Neurosurgical Society of Australasia Inc

The Management of Acute Neurotrauma in Rural and Remote Locations

A set of guidelines for the care of head and spinal injuries

FORWARD

These guidelines were first published in 1992 and revised in 2000. They are intended to assist medical practitioners responsible for the initial management of patients with neurotrauma in places remote from specialised services. The outcome from severe head and spinal injury is often determined by the adequacy of initial care from the scene of injury through to definitive care.

Since the first edition most rural practitioners have undertaken Early Management of Severe Trauma (EMST) training. This and the rural surgeons training scheme of the Royal Australasian College of Surgeons have given rural surgeons the skills to manage acute neurotrauma. These guidelines are compatible with the EMST approach and terminology. Many larger rural hospitals have access to CT scanning and teleradiology which are of great assistance in sharing the responsibility of neurotrauma management with the central neurosurgical services. All rural hospitals have access to retrieval services.

The guidelines are to be seen as part of a trauma management system beginning at the accident site and continuing through to definitive care at a regional or state trauma centre.

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EPIDEMIOLOGY

INCIDENCE

Traumatic brain injury (TBI) is responsible for 50% of trauma deaths and 70% of all road accident deaths. TBI is the commonest cause of permanent disability after injury. The commonest reason for hospital admission in persons under 45 years of age is trauma.

FACTORS IN THE RURAL ENVIRONMENT

Rural trauma often occurs in isolated areas at a distance from medical facilities, which may be limited, so there may be delay in definitive care. Rural crashes are often at high speed and occur in poor driving conditions. Injuries are often severe and multiple. The high incidence of single vehicle accidents may reflect driver fatigue.

FACTORS ADVERSELY INFLUENCING OUTCOME (DEATH AND DISABILITY)

The following factors may adversely influence outcome:

- Severity of primary injury
- Intracranial complications (haemorrhage, brain swelling)
- Hypoxia
- Hypercarbia
- Hypotension
- Anaemia
- Multiple injuries, proportional to Injury Severity Score (ISS)
- Age
- Prolonged prehospital time
- Admission to an inappropriate hospital
- Delayed or inappropriate interhospital transfer/retrieval
- Relative inexperience of medical staff in rural and remote areas
- Lack of medical facilities
- Delay in definitive surgical treatment

Children and elderly patients react particularly adversely to trauma. When a patient is over 50 years of age severe intracranial complications may develop from an apparently minor head injury such as a fall.

AVOIDABLE CAUSES OF DEATH OR DISABILITY

The following are avoidable causes of death and disability:

- Delay in instituting primary resuscitation for hypoxia, hypercarbia and hypotension
- Delay in initiating definitive neurosurgical care especially for the rapidly developing intracranial haematoma
- Craniocerebral infections
- Hydrocephalus

EVIDENCE OF THE MECHANISM OF HEAD INJURY

From the evidence of ambulance officers, police, eyewitnesses and the clinical examination, it is usually possible to deduce:

1. The site of injury
2. The type of impact
3. The pathology of injury

SITE OF INJURY

The effects of frontal, lateral and occipital impacts are influenced by the local anatomy such as the presence of air sinuses or large blood vessels and the thickness of the skull.

TYPE OF INJURY

Pure impact forces produce characteristic patterns of injury but in practice there is often more than one type of impact and the injuries are complex.

Acceleration/Deceleration

- This is applied to the entire head, and according to severity, may produce disordered consciousness, diffuse axonal injury and/or cerebral contusions (coup or contrecoup)

Local impact

- Produces local (coup) injuries to scalp, skull, meninges, brain and sometimes injuries at the opposite pole of the brain (contre coup)

Penetrating

- Injury along the pathway of penetration may damage blood vessels
- The extent of injury depends also on velocity and nature of the projectile

Crush injury

- Primary injury to the scalp, skull and cranial nerves
- Brain injury may be absent or minimum

PATHOLOGY OF INJURY

Primary Injury (the injury due to impact)

The initial or primary injury is the result of the mechanical deformation of the brain tissue and blood vessels at the moment of impact. There may be gross disruption of brain tissue and widespread changes at the cellular and microcirculatory level. Over the hours following injury interrelated biochemical and metabolic changes may lead to cellular swelling, raised intracranial pressure and ischaemia. There may be progressive structural damage to the cells and blood vessels. At present these changes are not preventable but in general, clinical deterioration indicates secondary effects which often are preventable. Primary injuries due to impact include:

Scalp
- Contusion
- Abrasion
- Laceration

Skull Fracture
- Open or closed (note – includes compound base of skull fracture without a scalp laceration)
- Linear, depressed, comminuted or some combination of the three

Meningeal Injury
- Dural tear with CSF leakage and/or pneumocephalus

Brain Injury
- Concussion
- Diffuse axonal
- Focal contusion, coup and contrecoup
- Laceration and penetration

SECONDARY INSULTS

The most important early preventable events or secondary insults are hypoxia and hypotension which must be corrected without delay. Clots may expand at different rates and this determines the urgency of surgical treatment. Raised intracranial pressure can be managed by early resuscitation and ventilation but may need intensive care protocols for longer care. Secondary insults following primary injuries due to impact include:

- Intracranial haemorrhage
- Cerebral hypoxia
- Cerebral swelling
- Metabolic disorders
- Infection
- Epilepsy

PREHOSPITAL CARE

Prehospital care follows Early Management of Severe Trauma (EMST) protocols for primary survey and resuscitation,and must be aware of the possibility of head injury. This phase of management takes particular attention to:

- Airway
- Breathing
- Control of haemorrhage
- Prevention and treatment of shock
- Prevention of hypothermia (which may aggravate coagulopathy) eg by using a space blanket
- Avoiding factors which can either cause or further increase raised intracranial pressure (such as the head-down position, hypoxia, hypercarbia, vomiting or fitting)
- Serious associated injuries especially spinal injury

It is essential to obtain and maintain adequate brain oxygenation and cerebral perfusion as early as possible.

POSITION OF THE UNCONSCIOUS PATIENT

The LATERAL position may be indicated for airway control if simple measures fail to maintain airway patency and intubation is not possible. In a patient with a suspected spinal injury care must be taken to maintain spinal alignment (see Spinal Injury, Prehospital Management, page 22). The patient is log rolled on to one side with the neck in a collar and supported throughout the manoeuvre. The body weight is supported by the lower shoulder, hip and the upper knee which is at right angles to the hip. The face is turned slightly downwards to allow the tongue to fall forward so that saliva or vomit will drain out. The head should be supported on rolls to avoid lateral flexion.

A patient with multiple trauma may not be able to be moved into the lateral position.

TRACHEAL INTUBATION

Tracheal intubation is indicated:

- If airway patency is inadequate despite an oral airway and adequate suction and/or the ventilation is insufficient
- If the GCS<9

Tracheal intubation should only be performed by a competent medical practitioner or by a paramedic specially trained and certified in this potentially dangerous procedure.

Patient restlessness and trismus may prevent intubation. It is preferable to perform a 'crash induction' with sedation and paralysis rather than have a struggling straining patient where the intracranial pressure will be significantly elevated by the attempts. If the necessary drugs are not available in the prehospital setting and if there is likely to be technical difficulty in intubation then the patient should be placed in the lateral position with an oral airway and oxygen if necessary using manual positive pressure bag ventilation with 100% Oxygen. Beware of excessive hyperventilation. It is preferable to have end-tidal CO_2 monitoring to avoid dropping the arterial pCO_2 level below 30 mmHg.

SPINAL INJURY

It is important to emphasise that, in a patient with suspected cervical spine injury and an obstructed airway, the immediate risk of hypoxia takes priority over the potential risk of spinal instability (See Spinal Injury, page 22).

PRIMARY HOSPITAL INITIAL MANGEMENT

STAGES OF INITIAL MANAGEMENT

The stages of initial management are:

1. Primary Survey
2. Resuscitation
3. Secondary Survey
4. Definitive Care

STAGE 1: PRIMARY SURVEY

PRIMARY SURVEY CONSIDERATIONS

- **A**irway with cervical spine immobilised in neutral position
- **B**reathing pattern and adequacy
- **C**irculation and haemorrhage
- **D**isability including a rapid neurological examination. This may be based on the AVPU scale and pupil reaction. The AVPU scale is:
  - **A**lert
  - Responding to **V**oice only
  - Responding to **P**ain only
  - **U**nresponsive.
- **E**xposure: completely expose the patient for an adequate examination but protect against hypothermia.

STAGE 2: RESUSCITATION

RESUSCITATION CONSIDERATIONS

1. Airway – ensure airway is patent

- In an unconscious patient: intubate if skilled personnel available
- Maintain cervical spine immobilisation until radiological examination excludes spinal injury

2. Breathing and oxygenation

- Ensure adequate ventilation
- Mechanically ventilate if intubated
- Give supplemental oxygen to all initially at 12 L/min of 100% Oxygen

3. Circulation support and control of haemorrhage

- Treat shock aggressively to improve tissue perfusion. Aim for a systolic blood pressure >90 mm Hg and preferably >100 mm Hg unless the patient is shocked due to penetrating torso trauma or severe blood loss from the extremities where relative hypotension is preferred.
- Stop external haemorrhage

4. Assess response to resuscitation using physiological parameters

- Pulse, blood pressure, skin colour, capillary refill
- Urine output

5. Nasogastric tube and urinary catheter

- Nasogastric tube and urinary catheter unless contraindicated
- Place an orogastric tube if there is severe facial trauma or suspected skull base fracture

6. Airway treatment

- Clinically detect and treat airway obstruction, tension pneumothorax, open pneumothorax, massive haemothorax, flail chest, cardiac tamponade.

IMPORTANT NOTES

- Primary Survey and Resuscitation occur simultaneously.
- Large volumes of crystalloids may result in cerebral swelling or electrolyte disturbances, particularly in the elderly, the young and in patients with previous cardiopulmonary or renal conditions.
- Head injury alone without scalp injury does not cause hypotension except uncommonly due to medullary failure in very severe or terminal injury. If hypotension is present, identify the cause eg, hypovolaemic shock or spinal injury. Blood loss from a scalp wound or head injury may cause hypovolaemic shock in children.

STAGE 3: SECONDARY SURVEY

SECONDARY SURVEY CONSIDERATIONS

- Neurosurgical assessment including Glasgow Coma Score (GCS) and external signs of injury to the head.
- Record the pulse, blood pressure, respiratory rate and temperature.
- Systematically examine each region of the body, ie, head-to-toe examination. Establish an injury list. Make sure to examine the back of the patient including the head and neck for unsuspected injuries.
- Place a gloved finger in scalp wounds to detect depressed fractures.
- Pay particular attention to the eyes for penetrating injuries. Remove contact lenses.
- Examine the external auditory canals for CSF, blood and ear drum trauma.
- Examine the face for facial fractures and the mouth for dental trauma, tongue and palate injuries and mandibular fractures.
- Examine the nose and note CSF leak or epistaxis.
- Connect to monitors as available.
- Radiological examination – lateral spine xray (must be able to see from cranio-cervical junction to C7/T1), chest, pelvis, other areas as indicated, skull xray and CT head scan (see guidelines page 11-12).

SPECIFIC NEUROSURGICAL ASSESSMENT

History

- Cause of injury. This may help in determining the mechanism and likely pattern of head injury.
- Loss of consciousness at the injury site. Did the patient talk before becoming unconscious? If so, there is a secondary cause for loss of consciousness such as hypoxia, hypotension, intracranial haematoma or seizures.
- Pupillary response. Were the pupils equal or unequal at the injury site? Initial equality with change to inequality suggests a lateralised mass lesion.
- Cardiorespiratory status and response to resuscitation at the injury site.
- History of drugs or alcohol prior to, and at the time of injury.
- Other medical disease, previous head injury or ocular conditions.

CNS Examination

- GCS.
- Pupillary responses. Are they equal or unequal? Is the reaction brisk, sluggish or unreactive? Have they changed since injury?
- Motor pattern, hemiparesis, quadriparesis, flexion or extension to pain (from supraorbital, sternal or fingernail bed pressure).
- Palpate the spine for tenderness and deformity.
- Look for signs of spinal injury such as priaprism or spinal shock.

The history and initial CNS examination set a baseline against which changes in the neurological condition can be compared.

USING THE GLASGOW COMA SCALE (GCS)

The GCS examines three areas of behaviour: Eye Opening, Best Verbal Response and Best Motor Response.

The Stimulus

Firm pressure over the supraorbital margin will demonstrate localisation of the painful stimulus. Sternal pressure will not distinguish clearly between localisation and flexion. If there is no localisation to pressure over the supraorbital margin, pressure over the nail bed will distinguish flexion withdrawal, flexion abnormal and extension.

The Response

Each side is tested but only the best response is marked on the time based charts, eg the best motor response means the best response from either right or left side.

The purpose of the GCS is to record level of consciousness, not focal deficits. Side to side differences are recorded on a separate *limb movement* scale.

Eye Opening

- E4. Spontaneously – Eyes are open when first approached.
- E3. To speech – The eyes are not open at the start of the examination but open when spoken to.
- E2. To pain – Eyes do not open when spoken to, but do so when pressure is applied to the patient's finger nail bed with a pen.
- E1. None.

Best Verbal Response

- V5. Oriented – Correctly states name, place and date.
- V4. Confused – Produces phases and sentences but is unable to give correct answers about orientation.
- V3. Inappropriate words – Speaks or exclaims only a word or two.
- V2. Incomprehensible sounds – Responses consist of groans or indistinct mumbling.
- V1. None.

Best Motor Response

- M6. Obeys commands – Obeys requests to "open your eyes" or "put out your tongue".
- M5. Localises pain – The patient does not obey commands, but is able to locate a painful stimulus (firm pressure over the supraorbital margin) and attempts to remove it.
- M4. Flexion – withdrawal – After painful stimulus to the nail bed, the arms bend at the elbow and pull away from the stimulus.
- M3. Flexion – abnormal – After painful stimulus to the nail bed: Either initial extension followed by flexion, or two of the following:–
  - (i) stereotyped flexion posture
  - (ii) extreme wrist flexion
  - (iii) adduction of the upper arm
  - (iv) flexion of the fingers over the thumb
- M2. Extension to pain – After painful stimulus to the nail bed, the elbow straightens. , The lower limb(s) straighten and the feet plantar flex.
- M1. None.

GLASGOW COMA SCORE

The numbers for each of the three parts of the scale are often added to give a Glasgow Coma Score, 3 being the lowest score and 15 normal.

$$\text{Coma Score} = (E + V + M) = 3 - 15$$

A GCS of 8 or less implies a severe head injury (assuming that non neurosurgical causes of coma have been treated). Patients with a GCS of 8 or less should generally be intubated and ventilated.

In describing a patient's state it is better to use the descriptors eg "eye opening to pain, incomprehensible sounds, localises pain" rather than "GCS = 9".

If the eye opening cannot be assessed due to injury or the verbal response due to intubation these facts should be noted. The motor response is still recorded.

Severe Head Injury GCS < 9

e.g.	no eye opening	1
	incomprehensible or less	1 – 2
	localises or less	1 – 5

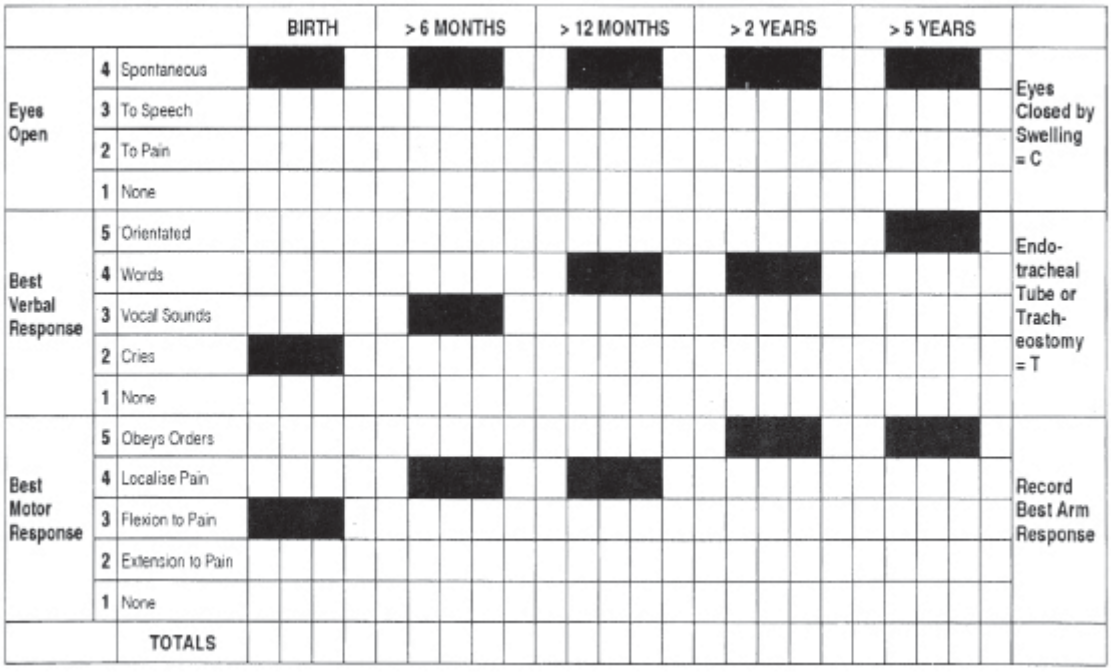
Moderate Head Injury GCS 9 – 13

e.g.	eyes open to speech	3
	confused or inappropriate	3 – 5
	localises - abnormal flexion	3 – 5

Mild Head Injury GCS 14 – 15

e.g.	eyes open spontaneously	4
	confused	4
	obeying commands	6

The adult scale is not applicable to children under 5 years of age, whose responses must be gauged against the norms for age.



Reilly PL, Simpson DA, Sprod R, Thomas L, Assessing the Conscious Level in Infants and Young Children: A Paediatric Version of the Glasgow Goma Scale, Children's Nervous System 4: 30-33, 1988

CT HEAD SCAN

Indications

Except for an uncomplicated minor head injury, ideally all patients should have a CT scan. Definite indications are:

- GCS <9 after resuscitation
- Neurological deterioration eg. 2 or more points on the GCS, hemiparesis
- Drowsiness or confusion (GCS 9–13 persisting >2 hours).
- Persistent headache, vomiting
- Focal neurological signs
- Fracture – known or suspected
- Penetrating injury – known or suspected
- Age over 50 years
- Post-operative Assessment
- Epileptic seizures
- Other risk factors such as the use of anticoagulation

Notes

- CT scanning may require a transfer to another facility. If the transfer is over a significant distance then discussion with the neurosurgical service should be considered before transfer
- Rapid neurological deterioration may require an immediate operation rather than the risk of delay in transferring to another hospital for a CT scan.
- Lesions may develop after an initial normal scan and the scan should be repeated if neurological deterioration occurs.
- A post-operative scan will demonstrate adequate removal of the haematoma, re-accumulation or the development of a new lesion.

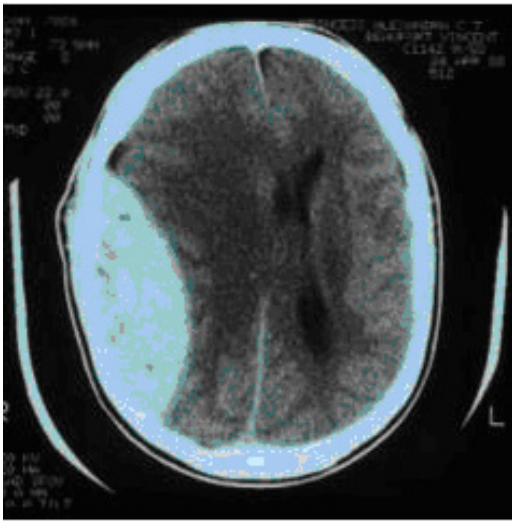


Figure 1A

An extradural haematoma with midline shift and compression of the ipsilateral ventricle. There is a small overlying scalp haematoma.

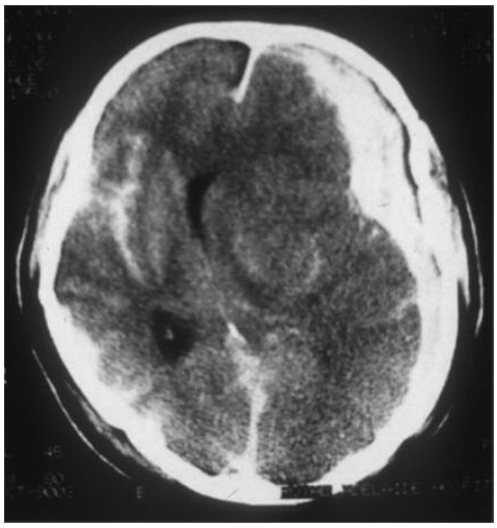


Figure 1B

A crescentic acute subdural haematoma. There is subarachnoid blood and marked midline shift. The opposite ventricle has enlarged.

SKULL XRAY INDICATORS

Figure 2A

Lateral
An irregular fracture runs posteriorly becoming thinner. The fracture line is not in the position of a suture or a vascular groove.

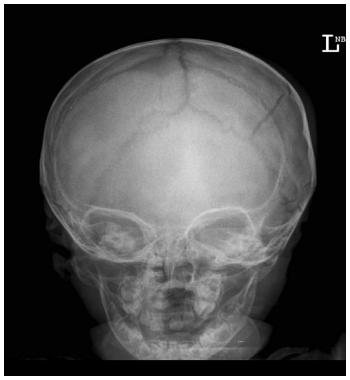


Figure 2B

Anteroposterior
The left parietal fracture line runs into the lamdboid suture.

Figure 2C

Towne's
The best view for showing the occipital bone.

In rural areas where a CT scan is not readily accessible, a plain skull xray can provide important information. The views required are lateral, anteroposterior and Towne's and a view tangential to the point of impact to show a depressed fracture.

Indications

- Loss of consciousness or amnesia
- Persisting headache
- Focal neurological signs
- Scalp injury
- Suspected penetrating injury
- CSF or blood from nose or ear
- Palpable or visible skull deformity
- Difficulty in clinical assessment
  - alcohol or drug intoxication
  - epilepsy
  - children
- Patients with GCS = 15, who are asymptomatic but "at risk" because of a direct blow or fall onto a hard surface, especially in a patient over 50 years of age.

A skull xray is useful for triage assessment.

- A skull fracture is associated with an increased risk of intracranial haemorrhage and a CT scan is indicated.
- Compound fractures, including fractures of the base of skull, are associated with an increased risk of infection.
- A depressed fracture increases the risk of epilepsy especially if associated with dural penetration.
- A fracture indicates the site for surgery particularly in a rapidly deteriorating patient in whom an extradural haematoma is suspected.
- The presence and volume of pneumocephalus is a consideration in aerial transport.

STAGE 4: DEFINITIVE CARE

DEFINITIVE CARE CONSIDERATIONS

This stage may require transfer to a major trauma service.

Fractures should be stabilised and any internal haemorrhage from the abdominal or thoracic cavities should be controlled before transfer.

Intravenous or subcutaneous narcotics may be used for the relief of pain however it is important to be aware that restlessness in a confused or drowsy head injury patient may be a sign of increasing intracranial pressure and requires urgent investigation and treatment.

CRITERIA FOR ADMISSION TO HOSPITAL

Patients should be admitted for continuing observation and management for the following reasons:

- Confusion or any other impaired level of consciousness
- Neurological symptoms or signs - including persistent headache or vomiting
- Difficulty in clinical assessment - eg due to alcohol or epilepsy
- Other medical conditions – eg coagulation defects, (especially anticoagulant medication), diabetes mellitus
- Skull fracture
- Abnormal CT brain scan
- Responsible observation not available outside the hospital
- Age – patients over 50 years of age
- Children (see Paediatric Head Injury, Page 21)

Note

If the loss of consciousness was brief (less than 5 minutes), none of the criteria for admission apply and more than 4 hours has elapsed since impact, the patient can be observed at home. The patient must be in the care of a responsible adult who is able to detect increasing headache and/or drowsiness and arrange urgent re-admission. All patients discharged after head injury must be given appropriate verbal and written discharge instructions.

CRITERIA FOR NEUROSURGICAL CONSULTATION

The indications for a neurosurgical consultation are:

- Skull fracture and confusion, decreased level of consciousness, epilepsy or any other neurological symptoms or signs
- Coma (GCS <9) continues after resuscitation
- Deterioration in neurological status such as worsening in conscious state (>2 points on GCS) fits, increasing headache or new CNS signs
- Confusion or other neurological disturbance (GCS 9–13) after > 2 hours with no fracture
- Compound depressed skull fracture
- Suspected base of skull fracture such as blood and/or clear fluid from nose or ear, periorbital haematoma or mastoid bruising
- Penetrating injury – known or suspected
- Abnormal finding on CT Scan - Minor focal contusions or subarachnoid haemorrhage increases the risk of later deterioration but after consultation with the neurosurgical service may be managed on site

INDICATIONS FOR TRANSFER TO A NEUROSURGICAL SERVICE

The indications and timing of admission to a neurosurgical unit should be decided in consultation. The specific indications are:

- GCS <9
- Deterioration in GCS of 2 or more points
- Focal neurological signs
- Penetrating injury
- Depressed fracture
- Compound fracture
- Persistence of: headache, vomiting or confusion (GCS 9–13) > 2 hours post admission

WHAT THE NEUROSURGEON WILL NEED TO KNOW

- Name and age of patient
- Mechanism and time of injury
- Cardiorespiratory status
  - Blood pressure, pulse rate
  - Respiratory rate
  - Oxygenation saturation (if available)
- GCS (preferably a description of the specific responses)
- Pupillary responses
- Motor pattern
- Alteration in baseline observations
- Non cerebral injuries
- Results of investigations
- Relevant previous medical conditions, medications or allergies
- Referring doctor, location and return phone number

TRANSPORT AND RETRIEVAL

The timing and method of transport, the personnel and equipment required will depend on the neurological state, injuries to other systems and cardiopulmonary stability. This should be arranged through the relevant integrated transport and retrieval system.

Non deteriorating patients with depressed and compound skull fractures do not require urgent on-the-spot surgery and can be transferred to the neurosurgical service.

See page 29 for regional retrieval services.

MANAGEMENT OPTIONS FOR A DETERIORATING PATIENT WITH SUSPECTED INTRACRANIAL HAEMORRHAGE

Brain compression due to an extradural haematoma (EDH) or other expanding intracranial haematomas is surgically remediable but the diagnosis may be difficult. The ”classical” picture of delayed deterioration after a lucid interval occurs in less than 50% of cases of EDH and is less common in other intracerebral haematomas: some patients are unconscious from the time of injury and others never lose consciousness.

Deterioration is defined as a decrease of GCS by 2 or more points, or pupillary enlargement.

Two courses of action are possible in this situation:

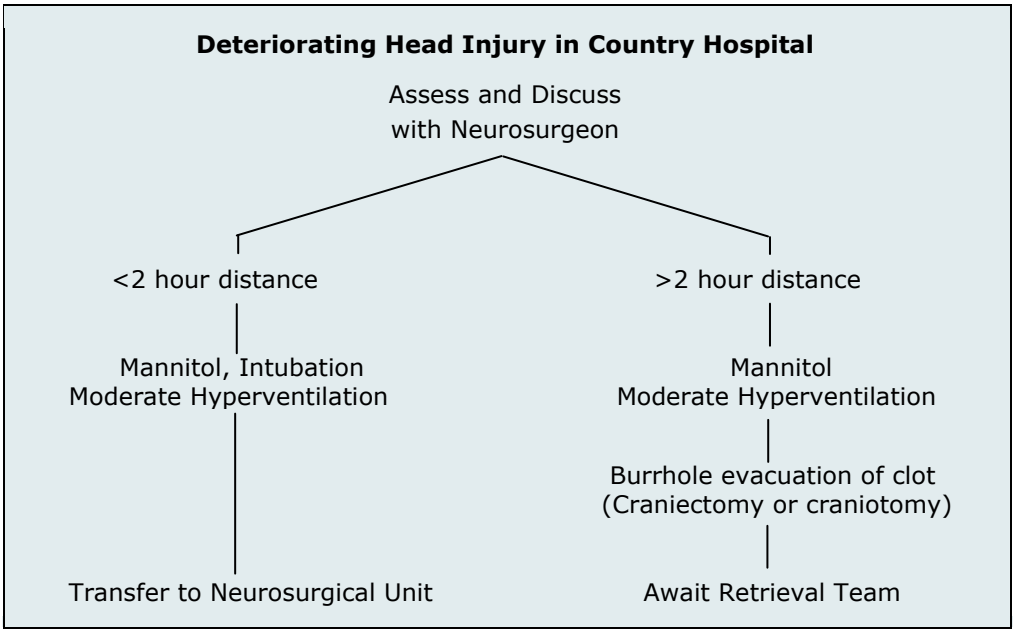
1. Transfer to a neurosurgeon within two hours, stabilising the airway and administering IV Mannitol, 20% solution, (1 Gm/kg body weight). Hypertonic saline is an alternative (see page 20).

2. If transfer will take longer than two hours burrhole exploration on site by the country practitioner or general surgeon in a regional hospital where neurosurgery is not available. In some situations, it may be possible to arrange for a neurosurgeon to travel with a retrieval team to complete the operation.

The decision made with neurosurgical consultation is based on:

1. Estimated transfer time
2. Clinical state – level of consciousness and pupillary size and light reflex
3. Rate of deterioration
4. CT scan (if available) or xray of skull
5. Level of surgical experience and range of neurosurgical equipment available at the regional hospital

Transfer of the relevant CT image can be made via a mobile phone or with mobile camera image in a JPEG format via the internet. Dedicated teleradiology systems may be available but the most important information is conveyed in the telephone conversation with the neurosurgeon.



Reference: Adapted from Extradural Haemorrhage: strategies for management in remote places, Simpson et al – Injury (1988) 19, 307-312

EMERGENCY SURGICAL TREATMENT

THE SIDE OF SURGERY

In the absence of a CT scan the side and site of the extradural haematoma is often indicated by:

1. Bogginess of the overlying scalp, local scalp injury or a fracture on skull xray.

2. Dilated pupil which occurs most often ipsilateral to the haematoma. If present, it is the most reliable guide to the side of surgery. This is usually a late sign and it is preferable to diagnose EDH before this occurs.

3. If there is no localising information such as scalp bogginess, fracture or pupillary dilatation, the known probabilities of EDH distribution can be used to find the clot. The majority (73%) are temporal, and 11% are frontal or subfrontal. Therefore the first burrhole should be placed low down in the temple just in front of the ear. If no clot is found at this site a frontal and then parietal burrhole should be made. If still negative, the other side should be explored.

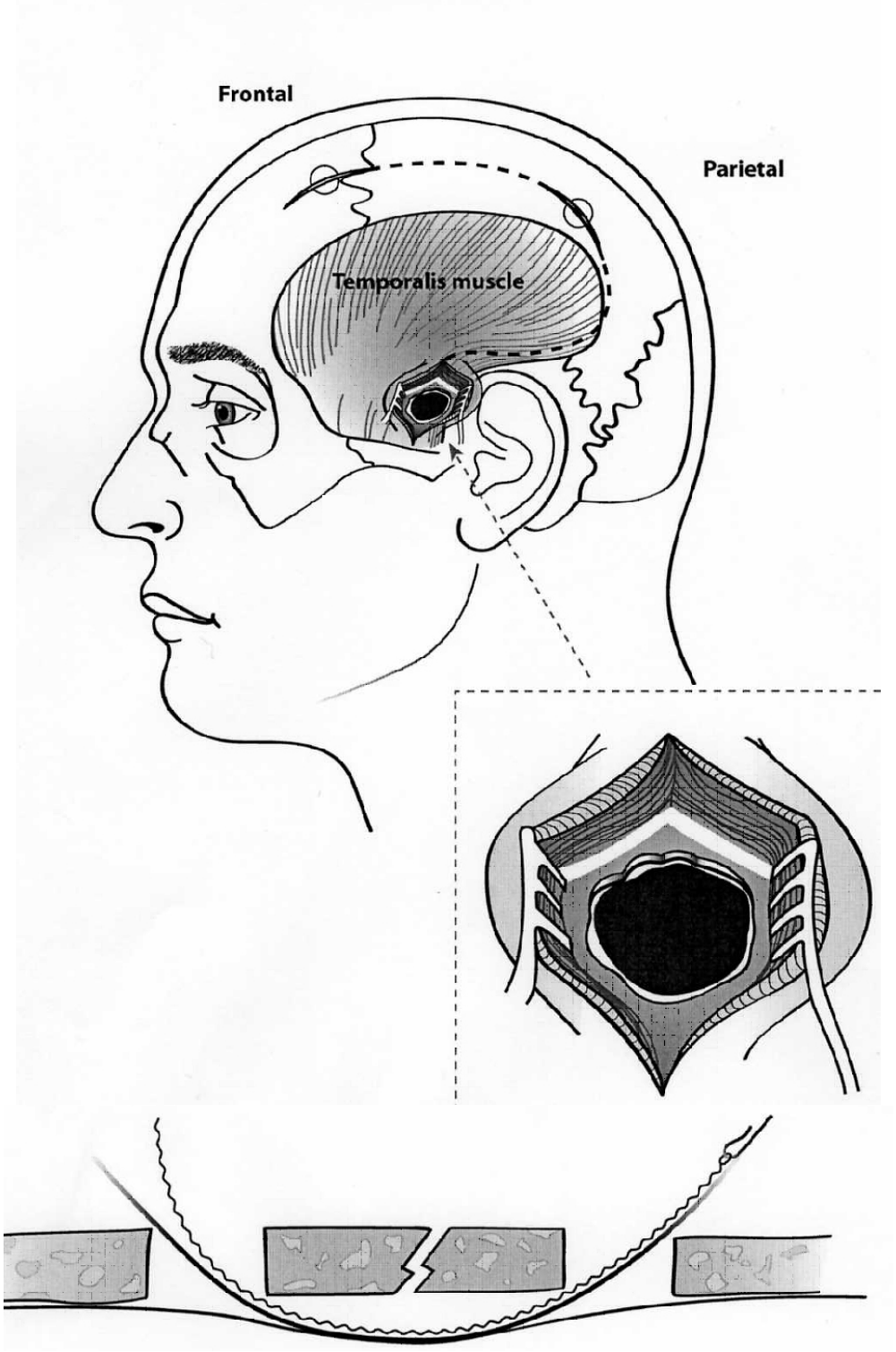


Figure 3 - Surgery for Extradural Haematoma

A) An initial temporal burrhole can be enlarged by craniectomy (insert). Other burrholes may be made in the frontal and parietal sites with the incisions placed so that they can be converted to a craniotomy flap if necessary (dotted line). The burrholes may be joined by a Gigli saw (see text).

TECHNIQUE

1. The scalp is infiltrated with 0.5% solution Lignocaine or 0.5% Bupivacaine . Adrenaline 1:200,000 is useful but not essential.

2. The scalp is incised and bleeding controlled with artery forceps placed on the galea and turned outwards to evert the galea or alternatively with Raney scalp clips.

3. The temporalis muscle is incised with cutting diathermy and held open with a self retaining retractor. The skull is then penetrated with a perforator and the conical opening enlarged with a burr. The Hudson brace should not be pressed hard into the temporal bone as it may plunge through.

4. The extradural haematoma usually has a significant proportion of semisolid clot, which cannot be evacuated through a single burrhole.

5. If the extradural haematoma is a solid clot the bone overlying the haematoma must be removed (ie unroofed) by nibbling it away. This is called a craniectomy. The haematoma can then be removed by suction under vision.

6. If the surgeon has the skill and equipment to turn a flap, this is preferable to nibbling the bone. It is better to use power tools if available and the surgeon is experienced with a craniotome, rather than Gigli saw (Fig 3b). The Gigli saw may waste precious time in the hands of an inexperienced operator. The cuts with the Gigli are slanted outwards creating a bevel so that the replaced bone flap does not sink. Bleeding from the bone edge is readily controlled with bone wax.

7. The dura should be seen to come up to the skull in each aspect of the wound. Bleeding points on the dura are coagulated with diathermy (bipolar is preferred, if available). Under-running the bleeding point with a suture (silk, vicryl or prolene) is an alternative.

8. Oozing from the dura can be controlled by hitching or "tenting" the dura to temporalis muscle or pericranium taking care not to penetrate the full thickness of the dura with the needle (curved, non-cutting). If oozing remains a problem, a suction drain should be placed in the extradural space and the wound closed.

9. If the bleeding is well controlled and there is no significant brain swelling the bone flap if cut may be replaced. Dural hitching stitches through its centre help to prevent extradural blood accumulating. If there is any doubt about haemostasis the bone flap should be left out, placed in a sterile container of antibiotic solution (eg flucloxacillin 1 Gm/litre) and sent with the patient. Alternatively it may be placed in the wound without being attached.

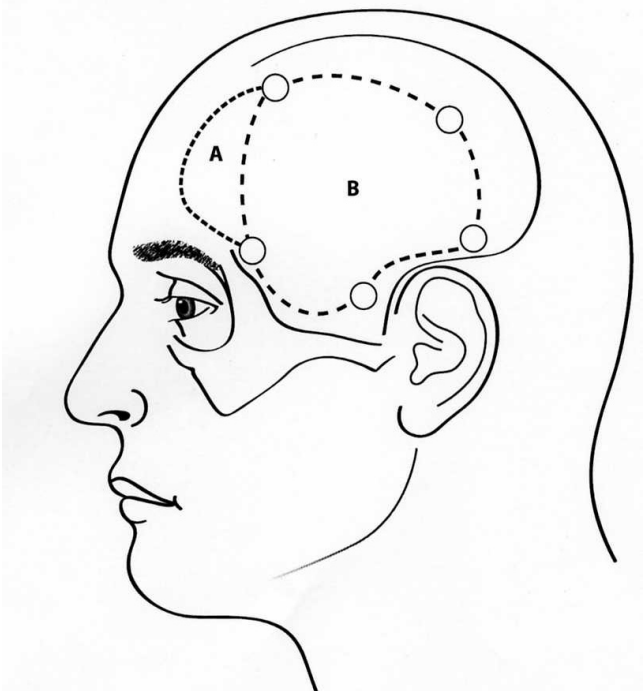


Figure 4 – Bone Flap Position

Burrholes for a planned lateral craniotomy as used for an acute subdural haematoma. The bone flap may be taken frontally (A) depending on the position of the clot.

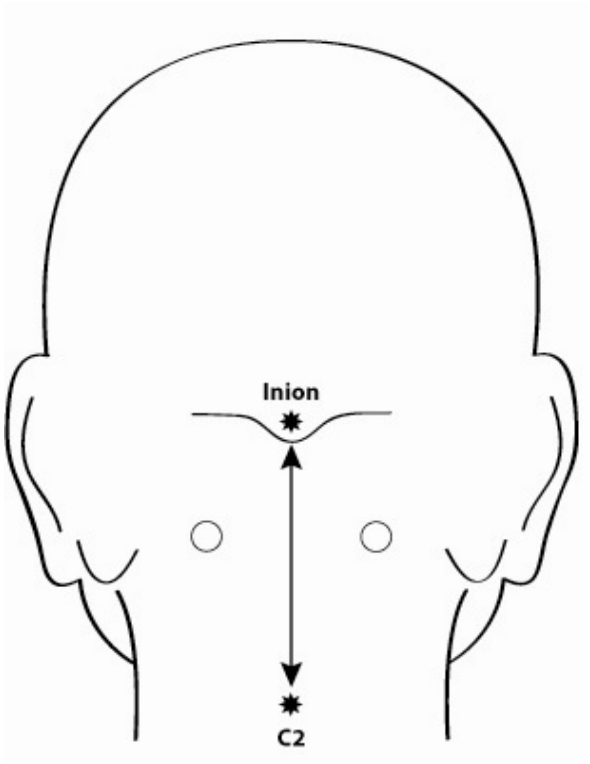


Figure 5 – Posterior Fossa Craniectomy

A posterior fossa craniectomy is rarely required in a rural setting. If it is performed under guidance from a neurosurgeon the landmarks for the initial burrholes are shown: the external occipital protuberance or inion, the midline from the external occipital protuberance to the spine of C2 and the mastoid processes. A midline incision exposes the occipital bone and a burrhole craniectomy is performed.

SURGERY FOR AN ACUTE SUBDURAL HAEMATOMA

The surgical procedure becomes more complex if the dura is opened, however evacuation of subdural blood, indicated by blue bulging dura may be advised under neurosurgical guidance. This operation involves removing more bone by nibbling or turning a flap (Fig 4). Multiple 1 cm incisions through the exposed dura often allow the underlying subdural blood to be drained without exposing the bulging brain. If a bone plate is cut it should not be replaced but transferred with the patient as noted above or placed in the subcutaneous fat of the abdominal wall.

INSTRUMENTATION

Adequate lighting, suction and diathermy are essential. Basic instruments required:

1. Hudson brace, perforator and burr.
2. Gigli saw blades, handle and guide
3. Bone wax.
4. Bone nibblers: Horsley and Pennybacker.
5. Malleable brain retractors.
6. Scalpels with No.10 & 15 blades.
7. Forceps: plain dissecting, toothed.
8. Periosteal elevator. sharp and smooth.
9. Brain needle with stillette.
10. Sharp dural hook.
11. Adson’s forceps.
12. Dural scissors (fine, blunt nosed curved tips).
13. Special curved artery forceps or Raney clips (if available).

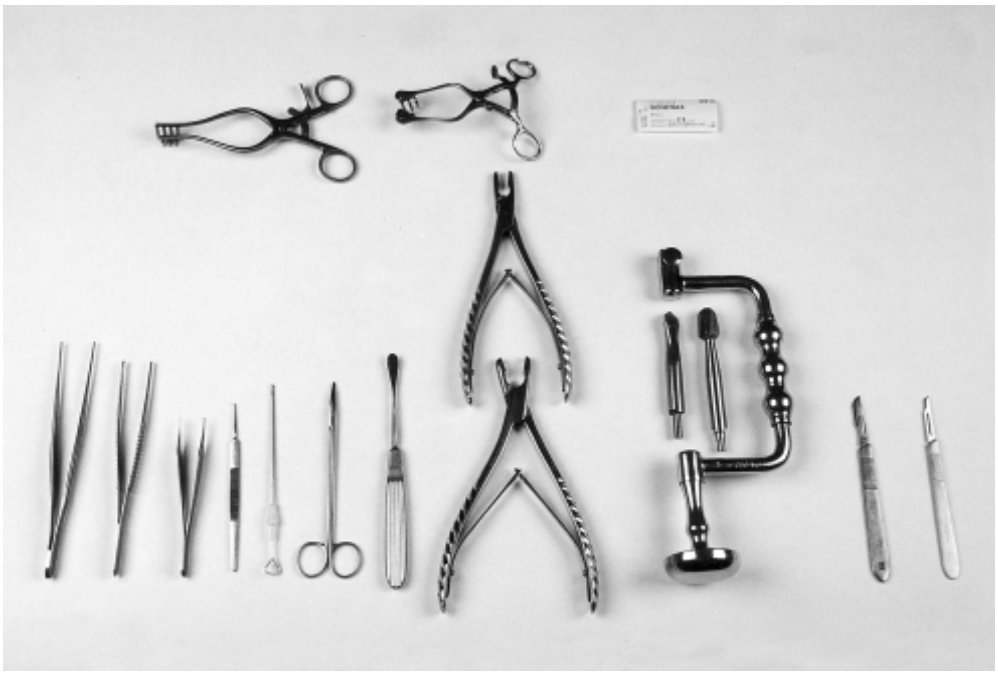


Figure 6 - The Basic Craniectomy Tray

COMA MANAGEMENT– NEUROLOGICAL DETERIORATION

INTUBATION AND VENTILATION

Intubate and ventilate with a Glasgow Coma Score <9.

It is essential to avoid hypoxia and hypercarbia. Hyperventilation ($PaCO_2$ below 30 mmHg) should be avoided. $PaCO_2$ should be maintained at 35-40 mmHg. Ventilation parameters should be based on blood gas analysis when available or pulse oximetry.

Ventilation Rates	Individual	BPM (breaths per minute)
Normal	Adult	10
	Children	20
	Infants	30
Hyperventilation	Adults	20
	Children	30
	Infants	35-40

Cerebral Perfusion Pressure

Hypotension (systolic blood pressure <90mmHg) must be avoided. A mean arterial pressure >90mmHg should be achieved as soon as possible. Recommended systolic blood pressure for age:

Age	mmHg
0-1	>65
2-5	>75
6-12	>80
13-16	>90

INTRAVENOUS FLUIDS AND ELECTROLYTES

Normovolaemia is the goal. Maintenance fluids should replace pathological losses avoiding both dehydration and over hydration. Isotonic crystalloids are recommended.

Serum electrolyte measurements should be undertaken early.

ACTIVE TREATMENT OF RAISED INTRACRANIAL PRESSURE

Active treatment should only be undertaken if there is evidence of neurological deterioration due to intracranial causes indicated by:

- Progressive neurological deterioration (GCS decreased by 2 points)
- Extensor posturing
- Asymmetrical, dilated or nonreactive pupils

Before taking active measures remedial extracranial causes for deterioration should be excluded, such as:

- Poor head or neck position
- Restricting neck ties
- Inadequate sedation
- Hypoxia due to underventilation

Treatment steps

1. Hyperventilate to 30mmHg $PaCO_2$ for 5-10 minutes, ceasing if the signs resolve.

2. Intravenous 20% mannitol. If the volume status is adequate then mannitol as a bolus infusion should be given and arrangements made to transfer the patient urgently to a neurosurgical unit.

   Dose: 0.5 to 1gm/kg body weight over 20 minutes. Fluid loss through diuresis should be replaced concurrently. Hypertonic saline is an alternative to mannitol. Dose:6 to 8 ml/Kg of 3% solution, or 4ml/Kg of 7.5% solution.

   The extended and repeated use of mannitol may aggravate cerebral oedema, and the repeated use of hypertonic saline or mannitol may be associated with electrolyte abnormalities, especially hypernatraemia. Hypertonic saline has also been used for resuscitation instead of isotonic crystalloid however it is not yet clear whether this has an advantage.

Head Posture

The head should be elevated to 20-30^{o} provided the patient is adequately volume resuscitated.

Corticosteroids

These are not recommended.

TRANSFER TO CT AND/OR NEUROSURGICAL UNIT

All patients with severe head injury should have a CT scan as soon as possible. The decision when and if to transfer the patient to a neurosurgical unit will depend on the nature of the primary injury, CT scan findings and the presence of neurological deterioration.

Early telephone communication with a neurosurgical unit should be established.

PAEDIATRIC HEAD INJURY

The patterns and the principles of management of head injuries in children are similar to those of adults but there are important differences. These relate to the developmental level of the child, anatomic features of the head and the response of the child's brain to a traumatic insult.

Special Points

1. In the young child it is not possible to employ the Glasgow Coma Scale for adults. A modified scale is adopted for infants and small children, recording the vocal response to stimulus (page 9). Fluctuation in the responses is often marked in children and an isolated recording on the chart may be misleading.

2. It is often difficult to decide whether or not there was loss of consciousness at the time of the impact. Concussion may be very brief and not appreciated by observers.

3. Persistent headache and vomiting in a child should be considered as indicating raised ICP until proven otherwise.

4. Blunt trauma to a child's head may be followed within a short period by the development of acute brain swelling. This may follow what appeared to have been a relatively minor head injury and may lead to rapid and profound decline in the conscious state. Acute brain swelling can only be diagnosed after a mass lesion is excluded by a CT scan. Brain swelling is treated by a period of ventilation and often ICP monitoring. Usually full recovery occurs.

5. An epileptic fit is more common in children after a relatively minor head injury. The immediate decline in the conscious state following such an episode confuses interpretation of the severity of the head injury. The child should have a CT scan to ensure that there is no intracranial haemorrhage.

6. An early seizure within one hour of the injury does not carry the same risk of late post traumatic epilepsy as in an adult. In general if the child makes a rapid and full recovery following a fit, there is no indication for anticonvulsant medication.

7. The thinness of the scalp and skull in a young child increases the risk of damage of the brain by penetration. Any puncture wound over a child's head must raise concern regarding the likelihood of penetration to the underlying brain. The entry wound must be carefully inspected for signs of fracture, discharge of CSF or cerebral tissue. If there is still doubt, it is imperative that a CT scan be undertaken to assess the extent of damage at that site. A referral to a neurosurgeon is required for repair of the defect. Penetration of the brain through the orbital roof or nose of the child may easily be overlooked.

8. The physical characteristics of a child's skull increase the likelihood of local injury. Depressed fractures, either simple or compound, are more common and may be associated with local damage to the underlying brain. The energy of impact may be substantially absorbed at the site of trauma minimising the acceleration effects on the brain. Even without loss of consciousness there may be severe focal injury. A plain skull xray, particularly a tangential view, may show the extent of the bone injury and a CT scan will show in addition, whether or not there is injury to the underlying brain.

9. The elasticity of the skull of a small child permits considerable deformation after impact without a fracture. The deformation may cause local injury to the brain or injury to the meninges resulting in an extradural haematoma. Hence the absence of a fracture in a child does not exclude the possibility of a haemorrhage.

10. Blood loss is of considerable importance in small children and infants. Circulating blood volume may fall dramatically from bleeding from a wound, bleeding into a scalp haematoma (particularly if subgaleal) or intracranial haematoma. In small infants with expansile skulls, intracranial haematomas may become extremely large. It is particularly important to realise that the blood pressure may be maintained as a response to raised intracranial pressure. With sudden reduction of raised intracranial pressure at surgery blood pressure may fall precipitously. It is essential in the small child when planning to undertake surgery of this type that immediate steps are taken to obtain blood for transfusion – in an emergency O-Neg blood may be necessary. Blood transfusion should be in place at the time of operation.

11. The brain of a small child is more likely to swell following blunt trauma and it is imperative not to over infuse such a patient. As in adults intravenous fluids should replace estimated existing losses. Delayed brain swelling may cause sudden unexpected deterioration and observation of the young child in hospital for 24hrs after minor injury is advisable.

12. In infancy the fontanelle is a most useful guide in assessing the intracranial pressure. The state of the fontanelle should be described to the assessing neurosurgeon.

13. There is a significant incidence of non-accidental injury. It is important to know that the history provided may be incorrect and mislead the assessing surgeon as regards the severity of an intracranial insult. The presence of retinal haemorrhages, subdural haemorrhage(s) and bilateral skull fractures suggests a non-accidental injury. Healing fractures in the limbs, cutaneous bruises and burns may also be present.

14. CT scanning may be difficult in a child. A general anaesthetic is preferable to sedation in the acute situation.

Notes

The assessment of small children with head injury is often difficult and consultation with a neurosurgeon is recommended at an early stage. The deteriorating child requiring transfer to the neurosurgical centre must be intubated by a person experienced with this age group. Over hydration must be avoided.

If the child's condition is such that transfer is not feasible the surgical principles outlined for the treatment of adults must be followed with the proviso that blood for transfusion should be obtained as soon as possible and available at the time of evacuation of the haematoma. After surgery the child should be transferred to a neurosurgical unit by an appropriately skilled retrieval team.

SPINAL INJURY

PREHOSPITAL MANAGEMENT

Always consider spinal injury in the unconscious patient, especially injury to the cervical spine or thoracolumbar junction.

1. Rapid clinical assessment

- Respiratory pattern – is the breathing only diaphragmatic?
- Voluntary movement and sensation in the limbs

2. Extrication from vehicle

- Maintain spinal alignment, especially avoiding flexion or rotation
- Avoid movements which increase pain
- If cervical injury is suspected apply a cervical collar or substitute (eg rolled up jacket).

3. Transport to primary hospital

- CPR takes precedence.
- Immobilisation
  - rigid cervical collar
  - sandbags and straps as needed
  - spine board
  - log roll for turns
- Position
  - if conscious, place supine
  - if unconscious, clear and control airway. Place in lateral position with neck immobilised. Protect airway from obstruction and inhalation.
- Give supplemental oxygen

PRIMARY HOSPITAL MANAGEMENT

1. Continue immobilization

2. Resuscitation

- Maintain airway and oxygenation. If intubation is required, nasotracheal intubation is preferable if possible.
- Avoid hypotension. Maintain systolic BP >90mm Hg. Differentiate between neurogenic shock and hypovolaemic shock (see following table).

3. More detailed evaluation

- History (mechanism of injury) and neurological symptoms
- Palpation of spine for tenderness or step
- Neck control, if conscious, by ability to lift head unaided
- Motor level assessment
  - voluntary limb muscle groups
  - rectal examination – voluntary and reflex sphincter contraction
- Sensory level assessment
- Evaluation of reflexes
  - muscle stretch reflexes
  - abdominal cutaneous reflexes
  - cremasteric
  - bulbocavernosus
  - anal cutaneous
- Evaluation of autonomic dysfunction
  - altered perspiration below lesion
  - priapism
  - urinary retention

4. Radiographic evaluation (see below)

5. Methylprednisolone

- This is not recommended

6. Nasogastric tube

7. Urinary catheter

8. Maintain normothermia (temperature regulation may be lost)

9. Lift or log roll two hourly to avoid pressure areas

10. Suspect other injuries

For example:

- Head injury.
- Haemopneumothorax or ruptured aorta with thoracic spine injury.
- Ruptured abdominal viscus with thoracolumbar injury. Particularly consider duodenal pancreatic or other retroperitoneal injury from lap seatbelt injury.

NEUROGENIC SHOCK

Clinical features	Cervical or high thoracic spinal cord injury Hypotension Bradycardia (tachycardia in hypovolaemic shock) Preserved urinary output Warm extremities
Treatment	Trendelenberg position Cautious fluid replacement Inotropes if necessary to maintain systolic BP > 90 mmHg

RADIOGRAPHIC EVALUATION

1. Unconscious patient

- Lateral cervical spine Xrays MUST VISUALISE TO T1/T2. "Swimmer's" view may be necessary, or
- CT scan of the spine segments under consideration.
- Thoraco-lumbar spine AP and lateral, depending on mechanism of injury.

2. Conscious patient complaining of neck pain

- AP, lateral, oblique and odontoid views. MUST VISUALISE TO T1/T2. "Swimmer's" view or helical CT scan may be necessary in some patients.
- If patient continues to complain of neck pain over subsequent days/weeks, especially if muscle spasm restricts movement on initial Xrays refer to spinal injury centre for evaluation.
- CT of injured segments.

3. Conscious patient complaining of back pain

- AP and lateral Xrays of the thoracolumbar spine and pelvis
- CT scan of burst fractures or other fractures where compromise of the spinal canal is suspected
- Consider oral contrast CT of upper gastrointestinal tract if duodenal injury is suspected

MR is performed in the spinal injuries centre when fractures are seen on CT and is used to aid the decision as to whether surgery is required and for the surgical planning.

Note

Dynamic scanning is not recommended. If instability is considered possible the patient should be transferred to a spinal injury unit for evaluation by helical CT scanning.

MOST APPROPRIATE HOSPITAL FOR ADMISSION

All patients with proven or potential spinal injury should be admitted.

- Local/district hospital – for pain from soft tissue injury +/- uncomplicated spinal fracture.
- Major neurosurgical/orthopaedic referral centre
  - for minor spinal cord or nerve root injury
  - complex spinal fracture, with sphincter function preserved
  - suspected instability
  - patients with multi trauma
- Dedicated Spinal Injury Unit
  - significant or deteriorating spinal cord function
  - cauda equina or nerve root injury or with sphincter disturbance

CRITERIA FOR CONSULTATION

The acute spinal service should be contacted if there is:

- Evidence of spinal cord or nerve root damage
- Concern regarding spinal stability

MANAGEMENT OF MODERATE HEAD INJURY

GENERAL PRINCIPLES

Most patients who sustain a moderate head injury (GCS 9–13) do not require transfer to a major trauma or neurosurgical unit; however they do require admission to hospital.

All patients who sustain a moderate head injury should, where possible, undergo an urgent CT scan of the brain. Their management should be discussed with the regional neurotrauma service and the teleradiology should be available for image review.

Particular attention needs to be directed to patients with:

- multiple system trauma
- age > 50 years
- children
- patient with a high risk of deterioration eg on anticoagulation

1. Primary Survey

- A - Airway
- B - Breathing
- C - Circulation
- D - Disability: neurological
- E – Exposure

2. Resuscitation

- Management of life-threatening conditions

3. Secondary Survey

- Examination of each region with particular reference to the chest, face and neck
- Xrays: chest and cervical spine and pelvis
- Blood alcohol estimation

4. Definitive Care

- Definitive neurosurgical management (see below)
- Comprehensive management
- Fracture stabilisation
- Surgery
- Stabilise for transfer

5. Radiological Intervention

If the CT Scan is available and is normal

- Continue regular observations
- Repeat the CT scan according to clinical indications

If the CT Scan is available and is abnormal

- Neurosurgical consultation, using teleradiology if available
- If there is a haematoma or other surgical condition – operate or transfer to the neurosurgical unit according to the criteria set out on pages 13 and 14.
- If surgery is not required

    - repeat scan after 24 to 36 hours to exclude a delayed intracranial haematoma
    - treat other injuries according to priority

- Transfer to a neurosurgical centre for ICP monitoring and management if:

    - prolonged anaesthesia necessary
    - ventilation necessary for any cause eg. multitrauma
    - CT scan shows worsening

If the CT Scan is not readily available (rural or remote location)

- Skull xray – presence of a fracture increases the probability of intracranial pathology, particularly a haematoma
- Neurosurgical consultation and/or transfer if:

    - No improvement in the neurological level >2 hours after establishment of the post resuscitation GCS
    - Deterioration of post resuscitation GCS by 2 or more points at any time

Modified from The Early Management of Severe Trauma Manual, National Road Trauma Committee, Royal Australasian College of Surgeons, AH Massma & Co, Melbourne, 2008

MINOR HEAD INJURY

A minor head injury is defined as by a GCS of 14 – 15. Admit and observe the patient if:

- there has been loss of consciousness or a period of post-traumatic amnesia – see comment below
- the patient remains confused
- the patient is under 5 or over 50 years of age
- focal neurological signs
- severe headache with or without vomiting

DISCHARGE OF A PATIENT AFTER A MINOR HEAD INJURY

Criteria:

- orientated in time and place
- no focal neurological signs
- no headache or vomiting
- no skull fracture
- a responsible person is available to continue observation of the patient

Discharge check list – advise to report back to hospital immediately if:

- vomiting
- severe headache or dizziness
- becomes restless, drowsy or unconscious
- has a convulsion or fit

Comment

It is common for a patient with a minor head injury to have amnesia for the incident and for a short period of time afterwards. This should not necessitate overnight admission unless other factors mentioned above are present after observation for 4 hours in the Emergency Department.

SPECIAL ISSUES

PREVENTION OF INTRACRANIAL INFECTION

Intracranial infection

This can result from a basal skull fracture or from a compound craniocerebral injury. CSF rhinorrhoea or otorrhoea, intracranial aerocele or a known or suspected penetrating injury require careful assessment. A neurosurgical consultation is indicated.

Immediate management

1. CSF rhinorrhoea or otorrhoea – swab for culture and sensitivity and observe.
2. Intracranial aerocele - observe unless marked brain displacement and impaired conscious level.
3. Penetrating craniocerebral injury – early neurosurgical repair.

Comment

The use of prophylactic antibiotic therapy remains controversial and may be regarded as optional. If prophylactic antibiotic therapy is given, a combination of Trimethoprim and an antibiotic of the Penicillin group is a logical choice.

RESTLESSNESS AND ANALGESIA

Before prescribing analgesia, it is important to determine the cause of restlessness eg cerebral hypoxia from airway inadequacy, poor ventilation or poor perfusion, raised intracranial pressure, pain, alcohol intoxication or a full bladder. Drugs other than paracetamol or codeine phosphate require neurosurgical consultation.

Comment

In the multiple injured patient who requires pain relief (other than for headache), small incremental doses of a short acting narcotic may be used provided the patient is observed constantly and monitored.

POST-TRAUMATIC EPILEPSY

The risk factors for epilepsy are intradural haematomas, dural laceration with cortical injury, depressed fractures, a post-traumatic amnesia period of 24 hours or early post-traumatic epilepsy.

Prophylactic anti-convulsant therapy in closed head injury is usually not indicated beyond the first week. A neurosurgical consultation is indicated if fits occur and for general advice about prophylactic anticonvulsant therapy.

Comment

Prophylactic anti-convulsant therapy:

1. In the conscious patient, oral phenytoin 400mg as a stat dose, 400mg in 12 hours followed by 300mg nocte, monitored by serum phenytoin level.
2. In the unconscious patient, intravenous phenytoin 1 Gm (<50 mg/min) continued as 100mgm 8 hourly.

Status Epilepticus

This is defined as the occurrence of two or more generalised tonic-clonic seizures without a return to consciousness between seizures.

Guideline

1. Support airway – may need intubation but only if skilled personnel available.
2. Support the circulation.
3. Take blood for glucose, electrolytes, calcium and blood gases.
4. Give 50ml of 50% glucose IV.
5. IV Diazepam 2–4mg/min until seizure stops or to a total of 30mg.
6. Slow IV infusion of Phenytoin (< 50mg/min) to a total of 20mg/kg body weight.
7. Slow IV injection of Clonazepam 1mg. This may be repeated intravenously or by slow infusion until controlled.
8. General anaesthesia.

Comment

The extent of therapy depends upon the response at each stage of treatment and upon medication and facilities available. Should intubation not be performed initially, it is important to monitor for respiratory depression from IV Diazepam.

SCALP WOUNDS

For the treatment of scalp wounds:

1. Shave at least 3cms around the wound.
2. Gently palpate the laceration with a gloved finger. This may provide information regarding the presence of an underlying fracture.
3. If a fracture is found unexpectedly, do not remove bone fragments. Contact the neurosurgical service immediately.
4. Scalp wounds may bleed profusely and cause hypotension, particularly in children. Secure haemostasis by pressure or early suturing.
5. If the wound edges are badly torn, excise nonviable scalp and where possible suture the scalp in two layers.

POST CONCUSSIONAL SYMPTOMS

After mild head injury about 50% of patients suffer a range of post concussional symptoms. These are commonly headache, dizziness, irritability, poor concentration, fatigue and anxiety. Persistent headache may require a CT to ensure that there is no intracranial clot. Most post concussional symptoms recover within a few months. There is no specific treatment but the patients should be reassured and treated symptomatically. Patients whose symptoms do not resolve may need referral to a neurosurgeon or a rehabilitation service.

NURSING MANAGEMENT

PRIMARY SURVEY

- Airway management: maintain cervical spine in neutral position
- Breathing
- Circulation
- Neurological Assessment:
  - Baseline assessment including Glasgow Coma Scale (GCS)
  - Pupils size, equality and reactivity to light
  - Check movement, power in all limbs
- Blood pressure, pulse, temperature and respirations

MANAGEMENT

1. Oxygen

2. Treat hypotension

3. Ongoing assessment

- Frequent serial assessment of GCS and vital signs
- Report changes in GCS of 2 points, or GCS less than 9, to medical officer
- Report new motor deficits or any change in pupillary size, equality or reactivity to light

4. Fluid management

- Check with medical officer if a pelvic or urethral injury is suspected
- Insert urinary catheter, unless contraindicated
- Maintain fluid balance

5. Intra-gastric tube

- Check with medical officer before inserting as fractures of the base of skull or facial bones may be present

6. Positioning

- Maintain cervical spine alignment until spinal injury has been excluded. The patient is lifted as for a spinal injury. A stiff neck collar is fitted and maintained until a spine injury has been excluded.
- Head of the bed is elevated 20° – 30° once hypotension has been treated
- Unconscious, non intubated patients in whom a spinal injury has been excluded are nursed in the lateral position with the spine in alignment

7. Confused patients

- Give oxygen therapy
- Avoid sedation as this will mask neurological changes
- Close supervision is essential

8. Management of CSF leaks and open wounds

- Report any fluid leakage from the ears or nose. The ears or nose may be covered with a bolster (do not pack). Monitor amount and colour of drainage.
- Any open scalp wound left unsutured is covered with saline soaked dressings during transfer of patient.

Comment

These guidelines are particularly applicable in rural hospitals where 24 hour on-site medical cover is not available.

SUMMARY OF HEAD INJURY MANAGEMENT

1. Airway – protect cervical spine
2. Breathing – oxygenation
3. Treat shock – control haemorrhage
4. Maintenance fluids after resuscitation
5. Full neurological examination early and establish a working diagnosis
6. Prevent secondary brain injury
7. Assess and treat non-cerebral injuries
8. Xray (or CT scan if available) when cardiorespiratory stability achieved
9. Consult early with a neurosurgical unit and consider transfer, particularly in the multiple injured patient (after stabilisation of extracranial injuries)
10. Continually re-assess neurological status

NEUROTRAUMA SYSTEMS – AN INTEGRATED APPROACH

A co-ordinated, comprehensive trauma system which delivers timely advanced trauma care lowers mortality following trauma. Rehabilitation services form an important component of this system.

The training of medical personnel in the Early Management of Severe Trauma (Advanced Trauma Life Support), and the formation of trauma teams in emergency departments ensures uniform standards of expert care.

A trauma system must be designed for a particular region, taking into account local geography, prehospital and hospital resources. The trauma system should provide a maximum prehospital time of 60 minutes, the "Golden Hour" of critical events following trauma. This time interval may be unavoidably extended in remote areas of Australia. The NRTAC Report* has set out the minimal requirements for the various levels of care in a trauma system including the availability of CT scanning and neurosurgery services. The installation of teleradiology systems will enhance the quality and accuracy of decisions on patients with neurotrauma in remote areas. Severe neurotrauma should be managed in a Major Trauma Centre.

An ongoing accreditation and audit process with uniform data collection and well defined audit filters should be built into the trauma system so that quality of care can be evaluated and benchmarked against national and international standards. A mechanism for feedback and continuing medical education of personnel should follow.

**Reference:*
Commonwealth Department of Health, Housing. Local Government and Community Services. National Road Trauma Advisory Council Report of the working party on trauma systems. Australian Government Publishing Services. July 1993.

Ministerial Review of Trauma and Emergency Services Report. Department of Human Services. Victorian Government. 1999

CLINICAL INDICATORS FOR A NEUROTRAUMA SERVICE

Indicators of the standard of neurotrauma management recommended by the Trauma Committee of the Neurosurgical Society of Australasia are:

- Patient with moderate (GCS 9–13) or severe (GCS < 9) head injury having head CT scan >2 hours after arrival at the major trauma centre
- Craniotomy for acute intracranial haematoma >2 hours after arrival at the major trauma centre
  - Exclusions are: ICP Monitoring or clinical decision by the surgical team to defer treatment
- Patient transferred from initial major trauma centre to an equivalent service in another hospital within 12 hours to arrival the first hospital
- Return to the operating theatre within 7 days
- Transfer from a general ward or high dependency ward to an intensive care unit
- Cardiac or respiratory arrest
- Unplanned readmission within 28 days of discharge
- Death

TRAUMA SERVICES - AUSTRALIA AND NEW ZEALAND

AUSTRALIAN CAPITAL TERRITORY

Canberra Hospital Admitting officer	0419218102

NEW SOUTH WALES

Aeromedical and Medical Retrieval Services (AMRS)	1800 650 004
Major trauma centres:	
John Hunter Hospital	02 4921 3000
Royal North Shore Hospital	02 9926 7111
Royal Prince Alfred Hospital	02 9515 6111
St George Hospital	02 9113 1111
Westmead Hospital	02 9845 5555
Liverpool Hospital	02 9828 3000

NORTHERN TERRITORY

Royal Darwin Hospital	08 8922 8888

SOUTH AUSTRALIA

Contact trauma units at:

Royal Adelaide Hospital	08 82224222
Flinders Medical Centre	08 82045542
Woman's and Children's Hospital	08 81617238

TASMANIA

Royal Hobart Hospital	03 6222 8308
Launceston General Hospital	03 6348 7399

QUEENSLAND

Direct to: Royal Brisbane Hospital Princess Alexandra Hospital Gold Coast Hospital Townsville Hospital	07 47961111
Retrieval Services Queensland	1300 799 127

VICTORIA

Trauma hotline to Adult Retrieval Victoria	1800 700 001
Royal Children's Hospital	03 9345 5522

WESTERN AUSTRALIA

State Retrieval Service	1800 625 800

NEW ZEALAND

Auckland City Hospital	09 367 0000
Christchurch Hospital	03 364 0640
Dunedin Hospital	03 474 0999
Waikato Hospital	07 839 8899
Wellington Hospital	04 385 5999

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