Part X: Trauma

Chapter 66: Management of Severe and Multiple Trauma

J A Judson

Trauma can be defined as physical injury. It frequently leads to death, hospital admission, and use of ICU resources. Trauma is usually categorized as either blunt or penetrating. In Western countries, severe blunt trauma is common, and is most frequently caused by road crashes, falls, and less commonly, blows and assaults. Severe penetrating trauma, usually from gunshots and stabbings, is less common except in larger cities of USA. In some respects, blunt trauma is more difficult to manage than penetrating trauma. Assessment is harder, because injuries are frequently internal and not initially obvious. They are also often multiple.

Of the trauma admissions to hospital, only a minority have severe or multiple trauma. Their life-threatening injuries are, in order of frequency, to the head, abdomen, and chest. However, the hospital resources used by these patients are out of proportion to their numbers. Required services include resuscitation, imaging tests, laparotomy and major surgery, respiratory support and Intensive Care. Craniotomy and thoracotomy are needed less frequently.

Emergency Assessment and Setting Priorities

1. Triage

An important first step in the management of severe trauma is triage, ie, to sort patients with acute life-threatening injuries and complications, from those whose lives are not in danger. The severity of total body injury is related to the number of separate injuries present, and to the severity of the individual injuries. Assessment can be made either at the scene of injury, or on arrival at hospital. As in any emergency, assessment, diagnosis and treatment must be concurrent. There is no time for detailed histories, examinations, investigations, and well-considered diagnoses, before starting resuscitation and emergency care. Those with severe injury can usually be distinguished early by the presence of (a) a depressed level of consciousness, (b) abnormal breathing, or (c) signs of shock.

(a) *Coma* in the trauma patient can be related to brain injury, hypoxaemia, shock, alcohol, or other drugs which have been taken. Frequently, a combination of factors is present, and the degree of physical head trauma is not known precisely.

(b) *Breathing difficulties* are common in patients with trauma to the head, face, neck and chest. If rapid or distressed breathing is present, airway obstruction, laryngeal injury, pulmonary aspiration, and lung or chest wall injury (especially pneumothorax and lung contusion) should be considered.

(c) *Shock* always requires explanation and is almost always hypovolaemic. However, cardiogenic shock does occur in the trauma patient. The earliest, most constant and reliable signs of shock are seen in the peripheral circulation. A patient with cold, pale peripheries has shock until proved otherwise. Hypotension is a later sign of shock, and tachycardia is not always present.

2. Priorities

A trauma patient often has multiple problems which require attention, and determining priorities is often not easy. In general terms, the priorities are:

(a) *Support life* - The patient is kept alive with whatever resuscitative techniques necessary, while various injuries and complications are attended to.

(b) *Locate and control bleeding* which may be external, internal or both.

(c) *Prevent brain stem compression and spinal cord damage.*

(d) *Diagnose, evaluate and treat* all other injuries and complications.

Basic Management Principles

A systematic approach to the management of severe and multiple trauma is important. A number of basic principles apply to the management of all patients with severe trauma:

1. Emergency Assessment

Before anything else, the following must be recognized and treated:

(a) *A - Airway obstruction* suggested by noisy (or silent) breathing with paradoxical respiration and respiratory distress.

(b) *B - Breathing difficulty* suggested by tachypnoea, mental confusion, cyanosis, and abnormal pattern of breathing.

(c) *C - Circulatory shock* manifested by cold peripheries with delayed capillary refill, low blood pressure, and rapid weak pulse.

2. Oxygen Therapy

High-flow oxygen by mask is given to any patient with fractured femur or a worse injury, because mild or moderate hypoxaemia is common. Patients with severe trauma frequently also require ventilatory support. A restless uncooperative patient may require anaesthesia with intubation and ventilation just to facilitate resuscitation.

3. Blood Cross-Match

Blood is cross-matched urgently. Six units should be requested in the first instance, instead of attempting to estimate the amount of blood loss beforehand. At the same time, blood is sent for baseline haematological, urea and electrolytes, and liver function tests.

4. Fluid Resuscitation

Resuscitation fluids are given. If necessary, 2 or 3 large 14 or 16-gauge intravenous cannulas are inserted in upper limb or neck veins.

5. Analgesia

Analgesia is often overlooked. Opioid drugs should be titrated intravenously, and never given intramuscularly or subcutaneously.

6. Urine Output

A urinary catheter is inserted, unless a ruptured urethra is suspected (because of blood at the urinary meatus or a severe fractured pelvis). Urine output monitoring is an important guide to resuscitation from shock.

7. Other Injuries

All injuries should be evaluated.

Evaluation of Injuries

Injuries are easily missed in an emergency, especially when one injury is obviously present. It is important to look systematically at all body regions, ie, head, face, neck, chest, abdomen, spine, pelvis, and extremities. The back of the patient, as well as the front should also be examined, and special attention is paid to regions with external lacerations, contusions, and abrasions.

1. *Head* - Neurological observations are made and the ears and nose are inspected for the presence of cerebrospinal fluid and blood.

2. *Face* - Bleeding into the airway should be excluded.

3. *Spine* - Signs of spinal cord injury should be looked for, ie, paralysis, diaphragmatic breathing, priapism, loss of vasomotor tone, and loss of anal tone. A cervical spine fracture or dislocation is assumed in all patients with head injury until proved otherwise.

4. *Chest* - Fractured ribs per se, are not usually important, but haemothorax, pneumothorax, lung contusion, and flail chest often require attention. Less common but very serious injuries occur to the heart and great vessels.

5. *Abdomen* - The spleen, liver, and mesenteries are often damaged. Retroperitoneal haemorrhage is common. Injuries to the pancreas, duodenum, and other viscera are less frequent, and are often missed until signs of peritonitis occurs. Renal injury with retroperitoneal haemorrhage is suggested by haematuria and loin pain.

6. *Pelvis* - Pelvic fractures may be difficult to detect clinically, especially in the unconscious patient. Blood loss may be massive, particularly with posterior fractures involving sacro-iliac dislocation. Ruptured bladder and ruptured urethra may be seen with anterior fractures.

7. *Extremities* - A litre of blood or more may be lost around a fractured femur. Long bone fractures are more serious if they are open, comminuted, or displaced, or if there is associated nerve or arterial damage.

8. *External* - Contusions nay be extensive and serious, especially in patients who jump or fall from high places, and may be overlooked if the back of the patient is not examined. Road crash victims may sustain serious burns.

Shock in the Trauma Patient

Cardiogenic Shock

If the trauma patient with shock has distended neck veins, possible injuries are cardiac tamponade, tension pneumothorax, myocardial contusion, and concurrent myocardial infarction.

Hypovolaemic Shock

If the neck veins are empty, hypovolaemic shock should be inferred. There are 5 possible sites of blood loss causing shock. Bleeding can be from one or more of these sites:

1. *External* - which is obvious from blood soaked clothing and the ambulance trolley.

2. *Major fractures* - which are obvious clinically (ie, femurs) or seen on a plain X-ray (ie, pelvis).

3. *Chest* - The chest X-ray will detect blood in the chest, and intrapleural drains will reveal the amount and rate of blood loss. The chest X-ray will also show signs of ruptured aorta, pneumo-haemothorax, lung contusion, and rib fractures.

4. *Peritoneal cavity* - as diagnosed by laparotomy, diagnostic peritoneal lavage or CT scanning.

5. *Retroperitoneum* - inferred, when all of the above are negative.

Diagnostic Peritoneal Lavage

Peritoneal lavage should be used to diagnose intra-abdominal bleeding, using 1 L of isotonic saline, particularly when the patient is unconscious or has multiple injuries. Clinical examination can be grossly misleading in these two situations. Caution is needed with pregnancy, previous abdominal surgery, or massive pelvic injury. A positive result is frank blood on incising peritoneum, or the return of pink lavage fluid. If lavage is not followed by laparotomy, a specimen of fluid should be sent to the laboratory for red and white cell counts and amylase level. Positive peritoneal lavages inevitably result in some laparotomies which do not reveal any intra-abdominal bleeding. However, in severe trauma, the additional morbidity of a negative laparotomy is negligible.

Fluid Resuscitation

Initial Fluids

The main fluid lost in trauma is blood, and almost all patients who are hypotensive or noticeably vasoconstricted, will need blood transfusion. However, since cross-matched blood is not immediately available, other fluids are used first. Uncross-matched, group O Rh negative blood is occasionally indicated in the patient who is exsanguinating, but in general, it is wasteful of blood products to infuse large quantities while bleeding is uncontrolled.

The first intravenous fluid given to a trauma patient should be isotonic saline or a balanced salt solution. Patients with shock may need 2-3 L in the first few minutes. One litre bags or bottles and giving sets with in-line pumps should be used on all IV lines. A colloid plasma expander can be the second fluid used, and by 20-30 minutes, cross-matched blood should be available. Freeze dried plasma should be reserved for massive transfusion or suspected coagulopathy. In these situations platelets may also be needed.

All resuscitation fluids have a high sodium concentration similar to that of extracellular fluid. Few trauma patients require any other type of fluid in the first day. It is not possible to have a resuscitation fluid which is low in sodium. Glucose 5% and glucose-saline solutions are not effective resuscitation fluids.

Urine Output

Hourly urine output is a useful guide to resuscitation from shock. The absolute minimal acceptable urine output is 0.5 mL/kg/h, but 1-2 mL/kg/h is more adequate. Frusemide has no place in initial resuscitation.

Inadequate Resuscitation

Patients in shock have depletion of interstitial fluid and need resuscitation fluid volumes greater than the actual volume of blood lost. With blunt injury, volume losses often continue for 24-48 hours. Prolonged shock from delayed and inadequate resuscitation and inappropriate fluids, leads to oliguric and non-oliguric renal failure, adult respiratory distress syndrome (ARDS), sepsis, and multisystem failure.

Pulmonary Oedema

Pulmonary oedema during trauma resuscitation is not usually related to fluid overload. Direct lung trauma, pulmonary aspiration of gastric contents, pulmonary responses to non-thoracic trauma, and reactions to resuscitation fluids can all cause "leaky" capillaries and produce non-cardiogenic pulmonary oedema.

Head Trauma

Serious injuries to the head are common, although those requiring an urgent cranial operation, less so. Their assessment and management can be difficult especially when other injuries are present. Head injury is frequently only one part of multiple trauma. Although the head injury may initially be the most obvious injury, it may not be the most important.

Emergency Treatment

Patients with airway obstruction or inadequate airway protection should be immediately intubated and hyperventilated under anaesthesia, to ensure optimal cerebral oxygenation and blood flow, until full evaluation of cerebral status is possible. Those with one or two unreactive pupils should be given mannitol 1 g/kg IV in an attempt to relieve brainstem compression, until definitive diagnosis and treatment can be arranged.

Shock cannot be attributed to brain injury unless brain death has occurred or is imminent. Shocked patients with head injury require the same fluid resuscitation as those without head injury. Management of shock and maintenance of cerebral perfusion is a vital part of managing head injuries. Contrary to common belief, sodium containing fluids are not inherently dangerous in head trauma. However, oncre resuscitation is complete, further sodium administration is inappropriate. On the other hand, excessive water administration is also inappropriate. Free water is potentially dangerous as it can lead to hyponatraemia, hypo-osmolality, and brain swelling. After initial resuscitation, a patient with head trauma may need less than 500 mL of water to maintain normal serum biochemistry.

Neurological Evaluation

Factors such as hypoxaemia, shock, alcohol and other drugs all depress consciousness and worsen neurological signs. Analgesia and anaesthetic drugs and muscle relaxants also interfere with neurological assessment, but are often essential for effective resuscitation. Clinical neurological information to be recorded, if possible, on all trauma patients include the following clinical observations for the Glasgow Coma Scale:

1. Does the patient obey a simple command?

2. Does the patient open his eyes?

3. The vocal responses, ie, whether uses conversation, words, grunts and moans, or remains silent.

4. The motor responses of each limb, ie, whether localizing, flexion, extension, or no movement.

5. Spontaneous eye movements and position.

6. Pupillary responses.

The above information, and changes with time, will enable management decisions to be made. A deteriorating level of consciousness, or the presence of lateralizing motor or pupillary signs, are indications for CT scanning if available, or for emergency burr holes. CT scanning is indicated in all patients who are unresponsive to vocal command, especially if rendered neurologically "inaccessible" by sedative and relaxant drugs.

Radiology for Trauma Patients

Patients with depressed consciousness, breathing difficulties, or unstable circulation, should not be sent to a remote Radiology Department, away from skilled supervision and facilities. They need X-rays where they can be cared for at the same time. Similarly, extensive radiography of distressed shocked patients in the Emergency Department is unacceptable. Less urgent imaging examinations should be performed in the Operating Room or the ICU. Only 5 examinations should be requested as portable procedures in the Emergency Department:

1. *Chest* - This is the only X-ray ever justified in an unresuscitated patient. If a pneumothorax is obviously clinically present, it is unnecessary to await a chest X-ray before insertion of an intrapleural drain. A supine film is usually most practical in the first instance, although an erect film gives more information. An erect film is a better examination for showing intrapleular air or fluid, ruptured diaphragm, and for defining an abnormal mediastinum.

2. *Lateral cervical spine* - This should be done in all patients with head injury or multiple injuries, as cervical spine fractures are often missed. In a patient with head or facial injuries, a cervical fracture should be assumed initially, and a cervical collar applied. A lateral cervical spine X-ray is taken later, when the patient has been resuscitated.

3. *Pelvis* - A pelvic fracture which is not clinically obvious can be the site of unexplained blood loss. A dislocated hip can be missed in a patient with multiple injuries, especially if unconscious.

4. *"One shot" intravenous urogram (IVU)* - In suspected renal trauma, this is a useful procedure before laparotomy. It often avoids the need for a lengthy investigation in the Radiology Department.

5. *Skull* - Plain skull X-rays do not often guide immediate management unless there is a depressed skull fracture present. A CT scan is more useful.

Other X-rays should be deferred until after adequate resuscitation, to be performed in the Radiology Department or the ICU.

1. *Extremities* - X-rays of the extremities for assessing orthopaedic injuries are not urgent unless there is vascular injury. Fractures of the extremities are usually obvious. These films should, therefore, not be taken in the Emergency Department unless the patient is going directly to the Operating Room.

2. *Spine* - X-rays of thoracic or lumbo-sacral spine are also seldom indicated in the Emergency Department. Clinical examination is more important.

3. *Abdomen* - A plain abdominal X-ray is of limited value in the initial evaluation of trauma. Abdominal CT is valuable in evaluation of the patient who is haemodynamically stable.

4. *Aortography* - If aortic rupture is suspected either from the nature of the injury, symptoms and signs, or chest X-ray, the radiologist responsible for aortography should be consulted immediately. In general, diagnosis of ruptured aorta takes priority over all other injuries, except in the patient who needs immediate laparotomy or craniotomy on clinical grounds. This approach is a calculated risk because the incidence of positive aortography is low.

5. *Interventional Radiology* - Percutaneous transcatheter embolization can be a life-saving haemostatic procedure in massive retroperitoneal haemorrhage associated with pelvic fracture. However, the logistics of caring for such haemodynamically unstable patients in the Radiology Department are formidable.

Severity and Morbidity of Trauma

An important development in trauma care has been systemic grading of the severity of injury. This is the Abbreviated Injury Scale (AIS), which can provide a basis for research, audit and allocation of resources. In concept, the AIS divides the body into 6 regions: heand and neck, face, thorax, abdomen, pelvis and extremities, and external. Criteria are laid down to grade specific injuries, and the severity within each body region is graded from 1-5. The AIS works best for blunt trauma, and is specifically designed for motor vehicle accidents. Multiple injuries are catered for by the Injury Severity Score (ISS), which is an empirical system based on the AIS grades for the various body regions. It gives a score between 0-75 for total body injury. Total severity of trauma is related not just to the severity of individual injuries, but also to the combined effects of multiple injuries.

Severity of injury measured by ISS corresponds with the need for therapeutic modalities like ventilatory support, duration of stay in ICU, and with mortality. An ISS of 16 or more is indicative of major trauma. Death with an ISS of 24 or less ir rare, and is usually related to management error. Mortality rises abruptly with a scale of 25 and over, mostly from the severe head injuries. Mortality is even higher at a score of 30 or more, particularly from exsanguination, but also from complications of respiratory failure and sepsis. With a rating of 50 or more, survival is not common, but is increasing, especially in young patients. There is very little margin for management error with injury of this severity.

AIS and ISS, unfortunately study only the anatomy of injury. Obviously other factors influence trauma mortality and morbidity. These include age, pre-existing health, pre-hospital and early hospital care, and complications. The degree and duration of shock is particularly important, proportionate with the probability of complications. Complications from trauma include aspiration, thromboembolism, renal failure, ARDS, sepsis, liver failure, and multi-organ failure.

In Western countries, trauma is a leading cause of death and disability under the age of 40, with the majority of deaths occurring at the scene of injury. Reduction of mortality depends on public education, on-site advanced care, rapid evacuation, trauma expertise (ie, trauma centres), and coordination of services.

Chapter 67: Severe Head Injuries

W. R. Thompson

Head injuries are a major medical and social problem in developed countries. Neurotrauma is the leading cause of mortality and morbidity in the 15-24 year age group. The death rate per 100,000 from neurotrauma in New South Wales in 1977 was 28, and in South Australia, 25. Statistics are often difficult to compare, because of differences in definition, coding, and data collection. Mortality from head injuries in the USA in the late 1970s was estimated to be 22-25 per 100,000, while in Britain it was 9 per 100,000. Motor vehicle accidents are responsible for approximately 60% of the deaths due to head injuries.

Hospital admission rates for head injuries in the USA and Britain are approximately 200-300 per 100,000 (ie, over 400,000 admissions in the USA per year). Most of these are admitted only for observation over 24-48 hours.

In general, only patients with severe head injuries, or who have associated multiple trauma or medical complications are admitted to the ICU. Severe head injuries form approximately 9-11% of the total head injury population. This is the group of hospital patients exposed to the highest mortality and morbidity. Aggressive ICU treatment has been shown to improve the outcome of severe head injuries, without increasing the number of severely disabled or vegetative survivors.

Initial Assessment

The severely injured patient must have a rapid but complete initial assessment. General measures are instituted to reduce the incidence of secondary insults, particularly hypoxia, hypercarbia and hypotension. These include:

1. Establishing Airway and Ventilation

Intubation and continuous mechanical ventilation (CMV) are required if ventilation or gas exchange are inadequate, and/or if the patient is incapable of protecting his airway. About 30% of severe head injuries, particularly those associated with multiple trauma, are hypoxaemic and should be intubated promptly. Adequate ventilation should produce a $PaCO_2$ of 25-30 mmHg (3.3-4.0 kPa) and PaO_2 greater than 70 mmHg (9.3 kPa). Until proven otherwise with cervical X-rays, these patients should be considered to have a cervical spine injury and handled appropriately.

2. Treatment of Shock

Hypovolaemia is a common finding in multiple trauma. However, shock is uncommon in isolated head injuries, except those involving young children, medullary injuries or large scalp lacerations. Prompt and effective resuscitation is required.

3. Clinical Examination

A full examination helps to determine priorities of treatment and ascertain other injuries.

4. Complete Neurological Examination

(a) *Conscious state* - The Glasgow Coma Scale (GCS) is advocated for all head injuries and has some prognostic significance by itself and in conjunction with other clinical and laboratory findings. It is useful for comparing treatment regimens from different centres, but is not a complete neurological assessment. Drug or alcohol intoxication will make assessment of conscious state difficult. Unfortunately, intoxicated patients often have an associated head injury.

(b) *Pupils* - The pupil size and reactivity are especially important. Abnormalities indicate compression and compromise of the third cranial nerve. This may help to localize supratentorial lesions. Signs of third nerve compression, depression of conscious state plus asymmetrical motor responses, are the triad of signs for transtentorial herniation. Extraocular movements (doll's eyes and reponse to aural caloric testing) are also important in the assessment of the mid brain and pons. The doll's eye manouevre should not be performed until fractures of the cervical spine have been excluded. Papilloedema is uncommon in the acute phase of head injuries.

(c) *Motor function* - Evidence of motor function, especially decerebrate rigidity, hemiplegia or other localizing signs are sought.

(d) *Other assessment* - These include the gag and cough reflex, cardiac status, particularly arrhythmias, ventilatory patterns, and examination of the remaining cranial nerves.

If the patient is repsonsive to commands or questions then a more detailed neurological assessment must be performed.

5. Further History

This should be obtained with particular reference to the circumstances of the injury and retrieval, seizures, intoxications, pre-existing medical problems and medications.

Patients with severe head injuries should be seen early by a neurosurgeon. Those with a GCS less than 8 or with progressive deterioration of neurological status, should be seen immediately. Early CT scanning should be performed. Intracranial mass lesions occur in only 6-7% of total head injury admissions, but in 40-60% of severe head injuries.

Further Diagnostic Measures

1. Computerised Tomography (CT)

The CT scan is the procedure of choice to determine the presence or absence of mass lesions. It will also indicate areas of oedema, infarction, contusion, intracranial air, and size of the ventricular system. In addition, the CT scan may help to decide on intracranial pressure (ICP) monitoring and may be of some prognostic value. It has replaced angiography, ventriculography and the exploratory burr hole in the emergency assessment and management of head injuries. If time permits and there are indications, views of the cervical spines are also obtained.

It is important to plan for all the logistical problems involved in moving an acutely injured patient to the CT scanner. The patient is required to lie completely still during the scan, otherwise an inadequate scan will result. Early generation scanners took approximately 20 minutes for a complete scan but newer scanners are much faster. Thus, many patients, if not already intubated at this stage, will require intubation and anaesthesia for the CT scan.

All routine preparations should be made for emergency neuroanaesthesia in cases with a potential intracranial collection. If such a collection shows on CT, the patient is kep anaesthetized and ventilated, prior to transfer to the operating theatre. Should the patient's neurological status deteriorate rapidly, a single cut CT scan through the mid-ventricular region may provide sufficient information for surgery. Such a patient should also receive mannitol in an IV dose of 0.5-1 g/kg before surgery.

2. Skull X-Rays

The presence of a fracture increases the likelihood of complications (ie, intracranial haematoma), and may help to localize an extradural haemorrhage. The position of a calcified pineal gland, if seen, may indicate shift of intracranial contents relative to the midline. Fractures of the base of the skull may be seen on X-ray without prior clinical indication of their presence. Skull X-rays are also important in the assessment and future planning of reconstructive surgery. However, skull X-rays are not generally as helpful as CT scanning, and their routine use in the emergency evaluation of head injured patients has been questioned.

The importance of adequate X-rays, if a fracture of the cervical spine is suspected has been stated.

3. Cerebral Angiography

This is now rarely indicated when there is ready access to a CT scanner. However, if an isodense traumatic lesion is seen on the CT scan, the clinical condition is not consistent with the CT finding, or a vascular lesion is suspected, then cerebral angiography should be performed. In the absence of a CT scanner, cerebral angiography can be used in the diagnosis of intracranial haematoma.

4. Ventriculography

Ventriculography has been to a large extent superseded by CT scanning. It will provide information on the degree of midline shift and allow measurement of the intracranial pressure.

5. Echo Encephalography

This has been superseded by the CT scanner.

6. Radio Isotope Scan

This is of little benfit compared to a CT, but it does give some information on cerebral vascularity. Newer imaging techniques, ie, positron emission tomography (PET) will provide additional information on cerebral blood flow and neuronal function.

7. Magnetic Resonance Imaging (MRI)

MRI of head injuries may have some advantages over CT scanning in:

(a) diagnosing and estimating the size of extracerebral fluid (especially small) collections;

(b) distinguishing chronic subdural haematomas from hygromas;

(c) displaying non haemorrhagic contusions.

However, there are many logistical problems in supporting and monitoring injured patients during MRI, and CT scanning remains superior for diagnosis of acute parenchymal and subarachnoid haemorrhages. CT thus remains the procedure of choice for acute head injuries and MRI has yet to find its place, particularly for severe head injuries. It has been suggested that MRI may be of prognostic value in the management of mild and moderate head injuries.

8. Intracranial Pressure (ICP) Monitoring

Surgically amenable intracranial mass lesions should be diagnosed and treated early in head injured patients. The continuous measurement of ICP is of great value, particularly in a patient who is comatose or on a ventilator, when assessment of neurological function is difficult. The value of ICP monitoring has been established. Prolonged levels of ICP over 25 mmHg (3.3 kPa) are associated with a very poor prognosis. It is reported that the outcome of head injuries may be improved if ICP over 15-20 mmHg (2.0-2.7 kPa) is treated with aggressive therapy. However, it has also been suggested that early evacuation of intracranial haematoma without ICP measurement can produce comparable results.

9. Recordings of Cerebral Activity, ie, Multimodality Evoked Potentials (MEP) and the Electroencephalogram (EEG)

These may be useful after the initial stabilization of the patient. They can aid in the monitoring of the patient's clinical course and specific neurological function.

Management

The aims of ICU management for head injuries are:

1. Early detection of changes in neurological status through constant observation and monitoring.

2. Prevention of secondary cerebral insults, especially those related to hyponatraemia, hypotension, hypoxaemia, hypercarbia and raised intracranial pressure.

3. Early diagnosis and treatment of medical and surgical problems, particularly intracranial mass lesions, cerebral oedema and epilepsy, which may be intercurrent or in the process of developing.

The main principles of management are as follows:

1. Constant Observation

Nursing observations as per GCS is extremely important. If deterioration occurs the cause must be sought.

2. Patient Position

If possible, the patient should be nursed in the head-up position (approximately 30-45°) with the head in a neutral plane relative to the body, in order to facilitate ventilation and reduce ICP.

3. Respiratory Care

Hypoxia, hypercarbia or respiratory obstruction must be avoided. The inspired oxygen should be adjusted to maintain a PaO_2 greater than 70 mmHg (9.3 kPa) and the ventilation adjusted to produce a $PaCO_2$ of 25-30 mmHg (3.3-4.0 kPa). Endotracheal suction and physiotherapy will increase the ICP, and that such manoeuvres should be preceded by adequate sedation and analgesia.

4. Blood Pressure Control

Control of the blood pressure (BP) to keep it within its normal limits (ie, a systolic BP of 100-160 mmHg (13.3-21.3 kPa). There are varying degrees of loss of autoregulation following head injuries. It is therefore important to prevent BP being in the ranges where the cerebral blood flow is pressure dependent.

In acute severe head injuries, vascular factors probably account for a greater proportion of the increase in ICP than cerebrospinal fluid (CSF) factors.

5. Surgery

Operative treatment is indicated for complications such as intracranial mass lesions, hydrocephalus and depressed skull fractures.

6. Treatment of Raised Intracranial Pressure

If intracranial mass lesions and hydrocephalus are excluded, then raised ICP in head injuries is either due to cerebral vasodilation, cerebral oedema or varying combinations of the two. In the acute stages, the vascular dilatation may be more important in the genesis of raised ICP, whereas in the later stages cerebral oedema may become more important. To date, it has been clinically difficult to separate these two and hence varying combinations of the following are used:

(a) *Controlled Ventilation*

It is well accepted that reducing the arterial $PaCO_2$ will result in a reduction in ICP. Hyperventilation is used extensively for this purpose. The arterial $PaCO_2$ should be maintained around 30 mmHg (4.0 kPa). In addition to reducing the arterial $PaCO_2$, controlled ventilation will facilitate optimal airway management and oxygenation. Duration of ventilation is generally 48-72 hours in the first instance, followed by an attempt to wean the patient off the ventilator provided ICP is controlled. If ICP rises during weaning, then ventilation is continued for a further 24-48 hours. Increases in ICP during controlled ventilation necessitate the checking of arterial blood gases, re-assessment of ventilation and CT scanning.

(b) *Osmotic Diuretics*

If the blood-brain barrier is intact, osmotic diuretics such as mannitol and urea will lower ICP by drawing fluid across the blood-brain barrier (thus reducing the bulk of the normal brain). Mannitol is generally used, as there is less rebound with mannitol than urea. If a patient deteriorates rapidly in the acute stage of a head injury, mannitol in a dose of 0.3-1.0 g/kg is used. The subsequent dose of mannitol is 0.25-0.5 g/kg every 6 hours. The osmotic diuresis should not be pursued at the expense of cardiovascular stability. If a diuresis does not occur, mannitol should not be continued.

Serum osmolality is used as a guide to mannitol therapy. It should not rise above 310 mosm/kg as mannitol itself will enter the brain and interfere with the efficacy of the dehydration therapy. If the serum osmolality exceeds 350 mosm/kg, serious cellular damage may occur. Treatment with mannitol is continued for only 24-48 hours, as eventually, mannitol will cross into the brain and cause an increase in brain volume, ie, "rebound phenomenon". In one study, empirical mannitol therapy without ICP monitoring produced similar results to mannitol given for ICP elevation greater than 25 mmHg (3.3 kPa).

(c) *Steroids*

The value of steroids to treat cerebral oedema associated with intracranial tumours is well documented and accepted, but remains unproven for cerebral oedema associated with head injuries. Saul et al have suggested that there may be a subgroup of head injured patients, who are early responders to overall treatment, whose outcome may be improved by steroids. However, several prospective double-blind studies have indicated that steroids do not significantly alter morbidity, mortality or ICP. As a result, the use of steroids in the management of head injuries has declined markedly.

(d) *Diuretics*

The reduction in brain oedema with frusemide may be due to mechanisms other than the diuresis per se. Use of both dexamethasone and diuretics has been shown to produce a greater reduction of brain oedema than the use of either agent alone. Frusemide is the diuretic of choice in patients with congestive heart failure plus cerebral oedema, and may produce less marked changes in serum electrolytes and osmolality than mannitol. Experimentally, frusemide can act synergistically with mannitol, thereby sustaining the osmotic gradient established with mannitol. Once-diuretic therapy (albumin plus frusemide) has similar cerebral effects to mannitol or frusemide.

(e) *Cerebral Metabolic Depression*

Treatment aims to reduce cerebral metabolic demand in tandem with reducing cerebral blood flow, thus preserving neuronal function. The agents generally used are the barbiturates, althesin (no longer available) or lignocaine. These agents may be used in patients with raised ICP, who are not responding to the above treatment, and who do not have surgically correctible mass lesion on repeat CT scanning. High doses of these agents are often required, and extensive cardiovascular monitoring and support are required together with ICP monitoring.

Barbiturate therapy is generally commenced at an ICP over 20-25 mmHg (2.7-3.3 kPa) with a closed skull, and over 15 mmHg (2.0 kPa) with a craniectomy. It reduces ICP, however, Ward failed to show that prophylactic pentobarbital improved outcome. Eisenberg recently reported that while high-dose barbiturates are only indicated in a small subset of patients, barbiturates are an effective adjuvant to "conventional therapy" for the control of ICP. In addition, there was a marked difference in the one-month survival between responders and non-responders to therapy directed at ICP control (ie, "conventional ± pentobarbital).

7. Fluid Balance

Following initial resusctiation and stabilization, strict countrol of fluid balance will help control cerebral oedema. However, fluid restriction should not be pursued at the expense of cardiovascular stability or renal function.

8. Electrolytes

Electrolyte disturbances are frequently seen in patients with head injuries as a result of the head injury, stress responses, osmotic diuresis, diabetes insipidus, fluid restriction, feeding regimens and medications. Regular monitoring of electrolytes, urea, creatinine, blood sugar and osmolalities are important in determining fluid and electrolyte therapy. It is important to prevent hyponatraemia and water overload.

9. Physiotherapy

Physiotherapy is important to remove lung secretions, prevent contractures, and in rehabilitation. Adequate sedation and blood pressure control prior to chest physiotherapy are required in order to prevent ICP elevation.

10. Antibiotics

These are used if there is a base of skull or compound fracture, or a fracture into a sinus. Antibiotics may also be used prophylactically following the insertion of an intracranial pressure monitoring device.

11. Treatment of Epilepsy

Epileptic seizures will markedly increase cerebral metabolic demands, and hence it appears logical to minimize the incidence of seizures. The routine use of phenytoin has been recommended for postoperative neurosurgical patients, including head injuries. However, the efficacy of prophylactic phenytoin to prevent early post traumatic seizures has yet to be firmly established. Acute seizures should be treated with a barbiturate or a benzodiazepine, and phenytoin commenced for longer term therapy.

12. Prophylaxis Against Gastric Ulceration

Gastroduodenal lesions, particularly erosive gastritis, are frequently seen on endoscopy in patients with severe head injuries, but significant haemorrhage only occurs in 10-14% of cases. Prophylaxis using antacids ± H2 receptor blockers should be considered pending the introduction of enteral feeding.

13. Feeding

Severe head injuries demonstrate markedly increased energy requirements, a negative nitrogen balance, weight loss and hypoalbuminaemia. Clifton recommended early enteral feeding while others have suggested that early parenteral feeding will improve outcome.

14. Other Additional Treatment

Other aspects of the management of head injuries deserve comment:

(a) *Temperature control* - Fever increases the metabolic demands of the brain and thus may exacerbate neuronal injury. It is therefore important to determine the cause and to treat appropriately. Although hypothermia has been shown experimentally to be protective to the brain in head injury and cerebral oedema, it has not become routine therapy.

(b) *Syndrome of inappropriate ADH* - This syndrome may be seen following a head injury and is managed as described in Chapter 79, Fluid and Electrolyte Therapy.

(c) *Diabetes insipidus* - may also follow a head injury.

(d) *Coagulopathy* - Coagulopathies are not uncommon in patients with severe head injuries, and must be looked for and treated promptly in order to reduce the occurrence of intracranial haemorrhage.

Prognosis of Head Injuries

A number of factors are important including the age of the patient, time-lag between injury and treatment, type of injury, Glasgow Coma Scale and severity of neurological deficit, plus the occurrence of complications, particularly hypoxaemia and hypotension. In general, poor motor function indicates a poor outcome, especially in the older age groups. Patients under 30 years of age have a better prognosis than those older with the same degree of head injury. However, it is important to avoid making a rash prognostic decision too early, as many head injured patients, particularly the very young, show a remarkable improvement with time.

Brain death, which is an indication for cessation of all active treatment is described in Chapter 42, Brain Stem Death.

Chapter 68: Faciomaxillary and Upper Airway Injuries

P. G. Moore

Faciomaxillary and upper airway injuries are common and pose problems in airway management. In severe cases, there are often associated injuries to the cranial fossae and brain, cervical spine, skeleton and chest. Management often involves many specialty disciplines (ie, otolaryngologists, oral surgeons and dentists, plastic surgeons, ophthalmologists, neurosurgeons, anaesthetists and trauma surgeons). Fragmented care is to be avoided and the intensivist may play an important role in coordinating the various services.

Mechanisms of Injury

Faciomaxillary and upper airway trauma are due to sharp or blunt injuries to the head or neck. Sharp injuries usually result in lacerations and penetrating injuries, whilst blunt injuries result in fractures to the facial skeleton. Over 50% of facial trauma are the result of motor vehicle accidents, most of the remainder are due to physical violence or sporting injuries, which tend to be less severe, and a small number occur as falls and work-related accidents. The severity of facial fractures are directly related to the degree of force applied and the velocity of injury. Over 50% of severe faciomaxillary injury are accompanied by other associated injuries.

Penetrating neck wounds are commonly due to knife and gunshot wounds. They may result in injury to the air passages (ie, pharynx, larynx, trachea, and lung), nervous system (ie, spinal cord, brachial plexus, cranial nerves, or peripheral nerves), blood vessels (ie, aortic arch, innominate vessels, carotid, jugular and subclavian vessels) and the gastrointestinal tract (ie, pharynx and oesophagus). Blunt injuries to the neck are rare and are commonly due to motor vehicle accidents or physical violence. They cause damage to the supraglottic airspaces, larynx and trachea and may lead to severe airway problems.

The pattern of injury has changed in recent years. Passenger restraining devices and improved motor vehicle design (ie, windscreen glass, dashboards and steering columns) have reduced the incidence and severity of facial injuries, and the use of helmets has decreased mortality and the incidence of facial and neurological injury in motorcyclists.

Acute Management

The acute management of faciomaxillary and neck injuries focus on airway patency, which is the major priority. Once the problems of airway management have been addressed, management of other life-threatening injuries and trauma-related major system failure will follow. Thus, treatment priorities are to clear and secure the airway, control haemorrhage, treat hypovolaemia, and evaluate for associated life-threatening injuries. When these are satisfied, management is directed towards the facial, neck and other injuries.

1. Airway Management.

The airway must be assessed in the early triage, to exclude airway obstruction, rupture, or bleeding, and determine conscious level and presence of a full stomach and cervical, skull, or associated injuries. Simple measures to clear the airway by suction, posture and insertion of an oropharyngeal airway wil suffice in many cases. An oropharyngeal airway is best avoided in the conscious patient, as discomfort or vomiting may result. Nasopharyngeal airways should be avoided in all injuries to the middle third of the face or with basal skull fractures. The airway should be observed regularly in the acute phase of injury, as increasing oedema, swelling and haematoma may compromise a previously patent airway. Stridor, voice changes, dysphagia, dyspnoea, haemoptysis or surgical emphysema following blunt injury to the neck, may indicate serious injury to the larynx, pharyngeal airspaces, or extrathoracic trachea.

Immediate orotracheal intubation by a *skilled* person under direct vision is indicated in cases of:

(a) severe obstruction;

(b) respiratory depression; and when

(c) general anaesthesia is required to manage concomitant injuries.

Thus, foreign material can be removed and correct tube placement ascertained. When anatomical disruption makes intubation difficult or impossible, an emergency cricothyroidotomy may be life-saving.

Nasotracheal intubation should not be attempted when midfacial injuries are present, and is absolutely contraindicated when basal skull fractures are suspected. The use of a fibreoptic laryngoscope may be difficult for anatomical reasons, and because blood may obscure lens vision. Furthermore, suctioning through the fibreoptic instrument may be inadequate to remove secretions, blood and foreign material. Blind intubation techniques are contraindicated in the acute phase of injury, because a disrupted anatomy may be present. If intubation difficulties are anticipated, tracheostomy under local anaesthesia should be considered. Formal tracheostomy is best performed as a planned procedure in the operating room under local or general anaesthesia provided airway patency and protection can be maintained.

Soft tissue injuried and facial lacerations may mitigate against the use of an air-tight face mask for oxygen therapy or general anaesthesia. The presence of an associated cervical spine injury should be confirmed when possible, and appropriate measures (ie, a cervical collar or neck traction) taken to minimize movement if intubation or tracheostomy is planned. In some cases, cervical injury is suspected but not confirmed, and urgent airway intervention is required. Under these circumstances, while the airway takes priority, care should be taken to minimize neck movement when intubation is performed.

2. Control of Haemorrhage.

Haemorrhage from the midface or base of skull may occasionally be massive, and in severe cases, difficult to successfully control. Provided the airway is secured, the use of topical vasoconstrictors, nasopharyngeal packs, or a Foley balloon catheter inflated in the nasopharynx, may control or reduce blood loss. If bleeding persists, coagulation studies should be performed and appropriate replacement therapy given. Operative reduction of fractures and direct ligation of bleeding vessels may be attempted when simple measures fail to control bleeding. When these measures are unsuccessful, more radical measures, including ligation of the external carotid artery or intra-arterial embolization performed under angiographic control, should be considered.

3. Clinical Evaluation of Injuries.

A history of how the injury occurred should be taken from the patient, bystanders, police, or paramedics. Physical examination includes inspection for facial deformity or asymmetry, malocclusion of dentition, palpation of facial bones (including orbital margins), instability and movement of facial fragments, motor and sensory function, visual disturbances (ie, diplopia, limitation of eye movement, and loss of vision) and presence of cerebrospinal fluid (CSF) rhinorrhoea.

4. Specific Investigations.

Most facial fractures can be easily diagnosed with a minimum of X-ray studies. Useful studies include stereo Water's view, stereo Caldwell's view, postero-anterior, lateral oblique and Panorex views. Two-dimensional and 3-dimensional CT provide additional information about specific patterns of fracture, and may facilitate surgical care. CT may also be useful when laryngeal injury is suspected.

General Management

Patients without airway obstruction are more comfortably nurse in 30° head-up position, to encourage drainage of blood, saliva and CSF away from the airway, while preventing obstruction by disrupted tissue. Once airway patency is secured or confirmed, maxillary and mandibular fragments can be repositioned and a headwrap applied to maintain stabilization. Any other associated injuries are then assessed.

After life-threatening matters have been addressed, definitive reduction of faciomaxillary fractures can be planned. There is a "grace period" of up to 10 days for such surgery. While there is no strong evidence that early fixation may be beneficial, patient comfort might be best served by such an approach. In some cases, particularly orbital injuries when ocular function is at risk, early surgery is mandatory. When gross facial swelling occurs, definitive surgery should be delayed while measures are instituted to reduce swelling. These include debridement of open wounds, removal of foreign bodies, closure of facial lacerations, initial non-definitive stabilization measures, use of ice packs, and head-up nursing of the patient to reduce venous pressure and encourage fluid resorption. Prophylactic antibiotics should be used for patients with CSF rhinorrhoea, compound wounds and when operative fixation of fractures is performed.

Specific Injuries

Fractures

The most common fractures of facial bones are the nasal bones (37%), zygoma and zygomatic arch (15%), mandible (11%), orbital floor (11%), and maxilla (8%).

1. Mandibular fractures.

The mandible occupies a prominent facial position, and therefore is easily fractured. Multiple mandibular fractures are common, and common fracture sites are the condylar neck, angle of mandible, alveolar process, symphysis, and body. Coronoid process fractures are uncommon, as the bone is protected by the zygomatic arch. Ramus fractures are rare, because the strength of the bone in this area transmits impact forces to other areas of the mandible. Body of mandible fractures are oftena accompanied by fractures of the opposite angle or condylar neck, due to transmitted forces. Direct symphyseal impact may result in parasymphyseal or bilateral condylar neck fracture. High speed injuries often result in compound or comminuted fractures at the impact point.

Mandibular fragments are often distracted due to the action of the muscle of the lower jaw. Respiratory obstruction may occur following bilateral mandibular angle or body fractures (Andy Gump fractures) due to posterior displacement of the tongue. In emergencies, respiratory obstruction can be relieved by forward traction of the tongue or by placement of an oropharyngeal airway. Mandibular fractures are definitively managed by internal wiring or plating of fractures, and when teeth are present, by intermaxillary fixation by wiring of upper and lower jaws together, using upper and lower arch bars.

2. Maxillary Fractures.

LeFort described a classification of maxillary fractures in 1901 which is still used today, although fractures are usually of mixed types. Airway obstruction often accompanies LeFort injuries. The soft palate may sag against the tongue, posterior pharynx, or a haematoma or oedema in the pharyngeal wall. Foreign debris may be present in the mouth, and nasal obstruction may occur due to septal dislocation, swelling, or blood clots and foreign material.

Isolated maxillary fractures are rare, because the impact needed to cause fractures is usually sufficiently severe to break other facial bones. Mandibular fractures may be present in as many as 55% of cases of maxillary fracture, depending on the type of LeFort injury. Fractures of nasal bones, zygoma, orbit and skull (particularly base of skull fractures) and soft tissue injuries, including ocular injuries, are often associated with maxillary fractures.

(a) LeFort I Fracture.

This is the least severe fracture and occurs in about 30% of maxillary fractures. It is a dentoalveolar fracture which follows a horizontal plane above the floor of the nose. The fracture (sometimes called Guerin's fracture) separates the palate from the remainder of the facial skeleton, and is usually caused by direct low-maxillary blows or by a lateral blow to the maxilla.

(b) LeFort II Fracture.

LeFort II fractures, also referred to as pyramidal fracturesw, are the most common maxillary fractures (42%). They extend from the lower nasal bridge through the medial wall of the orbit, and cross the zygomatico-maxillary process. They are caused by direct blows to the mid-alveolar area, or by lateral impacts and inferior blows to the mandible when the mouth is open, and consist of a freely mobile pyramidal-shaped portion of the maxilla.

(c) LeFort Fractures.

These are known as craniofacial dysjunctions because the fractures completely separate the midfacial skeleton from the base of the cranium, resulting in the characteristic "dish-face" deformity. The fracture extends through the upper nasal bridge and most of the orbit and across the zygomatic arch. The fracture involves the ethmoid bone, and thus may affect the cribriform plate at the base of the skull. LeFort III fractures usually occur as a consequence of superiorly-directed blows to the nasal bones, and occur in about 28% of patients with maxillary fractures.

Associated basal skull fractures occur in about 20% of LeFort III and some LeFort II fractures, and may lead to CSF leakage, meningitis and pneumocranium. Nasal intubation may result in passage of the endotracheal tube through the cribriform plate and into the cranial cavity. The maxillary antrums are often opaque due to the presence of blood clot.

Despite the LeFort classification, maxillary fractures may often be a mixed variety. Similarly, facial fractures may be comminuted and may not be symmetrically distributed.

Nevertheless, comminuted fractures usually follow the LeFort fracture lines. LeFort II and III fractures involve the orbit and are frequently associated with orbital blowout fractures through which ocular muscles may herniate. Definitive surgery may involve internal fixation with wiring and plating, and intermaxillary fixation. Often, external fixation is required with intermaxillary fixation and cranial suspension to wire fixation at frontal bones.

3. Fractures of Zygoma and Orbit.

The malar region absorbs lateral and oblique blows to the mid-face. The zygoma is uncommonly fractures, but its attachments to the maxilla, frontal, and temporal bones are vulnerable and may be disrupted. When the zygoma is displaced, disruption of the lateral wall and floor of the orbit may ensue. The eye and its function must be carefully examined when fractures involving the orbit are suspected.

Isolated zygomatic arch fractures are often stable after operative reduction, and may require no other active management other than "protective" measures to ensure the area is not accidently bumped. Unstable and comminuted fractures require internal or external fixation. "Tripod" fracture of the zygoma require open reduction. Herniation of orbital contents and entrapment of ocular muscles must be relieved by distraction of the fractures which, in turn, are stabilized by wiring. Autogenous bone grafts and use of alloplastic materials may be required to reconstruct the orbital floor, if the fractures are severely comminuted and if there is bone loss. Orbital blowout fractures are managed in the same manner.

4. Nasal Fractures.

These are the most common fractures of the facial skeleton. Bleeding may be copious, particularly in patients with underlying hypertension or bleeding tendency. Vasoconstrictor agents, such as adrenaline, may be useful in controlling bleeding; in most cases the bleeding will settle. In some cases, nasal packing or inflation and traction of a Foley catheter balloon into the nasopharynx may be required. Closed reduction and external splinting is required to manage nasal fractures and must be performed within 10 days of injury.

Soft Tissue Injuries

Basic tenets of wound management apply to all soft tissue injuries to the face and neck. The region is anatomically complex, and contains many important structures, and extensive wound debridement should be avoided. The rich regional vascular supply, to some extent, protects against nutrient devitalization. Minimal debridement and delayed wound closure provides the best approach to management of the heavily contaminated wound. Where there is extensive tissue loss, once the wound is clean, myocutaneous or osteocutaneous grafts may be performed by microsurgery. Penetrating neck injuries, particularly those due to knife and gunshot wounds, may produce life-threatening exsanguination injuries and require careful evaluation and early surgical exploration.

1. Facial Nerve Injuries.

Any wound around the anatomical vicinity of the facial nerve must be carefully assessed to exclude facial nerve injury. A thorough neurological test of facial nerve function should be performed in the conscious patient. However, because of extensive interneural connections between buccal and zygomatic branches of the facial nerve, a simple laceration of one branch may not produce any obvious clinical signs. Wound exploration should be carefully performed with the aid of a nerve stimulator before wound closure is performed.

Nerve lacerations medial to the orbit are not repaired due to extensive nerve arborization in these areas (before entering the facial musculature). Nerve lacerations lateral to the pupil should be repaired by a primary procedure before wound closure is performed. The amount of recovery of function, even in the best circumstances, is less than 50%. Dyskinesis is a frequent complication of repair, particularly when a major division of the nerve trunk is involved. Lacerations of marginal mandibular branch have poor recovery after repair. There are a number of procedures, including cross-facial nerve grafts and vascularized muscle transplants, which have been used with mixed results to improve outcome in long established facial palsy.

2. Parotid Injuries.

These injuries are characterized by a penetrating wound which lacerates the capsule and separates the parenchyma or parotid ducts. There is an intimate association between the parotid gland and Stensen's duct with the facial nerve, and an injury to one should draw suspicion to injury of the other. Simple lacerations to the parotid capsule are repaired by closure with absorbable suture. Minor collecting duct injuries require no specific surgical repair and any leakage of saliva soon ceases when the wound heals. The occasional formation of a sialocoele is resolved by serial aspirations. Major duct injury requires microsurgical reconstruction. With an injury to the extraparenchymal portion of Stensen's duct, it may be preferable to manage a parotid fistul to the oral cavity, and perform a delayed surgical repair weeks or months later.

3. Laryngeal Trauma.

Blunt or penetrating injuries to the larynx require immediate attention to the airway. If the airway is acutely compromised, an emergency tracheotomy or cricothyroidotomy may be preferable to blind or hasty intubation, which may misplace the endotracheal tube or extend the injury. Gaping wounds of the larynx can be intubated under direct vision, pending subsequent surgery. Simple contusions of the anterior neck may not cause serious laryngeal injury, and the patient can be managed by neck stabilization, head-up posture, and humidified oxygen therapy by face mask. Swallowing may be painful and may be accompanied by spasm or tracheal aspiration, and oral fluids or solids should not be given for 48 hours.

Blunt trauna to the larynx causing a compromised airway requires immediate attention, as laryngeal fracture or collapse is suspected. After the airway is secured by tracheostomy, a detailed examination including direct laryngoscopy should be performed. When the laryngeal skeleton is disrupted, surgical exploration and repair is indicated. Laryngotomy is required when fracture or disarticulation is present and definitive surgical repair can be performed. Post-traumatic fibrosis of the cricoarytenoid joint leading to impaired vocalization, can be minimized by careful surgical techniques. In some cases, particularly injuries to children, an internal stent may be required to minimise airway narrowing.

Following surgical repair, the tracheostomy is kept open for 7-10 days. After this time, the tracheostomy is plugged to test airway patency, and if satisfactory, the tracheostomy tube is removed. In extreme injuries, laryngeal function may not adequately recover and a permanent tracheostomy may ensue. In less severe cases, delayed reconstructive surgery should be attempted. Permanent voice alteration may remain as the minimum disability after laryngeal trauma.

Outcome

Management of the airway and other life-threatening injuries are priorities in the care of the traumatized patient. Mortality will be influenced by the care in the acute phase. However, appropriate and prompt definitive care of facial and neck injuries may significantly affect morbidity. In most cases, definitive treatment while the patient is receiving life support, may avoid complications which will significantly affect the patient's quality of life after recovery.

Chapter 69: Chest Injuries

G. M. Clarke

The commonest form of chest trauma in Australia is closed chest injury secondary to motor vehicle accident. Associated extrathoracic injuries, which themselves may be life-threatening, are often present.

If morbidity and mortality are to be minimized, swift assessment and resuscitation are carried out simultaneously. A team approach is necessary. The team leader must know his priorities as, in almost every case, respiratory and circulatory resuscitation will take precedence over everything else.

Initial management is directed toward detection and correction of life-threatening disorders. When these have been dealth with, a secondary assessment of the patient is made. It is during this secondary assessment that detailed radiological investigations are usually undertaken. However, the chest X-ray is an integral part of initial assessment and should be obtained as soon as possible.

Immediate Management

Obvious external bleeding is controlled. An intravenous cannula is inserted and basic circulatory resuscitation is initiated. Blood is sampled for cross-match, biochemistry and haematological tests. At the same time the respiratory and general measures listed in Table 1 are undertaken.

Table 1. *Immediate Management of Chest Trauma*

Assure patent airway, oxygenation and ventilation.
Exclude or treat:
- pneumothorax
- haemothorax
- cardiac tamponade

Assess for extrathoracic injuries.
Decompress stomach.
Provide pain relief.
Reconsider endotracheal intubation, ventilation.

1. Oxygenation

A clear airway must be assured. Oxygen is administered by face mask, and ventilation assessed. Immediate endotracheal intubation and controlled ventilation is indicated in compromised airways, severe head injuries, and gross hypoventilation and/or hypoxaemia unrelated to pneumothorax. Intubation and ventilation in the presence of tension pneumothorax carries the risk of a fatal outcome. Emergency cricothyroidotomy or tracheostomy is only rarely required when an upper respiratory tract obstruction cannot be bypassed by translaryngeal intubation. (See Chapter 20, Acute Upper Respiratory Tract Obstruction.)

2. Pneumothorax and Haemothorax

Pneumothorax and significant haemothorax are treated if present. A 12 or 14FG intravenous cannula may be inserted percutaneously to relieve tension pneumothorax in dire emergencies. Usually, however, there is time to insert a wide bore intercostal catheter under sterile conditions. A tube directed superiorly through the second anterior intercostal space will adequately drain a pneumothorax. Insertion through the mid-axillary line at the level of the nipple or above is recommended if a more lateral position is required. If a haemothorax is to be drained, the tube should then be directed posteriorly.

3. Cardiac Tamponade

Cardiac tamponade is suspected in any patient with thoracic trauma who exhibitis a low blood pressure and raised venous pressure. In this setting, the differential diagnoses are tension pneumothorax (the most likely) and severe heart failure (usually due to gross myocardial contusion, or prolonged and inadequately treated shock).

Emergency treatment of cardiac tamponade due to pericardial effusion is aspiration of the pericardial sac, preferably under continuous ECG control. The limb leads of the ECG are attached to the patient, and the chest lead connected to the metal hub of the 16FG aspirating needle by a sterile wire. The needle with plastic cannula is advanced towards the left shoulder at a 35 degree angle to the skin from a point 2 cm below the apex of an angle formed between the xiphoid process and the left 7th costal cartilage. Aspiration is made as the needle is slowly advanced. Remarkable improvement may follow the removal of as little as 30 mL of blood. Contact with the myocardium is denoted by ST elevation on the ECG or ectopic beats. When a positive tap is obtained, the plastic cannula is left in situ for continued drainage. Subsequent thoracotomy and full exploration will usually be necessary.

In penetrating injuriesz with suspected tamponade, many centres emply prompt thoracotomy with pericardial decompression, bypassing attempts at aspiration.

4. Extrathoracic Injuries

In assessing extrathoracic trauma, head, neck and abdominal injuries, and significant concealed blood loss must be excluded. This initial rapid assessment should be made before potent analgesics are administered.

5. Gastric Decompression

Gastric distension with attendant risks of regurgitation, vomiting and aspiration, especially in patients with associated head injury, is extremely common in cases of severe chest trauma. The stomach should be decompressed by a nasogastric tube. If urgent endotracheal intubation is necessary, a rapid sequence ("crash") intubation is recommended, including the use of cricoid pressure.

6. Pain Relief

Pain relief is usually obtained at this early stage with IV narcotics. This will frequently relieve respiratory distress in patients with fractures of the ribs and/or sternum.

7. Reconsideration of Mechanical Ventilatory Support

After the initial management, mechanical ventilatory support should then be reconsidered. Major indications are listed in Table 2. Ventilation should also be considered for patients with borderline respiratory distress associated with:

(a) gross obesity;
(b) significant pre-existing lung disease;
(c) severe pulmonary contusion or aspiration; and
(d) severe abdominal injuries requiring surgery.

Table 2. *Major Indications for Endotracheal Intubation and Ventilation*

Dangerous hypoxaemia and/or hypercarbia.
Significant head injury.
Gross flail segment and contusion and respiratory distress.

Specific Thoracic Injuries

Specific thoracic injuries should be systematically excluded.

1. Ruptured Aorta

A widened mediastinum should always arouse suspicion of a ruptured aorta. In one series, a mediastinal width greater than 8 cm was present in all 10 patients with ruptured thoracic aorta. Suspicion of aorta rupture in the presence of an widened mediastinum is further heightened if associated with one or more of the following:

(a) left haemothorax;
(b) depressed left main bronchus;
(c) blurred outline of the arch or descending aorta;
(d) fractured 1st rib or left apical haematoma; and
(e) displacement of the mid oesophagus to the right (easily detected when a nasogastric tube is in situ).

Aortography should then be undertaken. The classic site of traumatic rupture of the aorta is at the junction of the mobile arch and fixed descending aorta. This is immediately beyond the origin of the left subclavian artery. Rupture at this site is attributed to forward movement of the mobile arch against the tethered descending aorta in a deceleration situation (eg, motor vehicle accident). In about 10% of cases, the tear is in the ascending aorta or near the origin of the other great vessels. These tears are usually due to direct trauma. Treatment is prompt surgery and often necessitates cardiopulmonary or left atrio-femoral bypass. These techniques or local shunmts do not necessarily protect against consequent paraplegia.

2. Ruptured Diaphragm

The usual cause of a ruptured diaphragm is gross abdominal compression, and the incidence may have risen since seat belts were made compulsory. Rupture of the left diaphragm is more common. A haemo-pneumothorax is commonly misdiagnosed when the dilated stomach gives a horizontal air-fluid interface on the erect chest X-ray. A ruptured diaphragm, as an isolated injury, is often surprisingly well tolerated by the patient. Nevertheless, with a left diaphragmatic rupture, there is significant risk of gut strangulation, and surgical repair should follow basic resuscitation.

Rupture of the right diaphragm is more difficult to diagnose due to the presence of the liver. The radiographic appearance is similar to a paralysed right diaphragm. In the absence of right sided rib fractures, a small pneumothorax together with a "high right diaphragm" is suggestive evidence.

3. Disruption of Major Airways

Although signs and symptoms may vary according to the level of the rupture, the clinical picture is frequently that of respiratory distress, subcutaneous emphysema and haemoptysis. A pneumothorax, which may be under tension, is invariably present in those with ruptured bronchus. Mediastinal emphysema is commonly seen on the chest X-ray. With tracheal injuries, immediate management involves endotracheal intubation beyond the tear to ensure an adequate airway, prevent aspiration of blood, and to abate the air leak. A pneumothorax if present, must be drained. Suction to the intercostal catheter may be necessary to keep the lung expanded. After this is achieved, bronchoscopy and early primary repair is undertaken. Intubation with a double-lumen tube may be necessary if air leak from a disrupted bronchus is significant, to enable adequate ventilation of the patient as well as operative repair of the injury.

4. Massive Haemothorax

Immediate management involves insertion of a wide bore intercostal catheter and adequate resuscitation. Common causes include disruption of intercostal and/or internal mammary arteries. If the cause is massive bleeding from the aorta or major pulmonary arteries, the condition is usually fatal. Continued significant blood loss is an indication for early thoracotomy. Inadequate drainage of a haemothorax may require a thoracotomy and "decortication" at a later date. However, such decortication is rarely necessary.

5. Pulmonary Contusion

This is due to bruising of the lung and, as with any bruised tissue, becomes more oedematous over the following 48 hours. In the management, overhydration must be avoided. When associated with severe flail segments and respiratory distress, assisted ventilation is required, although this need not usually be prolonged.

6. Myocardial Contusion

Myocardial contusion is common in blunt chest trauma and may result in arrhythmias and cardiac failure. Both of these complications should be managed as in myocardial infarction. A standard 12 lead ECG may show a variety of abnormalities ranging from non-specific T wave changes to pathological Q waves. Abnormalities can also be demonstrated by myocardial nuclear scanning (not normally undertaken in the acutely injured patient). Serious damage to virtually every cardiac structure has, at some time, been reported. Cardiac injuries such as rupture of the ventricular free wall, interventricular septum, valvular apparatus, and disruption of major coronary arteries have usually been associated with penetrating injuries. However, many such complications have also been reported in non-penetrating chest trauma.

7. Systemic Air Embolism

This is more commonly seen in penetrating injuries and is immediately life-threatening. Though uncommon, it is probablyunderdiagnosed as it is unlikely to be proven at conventional autopsy. Air embolism is caused by a broncho-pulmonary vein fistula. It is suspected in the chest injured patient if:

(a) focal neurological signs exist in the absence of head injury;

(b) circulatory collapse immediately follows the institution of intermittent positive pressure ventilation (IPPV) in the absence of tension pneumothorax; and

(c) froth is obtained when arterial blood is sampled from a collapsed patient.

8. Oesophageal Perforation

Though usually due to penetrating injury, it can occur rarely with closed chest trauma. The patient may complain of retrosternal pain and difficulty in swallowing, and exhibit haematemesis and cervical emphysema. A chest X-ray may show mediastinal emphysema, widened mediastinum, pneumothorax, hydrothorax or hydropneumothorax. If suspected, a gastrografin swallow and/or endoscopy is performed. Treatment is immediate surgical repair. A gastrostomy and feeding jejunostomy are usually performed at the same time.

Management of a Flail Chest

The management of a flail chest remains unresolved. The concept of Pedulluft (the to and fro movement of air between the flail and non-affected sides of the thorax) has been shown to be incorrect. With a flail chest, overall ventilation may be reduced, but it is distributed to both lungs because the mediastinal shift equalizes the pleural pressures. Nevertheless, there is poor expansion in contused, low compliant lung areas, impairment of coughing and serious reduction in overall ventilation in gross cases. Moreover, gross mediastinal shifts may impair systemic circulation. While several basic approaches to managing a flail chest have emerged (Table 3), the ultimate choice of approach is determined by the severity of the chest injury, associated injuries and the method of pain relief.

Table 3. *Management of a Flail Segment*

Conservative
Assisted ventilation
- (a) Continuous positive airway pressure (CPAP)
- (b) Intermittent mandatory ventilation (IMV)

Controlled ventilation ± PEEP
- (a) Conventional IPPV
- (b) Independent lung ventilation

Surgical stabilization ± above measures.

1. Conservative Therapy

Conservative treatment involves oxygen by mask, adequate pain relief, and physiotherapy. It is the treatment required in a mild injury (ie, an isolated thoracic injury with fractured ribs, but without significant flail or disturbed blood gases). Similarly, it may be employed in the patients with a moderate injury (ie, a significant flail but with adequate blood gases and the ability to cough). "Prophylactic" ventilation in both of these groups has been deemed inappropriate, with possible disadvantages of barotrauma, infection, tracheostomy complications, and prolongation of hospitalization.

2. Mechanical Ventilatory Support

However, in a severe injury, ie, a gross flail segment with gross pulmonary contusion ± aspiration, and in a patient with associated head injury, endotracheal intubation and assisted ventilation is necessary. The early use of intermittent mandatory ventilation (IMV) has been claimed to result in a shorter duration of assisted ventilation. As with conservative therapy, increased residual deformity may well be the price for unrestrained used of this technique. Continuous positive airway pressure (CPAP) alone has not been fully evaluated. Independent lung ventilation, a technique of selectively ventilating each lung separately, using a double lumen tube, may be used to treat a unilateral pulmonary contusion and/or flail. (See Chapter 22, Mechanical Ventilatory Support.)

3. Surgery

There is revived interest in surgical stabilization of the chest wall. Advantage claimed are either a shorter period of assisted ventilation being required or a shorter hospital stay. Internal surgical stabilization undoubtedly reduces deformity, and a stable chest wall will help a patient to cope with an underlying lung problem. However, except for a broken sternum, rupture of the diaphragm, and in the course of an otherwise necessary thoracotomy, the case for surgical repair has yet to be established.

Complications

Following resuscitation and initial management, complications may follow which usually require treatment.

1. Sputum Retention

Adequate pain relief is the major determinant of whether sputum retention will occur in the spontaneously breathing chest injured patient as efficient coughing must be maintained. Similarly, assisted ventilation may be avoided in many moderately injured cases if the method of pain relief is carefully selected and significant respiratory depression is avoided. Options (see also Chapter 48, Pain Relief in Intensive Care) include:

(a) intravenous narcotics given by frequent small dose intermittently or by continuous infusion;

(b) entonox inhalation during physiotherapy;

(c) intercostal nerve block either:

(i) multiple individual nerve blocks (repeated as necessary) or

(ii) single large volume (eg, 20 mL 0.5% bupivacaine) into one intercostap space (uni- or bilaterally), spreading to block nerves above and below the site injected.

(iii) intrapleural bupivacaine (0.25-0.5%) via uni- or bilaterally placed intercostal catheters. Epidural catheters have been used for this purpose. Either intermittent or continuous infusion of bupivacaine may be employed.

(d) conventional epidural analgesia using agents such as bupivacaine; and

(e) epidural or spinal opioids.

For ventilated patients adequate humidification and frequent endotracheal and endobronchial suctioning must be employed. Frequent change in position is important. In ventilated patients, analgesic techniques producing respiratory depression are not a problem except during weaning or if IMV is used.

2. Bronchospasm

Bronchospasm suggests aspiration and is treated conventionally.

3. Tension Pneumothorax

The possibility of a late tension pneumothorax is ever present, especially if the patient is being ventilated with IPPV and positive end expiratory pressure (PEEP).

4. Acute Respiratory Failure

This is commonly seen in these patients. Causes include aspiration, pulmonary contusion, previous shock with delayed resuscitation, and fat embolism. If a classical adult respiratory distress syndrome (ARDS) occurs late after injury, then the most common cause is sepsis. However, humoral factors may play a role in the massively injured. Supportive treatment is instituted and, where possible, the underlying cause is treated. (See Chapter 25, Adult Respiratory Distress Syndrome.)

5. Infection

Sepsis remains a major cause of death in patients with severe chest and other injuries. The source of such infection is invariably endogenous, mainly coming from bacteria colonising the patient oropharynx and alimentary tract.

This has led to the use of parenteral antibiotic prophylaxis (eg, cefotaxime) active against community bacteria (eg, *S pneumoniae, H influenzae, B catarrhalis, S aureus,* or *E coli*) from the time of admission for 4 days. At the same time, oral and intragastric non-absorbable combinations of polymycin E, tobramycin and amphotericin B are administered, to prevent colonization and infection by *enterobacteria, pseudomonas* and fungi such as *candida.*

6. Thromboembolism

Preventative measures include frequent movement, full length leg stockings, avoidance of pressure on limbs, and low dose heparin (5000 units bd or tds) subcutaneously.

7. Inadequate Nutrition

Gastric atony and stasis are common. In many cases adequate enteral feeding is possible by appropriate posturing (eg, positioning on right side during feeding). In others, especially those with associated abdominal trauma, parenteral nutrition is necessary.

8. Coagulopathies

Prompt resuscitation, control of haemorrhage, and possibly, use of blood filters for massive blood transfusion help in this regard.

Prognosis

Reported mortality rates in chest injured patients vary greatly, often reflecting the severity of the chest injury and the extent of extrathoracic injuries. In one Australian series, of 1119 patients with chest and other injuries, the overall mortality rate was 5.3%. The 3 commonest causes of death were respiratory tract sepsis (35.6%), severe head injury (33.9%) and exsanguination (18.6%). Mortality rate was 37.5% for patients over 60 years of age who had respiratory failure, and for all age groups requiring mechanical ventilation, was 22.8%. Trunkey reported a 16% mortality in patients with isolated pulmonary contusion. When combined with a significant flail chest, the mortality rose to 42%.

Chapter 70: Spinal Injuries

M. M. Fisher

Introduction

The human spine is an engineering masterpiece designed to allow movement, maintain stability, and protect the spinal cord. Major trauma to the spine, especially when the underlying spinal cord is damaged, produces devastating injuries leading to economic, personal, and social tragedies. This situation is compounded by the development of paramedic services, which have lead to better survival of patients with high spinal injuries who in the past would not have reached hospital alive. The incidence of spinal injuries in Australia is 20-25 per million population per annum.

While significant advances have lead to improvements in both the rate and quality of survival of paraplegic and quadriplegic patients, the major thrust is in prevention and education - the use of appropriate safety helmets and car restraints; adequate preparation for contact sports, ie, football; and teaching of safety in water sports.

Aetiology

Motor vehicle (both car and motor cycle) trauma provide the major source of spinal injuries in Australia. The next commonest causes are football injuries and water accidents, especially those caused by diving into shallow water. Accidents related to hang gliding and ultralight aircrafts, falls and gunshot wounds comprise other common causes.

Spinal injuries are therefore likely to be associated with other injuries, particularly head and abdominal injuries, and aspiration of salt or fresh water. A careful check for other injuries should be mandatory in the patient with spinal injuries. Conversely, the multiple trauma patient should be assumed to have spinal injuries until proven otherwise.

Mechanism of Injury

The magnitude and type of injury depends of the ability of the spine to withstand and absorb various forces. Flexion injuries usually compress the vertebral bodies and disrupt the posterior longitudinal ligaments, leading to herniation of the intervertebral disc. Extension injuries disrupt the anterior ligaments and fracture posterior segments of the vertebral column. Compression injuries produce explosive fractures of the bodies and ligamentous rupture. Rotational injuries either cause fracture dislocations of the facets, which damage the midsection of the bodies, or disrupt the ligaments producing fractures. The combined rotation flexion and rotation extension injuries in the cervical region severely damage ligaments, bone and the underlying spinal cord.

Injury to the cord leads to the bruising or mechanical destruction of nerve, haemorrhage, reduced perfusion, oedema and necrosis. An element of the cord damage can be reversible, and up to 4 weeks may be required to assess the final degree of damage.

Initial Treatment

The initial management is rapid immobilization of the fracture area and evacuation to a centre dealing in spinal injuries. Paramedic and ambulance services usually have devices such as backboards, scoop stretchers (eg, a Jordan frame) and extricators which permit safe movement of the patient. The traditional "log rolling" technique is used, but movement of unstable thoracolumbar segments is possible. Nevertheless, it is still necessary in many first aid situations. Hard and soft cervical collars are inadequate to stabilize patients with suspected spinal injury who are awaiting radiological examination. The classic technique of sandbags at each side of the head should be used. As movement of either neck or body may extent the spinal injury, the body should be immobilized on the bed/trolley as well, by means of straps or sheets. Suction equipment should be immediately available at all times.

In high spinal injuries, intubation may be necessary to provide ventilation. The preferred method of stabilizing the neck during intubation is controversial. In one recommended technique, the patient is intubated after administration of IV thiopentine and muscle relaxants, with cervical traction applied longitudinally by means of skull tongs. Care is taken not to extend the neck, although a small degree of flexion is permissible. However, in a study performed on dead patients with cervical cord injuries, longitudinal traction during orotracheal intubation may produce subluxation at C6-C7 fracture dislocations. In practice, extreme care must be used. An array of accessories for difficult intubation should be ready prior to intubation. Consideration is given to intubating with a fibreoptic laryngoscope/bronchoscope or carrying out a cricothyrotomy in very unstable high spinal injuries.

During transport, regular assessment of ventilation and level of neurological deficit is essential, as both may deteriorate. The patients are vulnerable to hypothermia, becoming poikilothermic after high spinal injury. A transient hypertension and bradycardia may occur, but the usual cardiovascular feature is hypotension, which is difficult to treat. Patients are unusually sensitive to both volume loading and drugs because of loss of vascular tone, muscle activity and thoracic effects of breathing on venous return. Treatment should be cautious and titrated with repeated assessments.

Hospital Management

1. Initial Assessment

Upon arrival in hospital or ICU, the neck should be initially stabilized as described above. The next priority is radiological diagnosis/assessment, especially PA, lateral and through-the-mouth oblique x-rays, and CT scanning where possible. At the same time, ventilation is assessed and other injuries treated. Following neurological and radiological assessments, more definitive (surgical) stabilization is considered, which usually involves the use of skull tongs, halopelvic traction or anterior or posterior spinal fusion.

2. Circulation

Haemodynamic stability may be extremely difficult to achieve. Sympathetic outflow disturbances lead to hypotension, and the spinal injury associated injuries may both produce significant hypovolaemia. The radiological appearance of a widened mediastinum in thoracic spine injuries often leads to concern about aortic damage, and if associated signs are present angiography may be required. (See Chapter 69, Chest Injuries.) In high spinal injuries, a low blood pressure is tolerated in the early period provided that urine output, peripheral perfusion and acid base states are maintained.

3. Respiratory

Fractures above C5 lead to the loss of diaphragmatic function and those above C8, loss of intercostal function. Initial and repeated assessment of lung volumes is mandatory. Patients with forced vital capacities of less than 2 L will usually require mechanical ventilatory support. Atelectasis, particularly of the upper lobes, is common and bronchoscopic clearance may be necessary. Sitting patients more upright will increase functional residual capacity. Abdominal binding may assist ventilation. In patients who will require tracheostomy, it is good policy to perform tracheostomy early, and to use a speaking tube which provides obvious advantages especially in improving morale.

4. Nursing

Patients should be nursed supine on a bed capable of lateral tilting and allowing them to be lifted for skin care. Suprapubic catheterization or ureteric catheterization are necessary, and are replaced in males with uridome drainage after urodynamic assessment at 4-6 weeks. Prophylactic antibiotics are not indicated in early treatment.

5. Social Consideration

In injuries such as C1-C2 total quadriplegics, the wishes of the patient and family regarding continuation of treatment should be sought when the complete nature of the lesion is established.

Specific Treatment

Various modalities of treatment have been tried experimentally in animals and humans. Such treatments have included use of hyperbaric oxygen, direct cord hypothermia, osmotic agents, steroids and naloxone. The clinical evaluation of these therapies is extremely difficult and none have any proven value from controlled trials. An isolated case of a dramatic response to local hypothermia, and anecdotal responses to hyperbaric oxygen have been reported.

Complications of Spinal Cord Injury

1. Cardiovascular

Postural hypotension is common during rehabilitation. The cardiovascular system may be unstable for periods of up to a week, particularly during anaesthesia. Thromboembolic disease is also common. Although there is no controlled study on the prophylaxis of thromboembolism in spinal injured patients, available studies suggest that venous thrombosis occurs early, and that conventional prophylactic measures such as low dose subcutaneous heparin may reduce the incidence.

2. Skin

Pressure sores are a major problem and meticulous attention to turning, lifting and pressure areas is mandatory. Such areas may be complicated by soft tissue infections and osteomyelities which require surgical debridement.

3. Alimentary System

In the early stages, paralytic ileus and gastric distention are common, making enteral feeding difficult and predisposing to aspiration. Although with nasogastric decompression, the ileus usually improves, it may recur or become protracted. Abdominal pain may be a feature and pancreatitis should be excluded. Non specific changes in liver function tests occur in 50%. After neurological and cardiovascular stabilization, faecal impaction is a common problem requiring regular enemas and evacuation. Spinal injured patients are at risk from stress ulceration. Control of gastric pH is difficult in quadriplegics due to the loss of sympathetic stimulation of the stomach. H_2 blockers and antacids should be used and gastric pH monitored 4 hourly. Higher doses than usual of antacids and H_2 blockers may be necessary to maintain a pH less than 4.0.

4. Metabolic

Although the metabolic rate is low, muscle wasting and hypoalbuminaemia rapidly occur. Calcium excretion is increased and glucose intolerance may occur.

5. Genitourinary

Infection of the urinary tract is a major problem. In the early phase of spinal injury, a paralysed overdistended bladder is a danger and drainage is necessary. Reflex activity returns in 2-8 weeks and retraining, often with the help of self-catheterization can occur. Regular monitoring of renal function is mandatory in the early stages.

6. Neuromuscular

In the early phase, autonomic dysreflexa occurs in 50% of patients with lesions above T6. Symptoms include hypotension, sweating, blanching, headache, bradycardia and fever, and the episodes are often triggered by bowel or bladder distension. If prevention of the latter does not control the autonomic dysreflexia, alpha-adrenergic blockers may be necessary.

7. Other Complications

Causalgic pain and reactive depression are common. Non infective fevers frequently occur in the early phase of injury, but the majority of fevers are harbingers of infection.