalloid solutions are used. Whenever possible the fluid should be warmed to prevent further cooling of the patient.

A sustained improvement in the signs of shock will hopefully be seen, and this suggests blood loss is less than 25% of the blood volume. If the improvement is short lived, this indicates continuing haemorrhage that requires control. Surgical intervention may be required and further blood transfusion necessary. If no improvement in the condition of the patient is seen, then the blood loss is greater than 40% and almost certainly from thoraco-abdominal or pelvic injury. It is in these patients that O negative blood should be considered.

Case History

A 36 year old fisherman was attacked by a hippopotamus whilst fishing on the isolated Lake Iteshi-teshi in Zambia. The hippo held him by the abdomen and in throwing him from the water lacerated the anterior abdominal wall exposing abdominal contents. The wound was 2 feet long and associated with some bleeding. The fisherman's friend placed a suture in the wound using a fishing hook and line and applied pressure to the wound to stop further blood loss. He was taken to University Teaching Hospital, Lusaka in the back of a pickup truck. The journey took 15 hours. On arrival the fisherman showed all the signs of Class IV hypovolaemia. He was promptly resuscitated with oxygen and 4 litres of warmed saline over ten minutes. Blood was taken for ABO compatible cross match and a urinary catheter inserted. There was no residual urine. Within 30 minutes of arrival in hospital he had already received 3 units of warm ABO compatible blood. His condition was much improved; he had regained consciousness and was able to talk about his ordeal, his pulse rate had fallen to 90 bpm, he had a blood pressure of 120/90 mmHg and he had passed 50ml of urine. Following this prompt resuscitation, anaesthesia and surgery were uneventful, renal failure was avoided and the patient made a complete recovery. He is still fishing on Lake Iteshi-teshi.

Fig.6. Fisherman after attack by hippopotamus in Zambia.

Occasionally haemorrhage is not the cause of the hypotension. For example, septicaemia and spinal cord injury can cause hypotension, but in both there is a relative hypovolaemia and the treatment outlined above is unlikely to be harmful.

Hypotension may also result from cardiac failure which is, however, rare in trauma patients and is likely to be due to cardiac injury, either myocardial contusion (which should be suspected in blunt thoracic trauma), or cardiac tamponade (which should be suspected in penetrating chest injury when shocked patients do not respond to intravenous fluid and the hypotension is out of proportion to the apparent blood loss). Cardiac tamponade must be relieved immediately and is confirmed by Beck's triad; raised jugular venous pressure, muffled heart sounds and hypotension. Tachycardia and pulsus paradoxicus (a 15% drop in systolic blood pressure during inspiration) will be present. Cardiac tamponade is treated by needle pericardiocentesis. If caused by a penetrating implement, this must be left in place while awaiting surgery.

Practical procedure- Needle pericardiocentesis (*figure 7*). With the patient attached to a cardiac monitor, a cannula is slowly inserted immediately to the left of the xiphisternum aiming for the tip of the left scapula and is constantly aspirated until blood appears. The tamponade can be aspirated (often with dramatic improvement in the patient's signs) and the cannula left in place for further aspiration. A thoracotomy may be required to stop the bleeding. Widening of the QRS complex, ST segment changes or multiple ventricular dysrhythmias indicate myocardial damage and unlimited aspiration of blood unaccompanied by clinical improvement is indicative of ventricular aspiration.

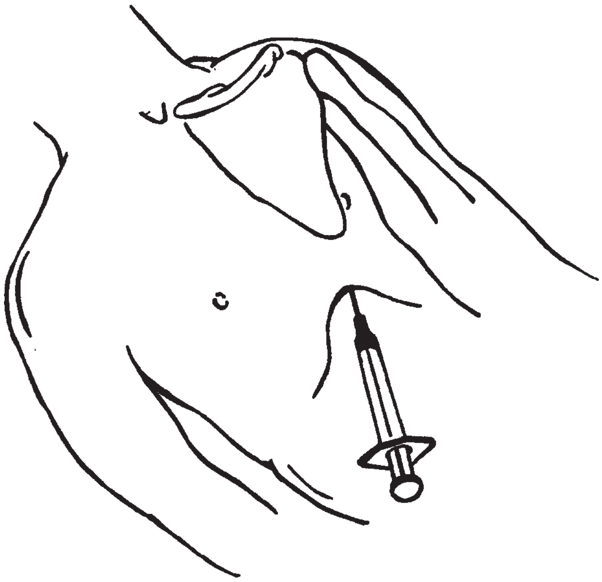


Fig.7. Direction of needle for perocardiocentesis.

All cases of traumatic cardiac tamponade require urgent surgical exploration.

Key points:

1. All trauma victims who are shocked have bled and are hypovolaemic until proven otherwise.
2. Commence rapid intravenous infusion immediately.
3. Warm intravenous infusions whenever possible.
4. Give warmed blood early in severe shock.

Disorders of the central nervous system: The central nervous system should be quickly assessed by ascertaining the level of consciousness, spinal cord function and pupillary response to light. Conscious level is assessed by recording patient eye opening and motor response to various stimuli. These are graded as spontaneous, in response to direct questioning, uncomfortable stimuli or none at all. All four limbs should be tested for response to assess spinal cord function.

Exposure: all multiple injured patients should be completely undressed. Clothes are cut off if necessary to minimise undesirable movement. This allows a thorough survey of injuries. The patient should, however, not be allowed to become hypothermic- and should be kept covered when possible and the resuscitation room should be warm. Injured children lose heat rapidly when exposed (even in hot environments), particularly if they are wet.

During the course of the primary survey, the four most important rules to remember are:

1. *The patient should be repeatedly reassessed, particularly if clinical signs change.*
2. *Any immediately life threatening condition diagnosed should be rectified without delay.*
3. *Penetrating wounds and implements must be left for formal surgical exploration.*
4. *Any external bleeding should be stopped by using direct pressure.*

Secondary Survey: Following the initial survey and resuscitation, the patient should undergo a thorough secondary survey with the aim of documenting any other injuries. During this survey, however, the basics of the primary survey (airway, breathing and circulation) should be regularly reassessed to detect any unexpected deterioration. The patient is best examined from head to foot by the team leader. Tetanus immunisation and prophylactic antibiotics can be administered if necessary. A history should be obtained and finally, the standard radiographs of the lateral cervical spine, chest and pelvis are taken. (Remember however, that lateral cervical spine radiographs may fail to reveal up to 20% of injuries). The temperature of the patient should be recorded. This may require the use of a low reading thermometer. Remember to keep the patient covered unless an examination or procedure is being carried out.

History: during the course of the secondary survey the following points must be clarified:

- **A**llergies
- **M**edications and tetanus immunity
- **P**revious medical history
- **L**ast meal
- **E**vents leading to the injury

Vital information can be gained from the history or the events leading to injury and particular attention should be paid to the mechanism of injury. The extent and severity of injury is related to the amount of energy transferred to the patient. In blunt trauma, commonly associated with road traffic accidents and falls, there are a number of situations which are associated with life-threatening injuries:

1. Road Traffic Accidents:
   - where speeds were in excess of 40 mph
   - where the victim was ejected from the vehicle
   - where other victims were killed
   - where there was severe disruption of the vehicle passenger compartment

2. A fall of greater than 10 feet (remember a patient who is six feet tall and sustains a head injury falling off a six foot wall has sustained an energy transfer to the head compatible with a total fall of twelve feet).

3. In penetrating trauma from gunshot the amount of tissue damage increases with the velocity of the bullet particularly if the bullet does not exit the body (when all of the projectile's energy is transferred to the tissues).

Head: a Glasgow Coma Scale score should be documented at this point (*Table. 3*). The scalp should be palpated for fractures, lacerations and other deformities. Adults rarely lose a significant amount of blood from scalp wounds but brisk bleeding should be stopped. Any injury to or around the eye should be noted. Periorbital and/or subconjunctival haemorrhage may indicate a base of skull fracture and penetrating injuries or foreign bodies are not uncommon.
Blood or cerebrospinal fluid coming from the ears or nose also indicates basal skull fracture. When blood is mixed with CSF the presence of CSF can be demonstrated by dropping the blood onto blotting paper when a double ring is formed.

Facial fractures must be sought by careful palpation, but only treated at this stage if likely to compromise airway patency. Swelling or haemorrhage associated with such fractures may cause delayed respiratory obstruction and must be anticipated. Movement of the maxilla indicates a middle third facial fracture.

Table 3. Glasgow Coma Scale

Eyes open:	***Score***
Spontaneously	4
To speech	3
To pain	2
Never	1
Best motor response:	
Obeys commands	6
Localises pain	5
Withdrawal from pain	4
Abnormal flexion	3
Extends to pain	2
No response	1
Best verbal response:	
Orientated	5
Confused	4
Inappropriate words	3
Incomprehensible sounds	2
Silent	1

Neck: the patient should be asked if they have any neck pain. With an assistant performing in-line immobilisation, the tapes, sand bags and neck collar should be gently removed and the neck examined for lacerations, swellings, tenderness or deformity of the cervical spine. Penetrating neck wounds must be explored under general anaesthesia.

A lateral X-ray of the cervical spine must show all the vertebrae including the body of the 1st thoracic vertebra. Traction downwards on the arms should help to obtain a good film. X-rays alone cannot detect all injuries to the cervical spine, and much depends on the history and examination as well as an experienced review of lateral, antero-posterior and odontoid peg radiographs.

Thorax: The entire chest must be examined for signs of injury. This includes palpating for fractures of the clavicles and ribs and the presence of subcutaneous emphysema. Percutaneous drainage of haemo-pneumothoraces must be performed when they are diagnosed or strongly suspected. Pleural drainage must also be considered in those with multiple rib fractures, particularly if undergoing positive pressure ventilation, due to the risk of developing a tension pneumothorax. Deceleration injuries may cause tracheobronchial injury, transection of the thoracic aorta, cardiac injury or diaphragmatic rupture.

Complete **aortic transection** is immediately fatal. Incomplete aortic transection is suggested by the history, chest X-ray signs of widening of the mediastinum, pleural capping (fluid shadow at apex of lung), and a shift of the trachea to the right and/or inferior displacement of the left main bronchus. Treatment of these injuries needs specialist facilities. Aortogram X-rays are used to diagnose aortic injuries and careful control of the blood pressure is necessary perioperatively to prevent ex-sanguination.

Cardiac contusion may be suggested by the history, inadequate response to intravenous fluids, high central venous pressure and ECG changes. Investigations include echocardiography which may show abnormal heart wall movements and/or pericardial effusions. Inotropic agents such as an adrenaline infusion may be required. Echocardiography is also useful for diagnosing heart valve rupture.

Diaphragmatic rupture is commoner on the left and is diagnosed if abdominal contents are visible in the hemithorax on a chest X-ray. However, positive pressure ventilation may have been required if respiratory failure was present, and this may reduce the hernia. If a diaphragmatic injury is suspected a naso or oro-gastric tube should be inserted and the X-ray repeated. Surgical repair is required if the injury is diagnosed. Right sided ruptures are difficult to diagnose, but a raised or irregular hemidiaphragm may suggest a defect.

Abdomen: the abdomen must be inspected for signs of injury and the presence of free intra-peritoneal fluid. Penetrating wounds should be examined at laparotomy if they breach muscle. Eviscerated bowel must be covered with packs soaked in warm saline and replaced under general anaesthesia. Pelvic injury may be diagnosed by clinical examination, but an X-ray should always be performed. Blood at the urethral meatus, scrotal haematoma or on a high prostate on rectal examination indicate urethral injury in the male. In these situations a supra-pubic catheter should be inserted. Otherwise a urethral catheter should be inserted, and the presence of any obvious or microscopic haematuria sought. The rectal examination may also reveal blood or pelvic fractures, and an assessment of anal tone can be made. A lax anal sphincter may indicate that spinal cord injury has occurred. The stomach may dilate acutely in trauma patients, and may need decompression using a nasogastric tube (or an oro-gastric tube if a basal skull or mid face fracture is suspected). Vaginal examination may show a pelvic fracture or breach of the vaginal vault.

If assessment is difficult or equivocal, then diagnostic peritoneal lavage is indicated. It should not be performed if there is a need for urgent laparotomy i.e. penetrating trauma, unexplained hypovolaemia, extruded bowel or radiological evidence of intra-abdominal trauma.

Practical procedure- diagnostic peritoneal lavage (DPL). A naso/oro-gastric tube and urinary catheter must be in position. Under sterile conditions, after infiltration with lignocaine and 1 in 200,000 adrenaline, a vertical skin incision is made one third of the distance from the umbilicus to the symphisis pubis. The linea alba is divided and the peritoneum entered after it has been picked up to prevent bowel perforation. A peritoneal dialysis catheter is inserted towards the pelvis and aspiration of material attempted. 1 litre of warm 0.9% saline is then infused, and after a 5 minute dwell time is allowed to flow back by gravity to a bag placed on the floor.

Indications for laparotomy are: the presence of bile, enteric contents or >5mls of blood aspirated before fluid is infused, or the inability to read standard newsprint through the returned fluid in the bag.

Limbs: Fractures, wounds and discoloration must be noted. Check pulses in all limbs even if no fracture is suspected. Fractures compromising circulation must be reduced to prevent distal ischaemia. If possible, sensation in the limbs is assessed. Fractures should be splinted to reduce pain and the risk of fat emboli. Swabs should be taken from open wounds, which can then be covered with a sterile dressing.

Contaminants and devitalised tissue should be removed. Large blood losses may be associated with long bone and particularly pelvic fractures, but in a shocked patient they must not be assumed to be the only cause. Early fixation of these fractures may reduce blood loss, accelerate mobilisation of the patient and reduce the severity of fat embolism. Signs such as increased limb swelling, pain and disordered sensation suggest compartment syndrome and urgent decompression by surgical fasciotomy is required.

Spine: hypotension with bradycardia is unusual in hypovolaemia but, if present, does not exclude haemorrhage, especially in elderly patients. It is, however, more likely to be due to spinal cord damage in a patient with a history suggestive of spinal injury. Fluid replacement should be guided by careful cardiovascular monitoring to prevent circulatory overload. Other indicators of cord damage are acute urinary retention, diaphragmatic respiration, priapism (persistent abnormal penile erection), lax anal sphincter and flaccid paralysis of the limbs. The cervical and thoracolumbar regions are most commonly affected by trauma, and appropriate radiographs should be taken. The patient must be log rolled (*figure 8*) and the entire spine examined for deformities or injuries. The rest of the back should also be examined at this point to exclude other injuries.

> ***Key point***
>
> During the secondary survey, a reassessment of the primary survey (airway, breathing and circulation) is often indicated. This takes priority over any other procedure being carried out. Once the secondary survey has been completed, the primary survey should be repeated to prevent any new complications from occurring during the course of the definitive treatment.

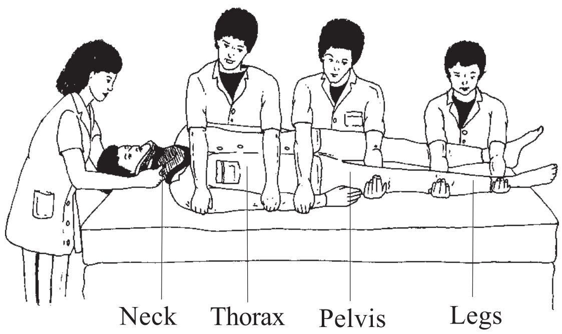


Fig. 8a. Preparation of log roll maneouvre

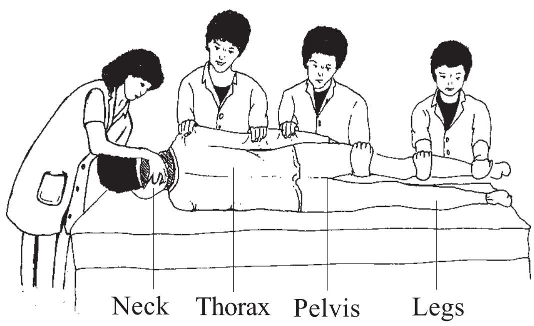


Fig. 8b. Log roll

Definitive treatment

The further treatment of the patient will depend on the injuries detected during the preceding examination. The highest priority is given to those that are life threatening. Thoracic and abdominal conditions may warrant surgery at this stage.

Case History

Following initial assessment and resuscitation, a 21 year old road traffic accident victim still had the signs of class 3 hypovolaemia after 6 litres of saline and 2 units of O negative blood had been given. Her abdomen was distended and the hospital had run out of blood that morning. The anaesthetist asked for the autotransfusion bottles to be made ready in theatre, and moved the patient into the operating theatre. A number of sterilised 500ml bottles containing 2g of sodium citrate and 3g of dextrose made up to 120ml with sterile water were ready. Anaesthesia was induced once the surgeon was scrubbed and the patient draped for laparotomy. This revealed a free intraperitoneal rupture of the spleen with over 2 litres of intraperitoneal blood. There was no obvious bowel injury and the blood *appeared to be uncontaminated. The blood was collected 500ml at a time into a kidney dish and the splenic vessels clamped. The scrub nurse poured the anticoagulant from the first of the prepared bottles into the kidney dish with the blood and mixed well. The nurse then filtered the mixture of blood and anticoagulant through 4 layers of sterile gauze back into the bottle, replacing the stopper, discarding any clots, and handing it to the anaesthetist before repeating the process with the next bottle. The anaesthetist then transfused the blood via a blood giving set (all of which have a 120micron filter). Four bottles of blood were returned to the patient who survived and made a good recovery. Autotransfusion is effective but needs preparation. If you cannot prepare your own anticoagulant as described, use the anticoagulant from purpose designed venisection bags available in your local blood bank.*

Transfer of the patient with multiple trauma can be hazardous. In all but the most desperate situations, the condition of the patient should be stabilised prior to transfer. The level of monitoring must be maintained during transport, adequate resuscitation equipment and drugs should be available, hypothermia avoided and the receiving area must be warned of the condition of the patient. The staff who accompany the patient should be experienced in transport of the critically ill.

Head injured patients

The definitive management of these patients is beyond the scope of this article, but some basic points can be reviewed. Many hospitals in the world do not have access to neurological services such as Computerised Tomography (CT) scanning. None the less, much can be achieved. In a review of severely head injured patients in hospitals in the developing world without access to CT scan or a neurosurgeon, 25% of a series of 214 severely head injured patients (Glasgow Coma Scale 8 or less) made a good recovery.

As with all trauma patients, the treatment of those with head injuries is dependant on the principle that no further damage should occur to the injured brain after the initial trauma. Any process resulting in inadequate brain perfusion may cause a secondary brain injury, and hypoxia, hypercarbia and hypotension must be prevented. The primary survey and secondary survey will help to detect these problems. The Airway, Breathing and Circulation should be assessed and treated appropriately, the nervous system surveyed and the entire patient examined.

Assessment: obviously, injuries to the head such as lacerations, bruising or evidence of fractures raises the possibility of an intra-cranial injury, but the presence of a head wound is not necessary for a serious injury to exist. If present wounds should be gently explored and documented. Dysfunction of the nervous system during the primary and secondary survey is assessed. A trend of clinical signs is useful and can be recorded on an appropriate chart (*figure 9*). This may be photocopied if required and used in your hospital.

A difficult problem in many trauma cases is differentiation between those patients who have a depressed conscious level due to cardiorespiratory problems and those who have a brain injury. It is also important to decide which patients require neurosurgical intervention. Although detailed examination, repeated observations and skull radiographs may help, the majority of seriously head injured patients undergo CT scanning in the developed world to assess the need for surgery. CT's reveal intracranial haemorrhages, cerebral oedema, midline shift and mass effect. They do not, however, show many changes in those patients with diffuse axonal injury. CT scans may give a false sense of security if performed soon after the traumatic event (up to 6 hours). The vast majority of patients going for CT scanning will require intubation and ventilation and this should be performed in a suitable area before transferring the patient.

Treatment: significant extradural and subdural haematomas require urgent evacuation. In units far from a neurosurgical centre, the general or orthopaedic surgeons must perform the necessary procedure. Where no CT facilities exist clinical indications of an intracranial haematoma in a patient with a head injury include a decreasing level of consciousness and a dilated pupil on the same side as the haematoma and less limb movement on the opposite side.

UPDATE IN ANAESTHESIA

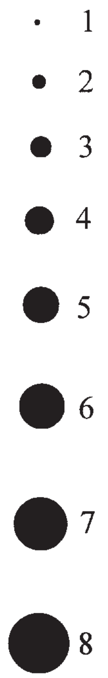
NEUROLOGICAL OBSERVATION CHART

NAME:	Hosp No:
Date:	Ward:

																																		TIME
COMA SCALE	Eye Opening	Spontaneous	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	Eyes closed by swelling = C
		To Speech	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
		To Pain	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
		None	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Best Motor Response	Co-operative	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	Usually the best arm response Paralysed = P
		Localises Pain	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
		Withdraws from Pain	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
		Abnormal Flexion	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
		Extends to Pain	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
		None	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Best Verbal Response	Orientated	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	Endotracheal tube or tracheostomy = T Aphasic = A
		Confused	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
		Inappropriate	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
		Incomprehensible	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
		None	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Totals:																																	

PUPILS		
	Right size in mm	+ reacts
	Pupil reaction	- no reaction
	Left size in mm	c eyes closed
	Pupil reaction	

PUPILS Scale (mm)



		Temperature (°C)
Blood Pressure (V Λ)	240	
	230	
	220	40 ■
	210	39
	200	38
	190	37
	180	36
	170	35
	160	34
Pulse (.)	150	33
	140	32
	130	31
	120	30
	110	
	100	
	90	
	80	
Resp. Rate (o)	70	
	60	
	50	
	40	
	30	
	20	
	10	

LIMB MOVEMENT			
	ARMS	Normal Power	Record right (R) and left (L) separately if there is a difference between the two sides.
		Mild Weakness	
		Severe Weakness	
		Spastic Flexion	
		Extension	
		No Response	
	LEGS	Normal Power	
		Mild Weakness	
		Severe Weakness	
		Extension	
		No Response	

Initials	

Management of patients with serious head injury is somewhat controversial. In most units in the UK, a period of sedation and controlled ventilation is undertaken. This allows a period of stability to be attained and cerebral oxygen delivery to be optimised, but it prevents serial measurements of the patient's level of consciousness. Each case must therefore be considered on its own merits. Controlled ventilation should be performed to treat hypoxia, repeated vomiting, agitation, fitting or evidence of raised intracranial pressure (ICP).

Raised ICP is suggested by a Glasgow Coma Scale of less than 8, slow pupillary responses to light, respiratory rate abnormalities, hypertension and bradycardia. The most reliable method of evaluating the ICP is to measure it directly, although there is no clear evidence that outcome is improved and many hospitals in UK do not routinely measure ICP in head injuries. Several methods are available including the intraventricular, subdural, extradural and intra-parenchymal monitors but none are commonly available in developing countries. They also have a significant complication rate due to bleeding, infection and brain injury.

When treating head injuries ensure that conditions predisposing to rises in intracranial pressure are managed properly. Therefore pain, fever, bladder distension, hyponatraemia, hypoxia, hypercapnia, hyperglycaemia and hypertension must all be treated. The patient should be nursed with a slight head-up tilt and endotracheal tubes must be taped (not tied) to encourage cerebral venous drainage. Raised intrathoracic pressure and rigid cervical collars also may impede venous return and ventilation patterns should be tailored individually. Sandbags, headtapes or external fixation e.g. calipers should be considered in the presence of a cervical spine injury. Coughing should be avoided, and therefore neuromuscular blockade may be required provided the patient is adequately sedated.

Once these general causes have been treated, any deterioration warrants consideration for repeat CT scan if this is available. The presence of a significant haematoma needs evacuation. Cerebral oedema is often treated with mannitol in order to increase the osmolarity of the blood. In the trauma setting, however, the blood-brain barrier may be disrupted allowing leakage of the mannitol thereby exacerbating the problem. It should therefore be used with care. Drainage of CSF may help to reduce ICP but requires an intraventricular catheter. Intracranial pressure can also be reduced temporarily by hyperventilation which results in cerebral vasoconstriction and thereby a reduction in intracranial blood volume. However, this effect only lasts for about 12 hours by which time homeostatic mechanisms reset themselves. Theoretically hyperventilation can also induce cerebral hypoxia, and most centres now ventilate patients to obtain a pCO_2 in the low-normal range. Cerebral blood volume can also be reduced indirectly by reducing the cerebral oxygen consumption. This is the rationale for the treatment of a raised temperature (and in some centres, the induction of mild hypothermia) and therapy with barbiturates. Although the latter decrease ICP, there is little evidence to confirm their effectiveness. If required, controlled ventilation is usually instituted for a period of 24 - 48 hours. If the patient is stable after this time, sedation may be stopped and the patient assessed. Re-sedation and ventilation may be required if neurological function is poor.

During the patient's hospital stay the head injury must not lead to inadequate holistic care. Attention must therefore be made to analgesia, prevention and treatment of infection, nutrition and physiotherapy. Poor recovery from head injury often overwhelms the family caring structure, and rehabilitation should be organised at the earliest opportunity. Apparent recovery may mask more subtle psychological defects, and therefore all patients recovering from severe head injuries must be assessed appropriately.

Anaesthesia for trauma patients

As with anaesthesia for all patients, the key to successful trauma anaesthesia is the adequate assessment and pre-operative resuscitation of the patient. In all but the most urgent surgery, there is sufficient time for this to be undertaken.

Preoperative assessment: all injuries should be noted. If the patient has been admitted using the trauma method outlined above, then it is unlikely that serious injuries will have been missed. When faced by patients who have not been subjected to a rigorous trauma team admission the anaesthetist should thoroughly examine the patient for head, spine, thoracic and abdominal injuries. The treatment of injuries that are life threatening or have the potential to become so must be given priority.

Continuous neurological observations will be disrupted by the administration of a general anaesthetic so that only emergency surgery should be undertaken during the period of observation. The feasibility of local or regional anaesthesia should be explored if surgery is required.

Those with thoracic injury should be investigated for the presence of fractured ribs as well as haemo- or pneumothoraces or other damage. If positive pressure ventilation is to be used then consideration must be given to prior insertion of an intra-pleural drain to prevent the development of a tension pneumothorax during anaesthesia. Possible cardiac contusion must not be overlooked. A 12 lead ECG recording may assist in detecting this in patients with chest trauma. It may present as hypotension despite adequate fluid replacement in a patient at risk. A CVP line is useful in such patients.

Starvation time prior to trauma anaesthesia is a contentious issue. In the patient undergoing immediate or early (<12 hours) operation the most important time interval is that between their last meal and injury, as after this time gastric emptying may cease. In those undergoing later surgery after a period of stabilisation and observation on the ward, the patient is often assumed to have an empty stomach if they are not in severe pain or have no other preoperative reasons to delay gastric emptying.

In addition a specific anaesthetic assessment should be performed. The appropriate investigations depend on the injuries sustained and the procedure to be undertaken. A blood crossmatch must be performed and an adequate volume of blood ordered. Premedication is usually not necessary if the patient is being kept pain free and the procedure is well explained. Preoperative antibiotics and tetanus vaccination are usually required.

Following assessment pain relief should be administered to the injured patient if surgery is going to be delayed. A variety of methods are available including nerve blocks, opioids (not in head injuries as they may mask deterioration in the patient's conscious level) or non-steroidal anti-inflammatory drugs such as aspirin or diclofenac (avoid in patients with peptic ulceration and asthmatics). Opioids are best administered slowly intravenously and titrated against effect. If they are given intramuscularly the drug may not be absorbed. Nitrous oxide (often in a 50% mixture with oxygen as "Entonox") is a useful analgesic which lasts as long as the patient breathes it. It should only be given to conscious patients who can hold the mask for themselves and must be avoided in chest injuries (risk of tension pneumothorax) and in diving accidents (risk of decompression sickness "bends"). It is a particularly useful agent to give the patient when they are about to be lifted or moved in a painful fashion.

Induction of anaesthesia: local or regional anaesthesia may be appropriate but multiple procedures in different body areas precludes it. The hypotension seen with epidural or subarachnoid blockade will be greater if the patient is hypovolaemic and this must therefore be corrected before the block is performed. Spinal or epidural anaesthesia must not be undertaken in head injured patients due to the risk of spinal CSF leakage giving rise to coning of the medulla.

General anaesthesia can be performed in the normal manner assuming the patient is adequately resuscitated and precautions are taken to prevent aspiration of stomach contents. Monitoring must be instituted prior to induction and a central venous catheter may assist in cases in whom a large blood loss is expected. Care should be taken not to move a suspected cervical spine injury during positioning of monitoring and airway manoeuvres. Depolarising neuromuscular blocking agents (suxamethonium) must be avoided in those with spinal cord damage or multiple injuries if the anaesthetic takes place more than 24 hours from the time of trauma. This is to prevent catastrophic potassium level rises which may occur in these patients for up to 6 months following the injury. Ketamine raises ICP and must be avoided in those at risk.

Thiopentone must be very carefully titrated and much smaller doses are usually needed in injured patients. Ketamine is a suitable induction agent for patients who have been, or who are hypovolaemic.

Maintenance of anaesthesia: Ventilation is controlled following the administration of a non-depolarising muscle relaxant to prevent hypercarbia as this will cause a rise in intracranial pressure. A combination of nitrous oxide (unless contraindicated - see below) and oxygen with a low concentration of an inhalational agent and opiates are suitable. Deep levels of anaesthesia with respiratory depression in the spontaneously breathing patient and coughing on the endotracheal tube cause a rise in intracranial pressure and must be avoided. Adequate attention must be paid to the prevention of hypothermia. Warmed intravenous fluids, blankets to cover the patient and a woolly hat are useful to limit heat loss. In prolonged procedures the temperature should be recorded (this can be done with an axillary thermometer) and appropriate action taken if it falls. Remember that halothane is more depressant to the cardiovascular system than ether or intermittent ketamine.

The positioning and movement of the patient must be carefully planned and supervised to prevent exacerbation of any injury. If actual or potential air filled spaces (pneumothoraces or suspected intracranial air with compound skull fracture) are present then nitrous oxide must be avoided. This is to prevent enlargement of the space due to rapid diffusion of nitrous oxide.

Blood loss can be large and in long procedures vigilance is required. The urine production must be monitored and an output of at least 1 ml/kg/hr should be maintained. The most likely cause of oliguria is hypovolaemia and intravenous fluid therapy should be titrated against urine output. Where there is difficulty about deciding how much fluid replacement is required and particularly in the presence of thoracic injuries, central venous pressure should be monitored.

In addition the patient must be observed carefully for any changes in vital signs which are unexpected and which might be the result of undiagnosed injury (for example hypotension caused by intra-abdominal bleeding may persist during an operation to stabilise a fractured femur). Good communication between surgeon and anaesthetist is vital.

Unexplained hypoxia in the perioperative period where there is a longbone or pelvic fracture may be due to **fat embolism** associated with the release of intramedullary fat into the venous circulation from the fracture site. This can occur at any time following fracture, but is more common if surgical fixation is delayed for longer than 8 hours. The lung injury is characterised by pulmonary capillary leak leading to pulmonary oedema (this occurs in the absence of heart failure and is known as low pressure pulmonary oedema). The X-ray findings are characteristic (*figure 10*). Hypoxaemia is always present and respiratory failure common. The lung injury can be associated with systemic capillary injury (the fat embolus syndrome) commonly affecting the cerebral circulation, leading to confusion and drowsiness. A petechial rash is usually present over the trunk and conjunctiva due to systemic capillary damage. Renal impairment can occur. Treatment of fat embolism involves respiratory support with oxygen therapy and ventilation, and circulatory and renal support if

Fig. 10. Chest X-ray

required. When suspected, fat em-bolism should also be treated with 500 mg intravenous methylprednisolone given over 30 minutes. Remember, however, there are other causes of hypoxia in the peri-operative period.

Reversal of anaesthesia and postoperative care: No patient should have their neuromuscular blockade reversed until they have been adequately resuscitated and have a normal blood pressure and pulse rate and adequate urine flow. Following prolonged surgery, and in patients with injury to a number of body systems, particularly head and chest, a period in the recovery room of 24 hours with continuous close observation and availability of an anaesthetist should be considered. Alternatively such patients should be admitted to an intensive care unit where adequate analgesia with intravenous opiates, ventilation, and treatment in response to a change in condition (for example blood loss due to a coagulation defect) can be provided.

Case History

A nine year old girl was admitted to a University Teaching Hospital following a serious car accident in which two people were killed. On primary survey she was dyspnoeic, though her airway was clear. She had absent air entry on the left side of her chest and dullness to percussion. Her trachea was not deviated. She was in hypovolaemic shock with a pulse of 150/minute and unrecordable BP. A distended abdomen was noted as was her depressed conscious level. There was some response to voice but she was making incomprehensible groaning sounds. Both pupils were reacting normally and there was a haematoma on her forehead. Her weight was estimated to be 30kg

Oxygen was immediately given at 8 litres / minute via a face mask and blood taken for crossmatch whilst two intravenous cannulae were inserted. Initially she was given a fluid loading of 10mls/kg body weight (300mls) of saline and then this was repeated using Haemaccel. This improved her blood pressure for only a short time and therefore another 300mls of Haemaccel was administered and then 2 units of uncrossmatched group O negative blood, which were warmed in a basin of water at hand temperature. During this time a surgeon had performed a secondary survey and decided to do an immediated laparotomy where a ruptured spleen was resected. He had also inserted a chest drain on the left side preoperatively and drained a haemo-pneumothorax.

Anaesthesia was induced with ketamine 1.5mg/kg and suxamethonium 1.5mg/kg and maintained with intermittent ketamine and and a muscle relaxant. Two further fluid boluses of Haemaccel were given after which the child stabilised. Postoperatively the child made a good recovery and was discharged home.

Summary

The key to successful trauma management involves prior preparation of the resuscitation room and creation of a trauma team in which the anaesthetist plays a vital role. Once mobilised, the team should be co-ordinated by a leader who should follow a regime based upon a primary survey and resuscitation, a secondary survey once the patient has been stabilised and prompt initiation of definitive treatment. A full history should identify mechanisms of injury. Anaesthesia for the trauma patient must involve a full assessment of the actual and potential injuries with the appreciation that resuscitation is often ongoing and the patient's condition can change dramatically.

ATROPINE

Dr LM Pinto Pereiro, The University of the West Indies

Atropine a naturally occurring alkaloid of "*atropa belladonna*", is a competitive antagonist of muscarinic cholinergic receptors. It is absorbed from the gastro-intestinal tract, and is excreted in the urine. Atropine undergoes hepatic metabolism and has a plasma half-life of 2 - 3 hours. Atropine ampoules should be stored away from light and never be frozen.

Uses: When used as premedication for anaesthesia, atropine decreases bronchial and salivary secretions, blocks the bradycardia associated with some drugs used in anaesthesia such as halothane, suxamethonium and neostigmine, and also helps prevent bradycardia from excessive vagal stimulation.

Dose and Administration: Around 500 - 600mcg are used as a premedication in adults administered intramuscularly 30 - 60 minutes before surgery. Alternatively it may be given intravenously at induction of anaesthesia. Children should receive 20mcg/kg.

When used to treat bradycardias 250 - 500mcg is generally effective in adults whilst children should receive 10-20mcg/kg.

During reversal of neuromuscular blockade in adults 1 - 1.2mg of atropine is given mixed with 2.5 - 5mg neostigmine.

Main effects: There is usually an increase in heart rate and sometimes a tachycardia as well as inhibition of secretions (causing a dry mouth) and relaxation of smooth muscle in the gut, urinary tract and biliary tree. Since atropine crosses the blood brain barrier CNS effects in the elderly may include amnesia, confusion and excitation. Pupillary dilatation and paralysis of accommodation occur, with an increase in intraocular pressure especially in patients with glaucoma. Occasionally small intravenous doses may be accompanied by slowing of the heart rate due to a central effect - this resolves with an extra increment of intravenous atropine.

Cautions: Avoid large doses of atropine in the elderly. Glycopyrrolate, which does not cross the blood brain barrier, is not associated with CNS excitability but is more expensive and less effective for treating bradycardias. Atropine should be avoided when possible in febrile children as the body temperature may be further increased, particularly in places with a high environmental temperature.

Adverse effects: Being a sympathetic cholinergic blocking agent, signs of parasympathetic block may occur such as dryness of the mouth, blurred vision, increased intraocular tension and urinary retention.

CONTINUOUS FLOW ANAESTHETIC APPARATUS - THE BOYLE'S MACHINE

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Continuous flow anaesthetic machines date back to the first availability of compressed gases, and despite numerous modifications the modern apparatus retains many of the features of the original Boyle's machine, a British Oxygen Company trade name in honour of the British anaesthetist H E G Boyle (1875- 1941). This article describes the basic principles of continuous flow apparatus and will be followed in the next edition of Update by a description of anaesthetic circuits.

Basic Design: Pressurised gases are supplied by cylinders or pipelines to the anaesthetic machine which controls the flow of gases before passing them through a vaporiser and delivering the resulting mixture to the patient via the breathing circuit.

Medical gas supply.

Cylinders: Anaesthetic gas cylinders are made of molybdenum steel and should be regularly checked by the manufacturer for faults.

Different gases are supplied at specific pressures. The standard E size oxygen cylinders attached to anaesthetic machines are supplied at 134 bar pressure and contain 680 litres of oxygen.

During compression nitrous oxide becomes a liquid, which then evaporates to form a gas as it is released. This process causes cooling of the cylinder. The pressure in an E size nitrous oxide cylinder is 44 bar which releases 1800 litres of nitrous oxide during use. Unfortunately there is no international colour coding system for the contents of anaesthetic gas cylinders (or pipelines). In the USA oxygen is supplied in green cylinders, in the UK the cylinders are black with white shoulders and in Germany they are blue. Under circumstances where the supply of oxygen is unreliable the only true method of identifying the contents of an oxygen cylinder is to use an oxygen analyser.

In order to ensure that the correct cylinder is attached to the yoke of the anaesthetic machine a series of pins on the machine yoke is made to fit an identical pattern of indentations on the cylinder.

This is known as the pin-index system. It is not foolproof, however, as the pins may be deliberately

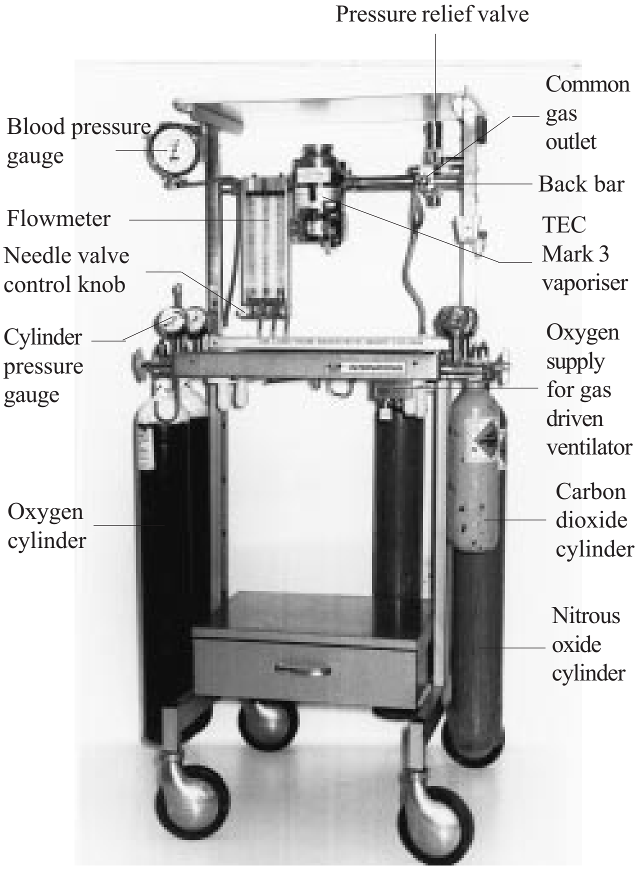

Fig.1. BOC Boyle International Continuous Anaesthetic Machine

removed allowing the wrong cylinder to be fitted to the machine.

A small metal and neoprene seal (Bodok Seal) ensures a gas-tight fit between the cylinder and anaesthetic machine yoke. Under no circumstances may oil or grease be used as a seal; the pressurised gases give off heat as they are released from the cylinder and may cause explosions if oil is used. Before attaching a full cylinder to the machine briefly open and close the cylinder valve to clear any dirt from the port.

Anaesthetic machines operate at 4 bar pressure and therefore the compressed medical gases in cylinders pass through reducing valves to bring the gas pressure to a constant 4 bar. Non-return valves prevent empty cylinders still attached to the machine from refilling from fresh cylinders. Until recently cylinders of cyclopropane and carbon dioxide were also commonly found on anaesthetic machines. Cyclopropane is now rarely used and carbon dioxide should only be attached if the anaesthetist wants to use it for a specific reason.

Pipeline Supply: Larger hospitals supply medical gases from a central store via pipelines in the floor and walls. The central store may be a bank of large cylinders, or in the case of oxygen, a large insulated tank of liquid oxygen maintained at approximately minus 165 degrees centigrade. The piped medical gases are delivered to specific ports located in the wall of the operating theatre and anaesthetic room. Non-interchangeable spring loaded valves (Schraeder Valves) are inserted into the wall ports and connect to the anaesthetic machine via flexible but non-crushable tubing. The valves are specific for each gas and the tubing is colour coded and permanently bonded to the individual valve.

The pressure in anaesthetic gas pipelines is 4 bar (the same as the working pressure of the anaesthetic machine). All anaesthetic machines, including those on pipeline gases, should have reserve gas cylinders attached, but turned off.

Flow meters: The gases from both cylinders and pipelines flow through narrow steel tubing to the rotameters where the flow rate of the gases is controlled by a needle valve. The flow rate of the individual gas is shown by a float or bobbin in a vertical glass tube. These tubes are individually calibrated by the manufacturer and are not interchangeable. The control knob for oxygen is larger and different in shape to the nitrous oxide control. In the UK, the left rotameter is oxygen whilst in the USA oxygen is on the right!

After the gases have passed through the rotameters the different gas tubes are joined together with oxygen added last so that the chances of an hypoxic

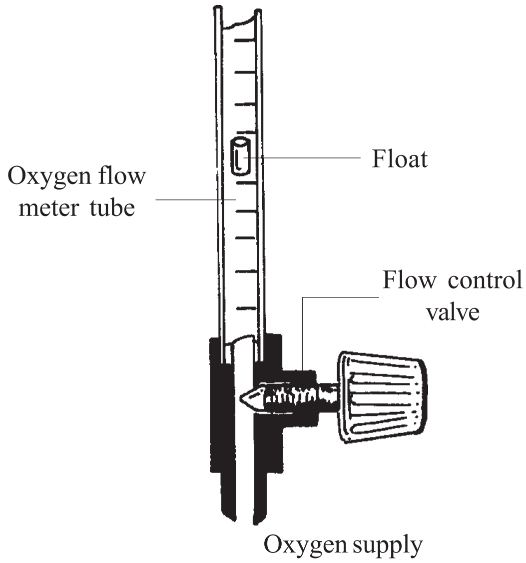

Fig. 2. Oxygen rotameter

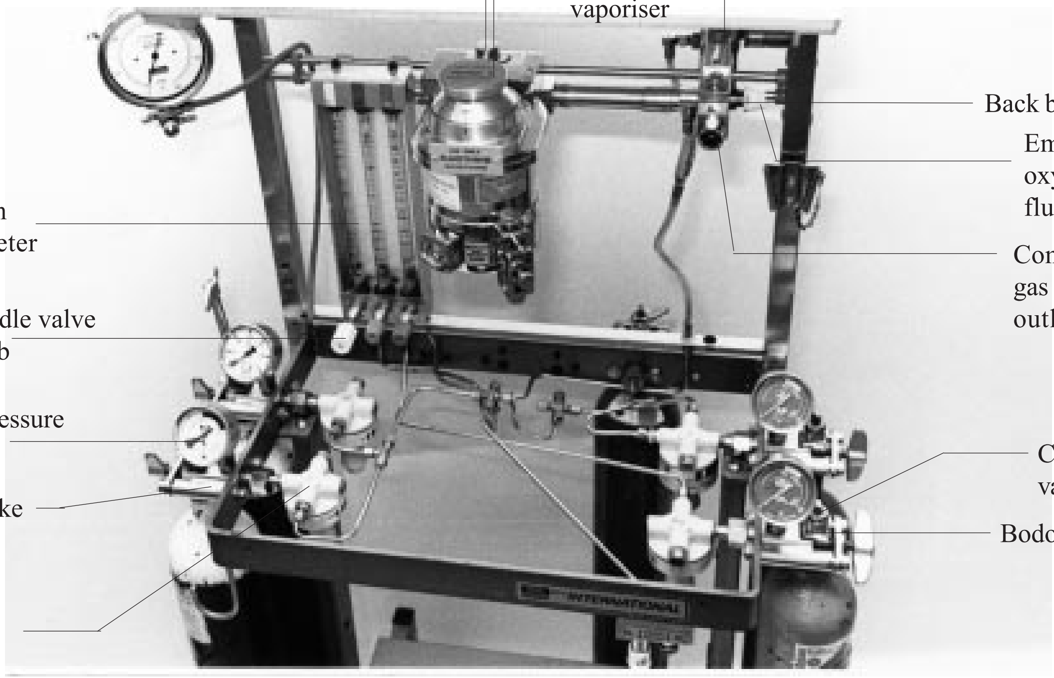

Fig.3. BOC Boyle International Continuous Anaesthetic Machine

mixture resulting from a leak of gases is minimised. Many machines now also link the flow of nitrous oxide to that of oxygen to ensure that a minimum of 25% oxygen will always be delivered.

Vaporisers: A volatile anaesthetic agent is supplied as a liquid and then vaporised (evaporates into a gas) before being mixed with the anaesthetic gases. Vaporisers are generally fitted on the "back bar" of the machine. Modern vaporisers are agent specific and automatically compensate for the temperature drop as the anaesthetic liquid evaporates. Some have a special filling system to ensure that they are filled with the correct agent. Although more than one vaporiser may be fitted to the machine, most back bar systems prevent more than one vaporiser from being used at any one time. Back bars may be equipped with systems such as the "*Selectatec*" mechanism which allow vaporisers to be easily exchanged between machines.

Unlike the Boyles bottle where a large proportion of the gas is passed over or bubbled through the volatile anaesthetic agent, modern continuous flow vaporisers split off a small proportion of the gas flow and completely saturate it with the volatile agent. These are known as "plenum" vaporisers, have a very high internal resistance and can only be used with pressurised medical gas supplies. All these vaporisers must be correctly attached to the anaesthetic machine with the back bar locking mechanism fully engaged to avoid leaks.

Pressure Relief Valves: If the anaesthetic machine is fitted with a pressure relief valve it will usually be located on the back bar distal to the vaporisers. The valves are designed to protect the machine and vaporisers against high pressures. They do not offer any protection to the patient. By occluding the common gas outlet with a thumb the pressure rises within the machine and will open a pressure relief valve, commonly at about 35kPa. Never try this in a machine without checking to see if a valve has been fitted.

Emergency Oxygen Flow: An additional high flow rate emergency oxygen supply (35 litres/min) bypasses the flow meters and vaporisers joining the common gas pathway near the common gas outlet. This emergency oxygen supply is operated by a spring loaded button. If this flow is accidentally left on there is a risk of diluting the other anaesthetic gases resulting in light anaesthesia or even awareness. Some modern machine are designed so that the flow cannot be left on.

Oxygen Failure Alarms: The risk of supplying an hypoxic gas mixture to the patient must never be forgotten. Oxygen failure warning devices are now fitted to all anaesthetic machines. Most are powered only by the oxygen pressure and do not depend on mains electricity or battery power. They are activated by a fall in oxygen pressure and emit a loud whistle that may only be reset by the return of the correct oxygen pressure. Until that time all the gases are vented to the atmosphere and away from the patient by a safety valve.

Non-return valves prevent empty cylinders from being refilled by other cylinders if they are left turned on. These are also fitted on the back bar and prevent gases from being pumped backwards through the vaporisers. This may occur during the ventilation cycle of a minute volume divider ventilator such as the Manley ventilator when the flow of gases from the common gas outlet may be briefly reversed. Without a non-return valve these gases can be pumped backwards through the vaporisers thus increasing the concentration of volatile agent being delivered.

Checking the Anaesthetic Machine

The anaesthetist is responsible not only for the peri-operative care of the patient but also for ensuring that all the equipment being used functions without fault. A guide to checking a Boyles anaesthetic machine which uses cylinders as the source of compressed gases is shown in Table 1. This should be performed before each theatre list.

If the machine is attached to pipelines then do the above test attaching and detaching pipelines as well as checking the cylinders.

Table 1. Checking a Boyles anaesthetic machine which uses cylinders as the source of compressed gases.

If an oxygen analyser is available, use it. It is the only way to verify the contents of an oxygen cylinder.

1. Check that cylinders are securely attached and turned off.

2. Open all flow meter control valves and check there is no flow.

3. Turn on oxygen cylinder and check its contents on pressure gauge. Set the rotameter to read 4 litres/minute. If a second oxygen cylinder is present, turn off the first and check the contents of second. Check there is no flow at the nitrous oxide rotameter.

4. Turn on the nitrous oxide cylinder and check the contents on the pressure gauge. Set the rotameter to 4 litres/minute and check the oxygen rotameter setting has not changed. If a second nitrous oxide cylinder is present turn it on to check its contents then turn it off again.

5. Turn off the oxygen cylinder and empty system via oxygen flush. The oxygen warning device should sound (if fitted), and should vent all gases from the machine. There should be no flow at the common gas outlet.

6. Turn on the oxygen cylinder again.

7. Check that the vaporisers are properly fitted to the back bar, with no leaks. They should contain an adequate amount of volatile anaesthetic agent and the controls operate throughout their full range without sticking.

8. If the anaesthetic machine is fitted with a pressure relief valve it should be tested by occluding the common gas outlet with a thumb whilst gas is flowing. The pressure relief valve should open with an audible release of gas. Do not do this test if a PRV is not fitted as it may damage the vaporisers.

9. Check your breathing circuit to ensure that it has been assembled correctly, close the valve, fill with gas and squeeze the resevoir bag to ensure there are no leaks. Open the valves following this check and ensure circuit empties.

10. Check the function of other equipment such as suction apparatus and laryngoscopes and ensure that all the drugs, endotracheal tubes, facemasks and airways you may require are present.

ANAESTHESIA FOR OPHTHALMIC SURGERY - *Part 1 : Regional Techniques*

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Ophthalmic surgery can be performed under either regional or general anaesthesia. This article describes regional anaesthesia. In the next issue general anaesthesia will be discussed.

Anatomy: Some basic knowledge of the anatomy of the orbit and its contents is necessary for the succesful performance of regional anaesthesia for ophthalmic surgery. If possible carefully examine the orbit in a skull whilst reading this article. This will make understanding the techniques described easier.

Each orbit is in the shape of an irregular pyramid with its base at the front of the skull and its axis pointing posteromedially towards the apex. At the apex is the optic foramen, transmitting the optic nerve and accompanying vessels and the superior and inferior orbital fissures transmitting the other nerves and the vessels.

The depth of the orbit measured from the rear surface of the eyeball to the apex is about 25 mm (range 12-35 mm). The axial length (AL) of the globe (eyeball) is the distance from the corneal surface to the retina and is often measured preoperatively. An axial length of 26mm or more denotes a large eye, indicating that great caution is necessary as globes longer than this are easier to perforate during regional anaesthesia.

The angle between the lateral walls of the two orbits is approximately 90^{o} (and the angle between the lateral and medial walls of each orbit is nearly 45^{o} (*see figure 1*). Thus the medial walls of the orbit are almost parallel to the sagittal plane. (The sagittal plane passes directly from front to back of the body). The orbit contains the globe, orbital fat , extraocular muscles, nerves, blood vessels and part of the lacrimal apparatus.

The Globe (*eyeball, see figure 1 & 2*): is situated in the anterior part of the orbital cavity closer to the roof than the floor and nearer the lateral than the medial wall. The sclera is the fibrous layer of the eyeball completely surrounding the globe except the cornea. It is relatively tough but can be pierced easily by needles. The optic nerve penetrates the sclera posteriorly 1 or 2 mm medial to, and above, the posterior pole. The central retinal artery and vein accompany the optic nerve. The cone refers to the cone shaped structure formed by the extraocular muscles of the eye.

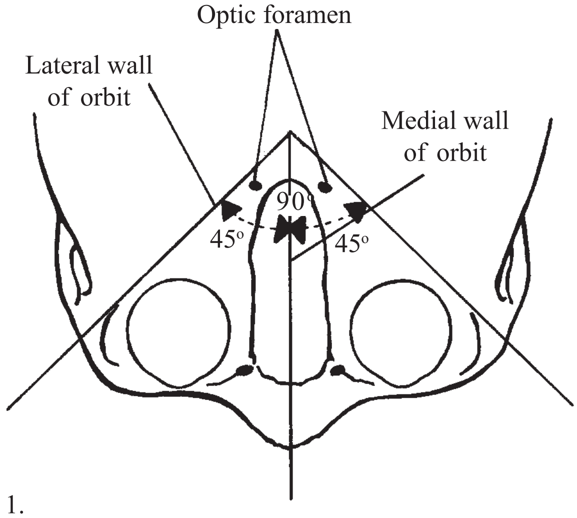

Fig. 1.

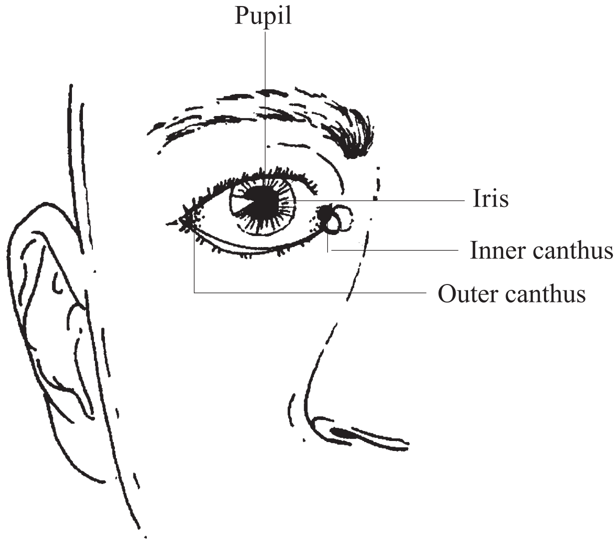

Fig. 2.

The orbital fat is divided into central (retrobulbar, intracone) and peripheral (peribulbar, pericone) compartments by the cone of the recti muscles. The central space contains the optic, oculomotor, abducent and nasociliary nerves. The peripheral space contains the trochlear, lacrimal, frontal and infraorbital nerves. All the motor and sensory nerves can be blocked by an injection into the orbital fat.

The extraocular muscles: The combined actions of the four rectus and two oblique muscles on each eyeball allow elevation, depression, adduction and abduction. Under normal circumstances unmodified activity of one muscle is rare but testing individual muscle function becomes necessary after local anaesthetic block to identify the unblocked nerve when some movement is still present.

Nerve supply to the eyes: The motor nerve supply to the extraocular muscles is easy to remember using the pseudoformula $LR_6(SO4)_3$ - lateral rectus by the sixth (abducent) cranial nerve, superior oblique by the fourth (trochlear) and the remainder by branches of the third (oculomotor) nerve.

The sensory supply is mainly from the ophthalmic division of the 5th (trigeminal) cranial nerve (*table 1*). The lacrimal branch innervates the conjunctiva and the nasociliary branch the cornea, sclera, iris and ciliary body. The second cranial nerve (optic) conveys vision.

The parasympathetic supply is from the Edinger Westphal nucleus accompanying the 3rd nerve to synapse with the short ciliary nerves in the ciliary ganglion. The sympathetic fibres are from T1 (the first thoracic sympathetic outflow) and synapse in the superior cervical ganglion before joining the long and short ciliary nerves.

Injection of local anaesthetic solution into the lateral adipose compartment from an inferotemporal needle insertion normally blocks the nasociliary, lacrimal, frontal, supraorbital and supratrochlear branches of the ophthalmic division of the trigeminal nerve and the infraorbital branch of the maxillary division.

Injection into the medial compartment through a needle placed between the caruncle and the medial canthal angle usually blocks the medial branches of the nasociliary nerve, the long ciliary nerves, the infratrochlear nerve and medial components of the supraorbital and supratrochlear nerves.

Blood vessels : The main arterial supply to the globe and orbital contents is from the ophthalmic artery which is a branch of the internal carotid artery and passes into the orbit through the optic canal inferolateral to the optic nerve and within the meningeal sheath of that nerve. In the elderly and hypertensive patient it is tortuous and vulnerable to needle trauma when it may bleed profusely. Venous drainage is via the superior and inferior ophthalmic veins.

Table 1. Summary of sensory nerve supply

Sclera and cornea	Short ciliary nerves Long ciliary nerves	
Conjunctiva	Superior	Supraorbital nerve Supratrochlear nerve Infratrochlear nerve
	Inferior	Infraorbital nerve
	Lateral	Lacrimal nerve (with contribution from zygomaticofacial nerve)
	Circumcorneal	Long ciliary nerves
Periorbital skin	Supraorbital Supratrochlear Infraorbital Lacrimal	

The lacrimal apparatus has orbital and palpebral components. The orbital part lies in the lacrimal fossa on the anterolateral aspect of the orbital roof, and the palpebral part is situated below the levator palpebrae superioris aponeurosis and extends into the upper eyelid secreting tear fluid into the superior conjunctival fornix.

Lacrimal drainage occurs through superior and inferior lacrimal puncta near the medial ends of both lid margins which form entrances to the 10-mm long lacrimal canaliculi medially passing through the lacrimal fascia to enter the lacrimal sac. The nasolacrimal duct connects the inferior end of the lacrimal sac to the inferior meatus of the nose.

The anatomical features of the orbit described above permit the passage of needles into fibro-adipose compartments in the orbit avoiding close contact with the globe, major blood vessels, extraocular muscles and the lacrimal apparatus.

Types of regional anaesthesia for ophthalmic surgery:

- *Peribulbar block (Pericone block)*
- *Retrobulbar block (Intracone block)*

The most popular technique for regional anaesthesia in eye surgery is now a peribulbar block. This has largely replaced retrobulbar blocks and general anaesthesia for many types of eye surgery.

Preparations

1. An intravenous cannula is inserted to allow immediate venous access in case of emergency.

2. The conjunctival sac is anaesthetised with amethocaine 1%. Three drops are instilled and this is repeated 3 times at 1 minute intervals.

3. A 10ml syringe is prepared containing 5 ml bupivacaine 0.75% plain plus 5ml lignocaine 2% with 1:200,000 adrenaline. Hyaluronidase 75 units is added to improve diffusion of the anaesthetic mixture within the orbit, giving faster onset and prolonged duration of anaesthesia.

4. A 25 gauge, 2.5 cm disposable needle is attached to the syringe.

5. The patient lies supine and is asked to look directly ahead focussing on a fixed point on the ceiling, so that the eyes are in the neutral position.

Performance of the block

Two transconjunctival peribulbar injections are usually required.

Inferotemporal injection (*figs 3 - 5*). The lower lid is retracted manually and the the needle is placed half way between the lateral canthus and the lateral limbus. The injection is not painful as it is passing through an already anaesthetised conjunctiva. If there is not enough room for the needle to be positioned correctly then the injection may be made directly through the skin. The needle is advanced in the sagital plane, parallel to the orbital floor passing under the globe. There is no need to apply pressure to the syringe as it will easily advance without resistance.

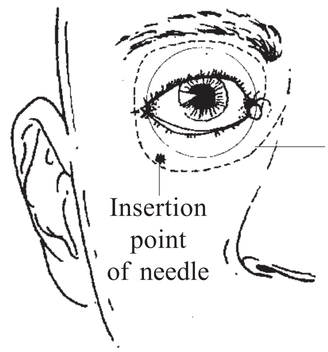

Fig. 3. View from front

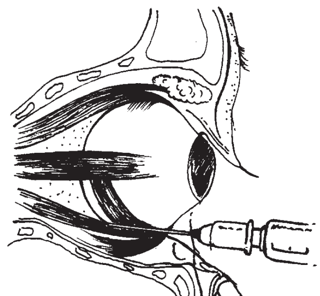

Fig. 4. View from side

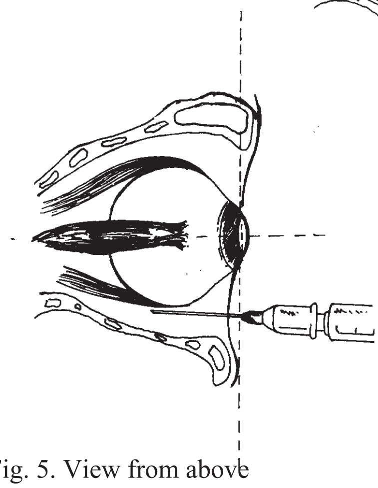

Fig. 5. View from above

When the needle tip is judged to be past the equator of the globe the direction is changed to point slightly medial (20°) and cephalad (10° upwards) to avoid the bony orbital margin. Advance the needle until the hub (which is at 2.5 cm) is at the same depth as the iris. Following negative aspiration 5 ml of the solution is slowly injected. There should not be any resistance while injecting. If resistance is encountered, the tip of the needle may be in one of the extraocular muscles and should be repositioned. During the injection the lower lid may fill with the anaesthetic mixture and there may be some conjunctival oedema.

Within 5 minutes of this injection, some patients will develop adequate anaesthesia and akinesia (lack of movement), but the majority will require another injection.

Nasal injection (*figures 6,7*). The same needle is inserted through the conjunctiva on the nasal side, medial to the caruncule and directed straight back parallel to the medial orbital wall pointing slightly cephalad (20°) until the hub of the needle is at the same level as the iris. The needle traverses the tough medial canthal ligament and may require firm gentle pressure. This may cause the the eye to be pulled medially briefly. After negative aspiration another 5ml of the anaesthetic mixture is injected.

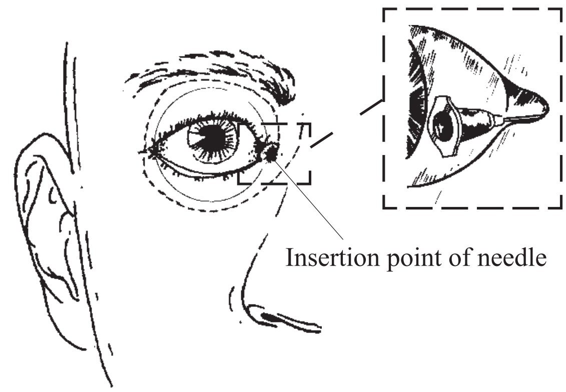

Fig. 6.

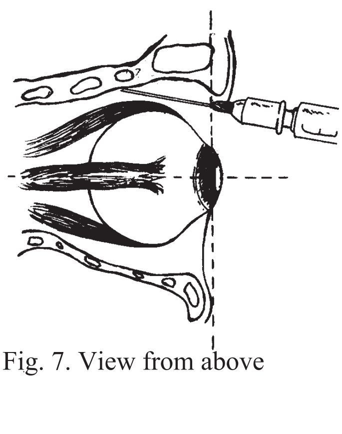

Fig. 7. View from above

The eye is then closed with adhesive tape. A piece of gauze is placed over the lids and pressure applied with a Macintyre oculopressor for 10 minutes at a pressure of 30 mmHg. If no oculopressor is available gently press on the eye with the fingers of one hand. This is to lower intraocular pressure (IOP) by reducing aqueos humour production and increasing its reabsorbtion.

Assessment of the block is usually judged after an interval of 10 minutes.

The signs of a succesful block are:

- Ptosis (drooping of the upper lid with inability to open the eyes)
- Either no eye movement or minimal movement in any direction (akinesia)
- Inability to fully close the eye once opened.

Since the local anaesthetic is placed outside the muscle cone the concentration around the optic nerve may not be sufficient to abolish vision completely. Some light perception will therefore remain; however the patient is not able to see the operation.

If, after 10 minutes the block is inadequate a supplementary injection of 2-5 ml of the anaesthetic mixture may be required. If the residual eye movements are downward and lateral, the supplementary injection is given at the inferotemporal site and if upward and medial, at the nasal site. Pressure is then reapplied for a further 10 minutes.

Care of patient. The patient must be made comfortable in the operating theatre using pillows and pads as required. An assistant should remain with the patient monitoring their condition and giving reassurance. Patients should be asked to remain silent and to squeeze the assistant's hand before any movements are made in order to warn the surgeon. A right angle screen can be used to keep the drapes away from the patient's face and to support an oxygen delivery system. A high flow of oxygen (8l/min) can be used to increase the FiO_2 and prevent CO_2 accumulation. Sedation is rarely required and should be limited to small increments (1mg) of midazolam. Oxygen saturation, ECG and blood pressure should be monitored throughout. Avoid oversedation of patients who may then wake up and move during the operation.

Retrobulbar block. The conjunctiva is first anaesthetised as described under peribulbar block. A 3 cm needle is inserted half way between the lateral canthus and the lateral limbus in the lower conjunctiva. It is first directed backwards under the globe and then after the equator of the globe has been passed the needle direction is changed upwards and inwards to enter the space behind the globe between the inferior and lateral recti muscles. After aspiration 4 ml of local anaesthetic solution is injected slowly. Retrobulbar block has largerly been replaced by peribulbar block because of the higher incidence of complications (see below) and the occasional need for an additional facial nerve block.

Complications of regional blocks for ophthalmic surgery may result either from the agents used or the block technique itself.

Intravascular injection and anaphylaxis can occur, hence resuscitation facilities must always be readily available.

Haemorrhage: Retrobulbar haemorrhage is characterised by a sudden rise of IOP and usually requires postponent of surgery. It is very rare with shallow retrobulbar or peribulbar injections. Subconjunctival haemorrhage is less significant as it will eventually be absorbed. Surgery need not be postponed.

Subconjunctival oedema (chemosis): This is undesirable as it may interfere with suturing. It can be minimised by slowing the rate of injection. It rapidly disappears when gentle pressure is applied to the closed eye.

Penetration or perforation of the globe: This is more likely to occur in myopic eyes which are longer but also thinner than normal. A diagnosis of perforation may be made if there is pain at the time the block is performed, sudden loss of vision, hypotonia, a poor red reflex or vitreous haemorrhage. Perforation may be avoided by carefully inserting the needle tangentially and by not going "up and in" until the needle tip is clearly past the equator of the globe.

Central spread of local anaesthetic: This is due to either direct injection into the dural cuff which accompanies the optic nerve to the sclera or to retrograde arterial spread. A variety of symptoms may follow including drowsiness, vomiting, contralateral blindness caused by reflux of the drug to the optic chiasma, convulsions, respiratory depression or arrest, neurological deficit, and even cardiac arrest. These symptoms usually appear within about 5min.

Oculocardiac reflex is the bradycardia which may follow traction on the eye. An effective local block ablates the oculocardiac reflex by providing afferent block of the reflex pathway. However the institution of the block and especially rapid distension of the tissues by the solution or by haemorrhage might occasionally provoke it. Careful monitoring is essential for early detection.

Optic nerve atrophy. Optic nerve damage and retinal vascular occlusion may be caused by direct damage to the optic nerve or central retinal artery, injection into the optic nerve sheath or haemorrhage within the nerve sheath. These complications may lead to partial or complete visual loss.

Advantages of local blocks over general anaesthesia:

1. May be performed as day cases
2. Produce good akinesia and anaesthesia
3. Minimal influence on intraocular presssure
4. Require minimum of equipment

Disadvantages:

1. Not suitable for some patients (children, mentally handicapped, deaf, language barrier)
2. Complications as above
3. Depend on the skill of anaesthetist
4. Unsuitable for certain types of surgery (e.g. open eye surgery, dacrycystorhinostomy)

Letter to the Editor:

LOW SPINAL ANAESTHESIA FOR CAESAREAN SECTION

Dr David Wilkinson, Hlabisa Hospital, P Bag X5001, Hlabisa 3937, South Africa

Sir,

I read with interest the two issues of Update in Anaesthesia that covered anaesthetic management of Caesarian section (No 2, 1992) and spinal anaesthesia (No 3, 1993). I have developed a technique of "low spinal anaesthesia" for routine use in caesarean section. A prospective evaluation of 100 consecutive cases has been published[1], and since then many hundreds of Caesarian sections have been done at this hospital using the technique with no adverse effects.

This procedure was adopted when both ventilators in our hospital were unserviceable at the same time; none of the doctors had any experience with spinal anaesthesia and I was fearful of using the full spinal described in Primary Anaesthesia[2]. A saddle block with infiltration of the abdominal wall proved less than satisfactory when teaching new doctors to perform Caesarian sections. An increase in the volume of anaesthetic given to produce a saddle block was therefore tried, to produce a "low spinal". This seemed to provide satisfactory surgical conditions and has proved to be a safe anaesthetic with minimal risk of hypotension and high spinal block.

The technique is as follows. A pre-load with 500-1000ml of a crystalloid is completed in theatre and good venous access ensured (sodium citrate and metoclopromide is given in the labour ward). A lumbar puncture (L3-4) is performed in the sitting position and hyperbaric bupivacaine 1.5ml is injected slowly when free flow of cerebrospinal fluid is obtained (plain bupivacaine is used if necessary). The patient remains seated for 5 minutes with a nurse close by. She then lies flat with a left lateral tilt and a slight head-up tilt. Her head is placed on a pillow. Surgery proceeds as usual.

In only 3 of 100 consecutive cases was the anaesthetic judged inadequate by the surgeon. Patient tolerance (as judged by facial expression, verbal complaint etc) was fine in 87. In 11 women pethidine 50mg was given during the procedure for discomfort and ketamine 0.5mg/kg was given in 2 for incomplete block. In no cases was the procedure abandoned. No cases of total spinal were seen and ephedrine was not needed to counteract hypotension.

In 59 women the systolic blood pressure (SBP) dropped by an average of 16%. In only 5 women did the SBP drop by 39mmHg or more and 2 of these were associated with brisk uterine haemorrhage. All responded to intravenous fluids. Having performed several hundred caesarian sections under general anaesthetic I was struck by how good the fetal condition remained under spinal. Of the 108 babies delivered at the 100 sections, 91% had an Apgar score of 10 at birth, 93% had an Apgar score of 10 at 1 minute, and all but one had an Apgar of 10 at 2 minutes.

Patients were highly satisfied with the procedure; 99% said they would have a spinal again if necessary. Of the 42 who had had a previous Caesarean section under general anaesthetic 38 said they preferred spinal; mainly because they remained awake but pain-free, were able to see the baby immediately and because the postoperative course was more pleasant.

Since then hundreds of cases have been done at this hospital using this technique. There have been no cases of total spinal or significant hypotension, and we use it for all Caesareans including fetal distress and cord prolapse. The only contraindication is severe haemorrhage.

This technique is simple and effective, and thus can be recommended to colleagues working in resource-poor settings. While no anaesthetic is ever completely safe, some are safer than others. Having done many hundred caesarian sections using both techniques (often alone), there is no doubt that low spinal is best for the mother, baby and doctor in almost all circumstances.

1. **Wilkinson D**. *Low spinal anaesthesia for caesarian section* S. Afr. Fam. Pract. 1993; 14:7-10
2. *Primary Anaesthesia*. Ed. **M. King** Oxford University Press, Oxford, UK.

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