MINIMUM REQUIREMENTS FOR MANAGEMENT OF NEUROTRAUMA (DRAFT 23/3/2014)

Introduction

This document is based on Guidelines for the Management of Acute Neurotrauma in Rural and Remote locations prepared by the Neurosurgical Society of Australasia and the Royal Australasian College of Surgeons (2009).

Those guidelines were designed to assist medical personnel confronted with the need to treat patients with severe neurotrauma without on-site neurosurgical assistance. It has been adapted here to provide a framework on which to develop practice guidelines adapted to local needs, taking into account available expertise and organization.

The document considers:

- Neurotrauma prevention
- Education of medical and paramedical staff
- The structure of a trauma system
- 3 phases of medical care - Prehospital care,
  - Inhospital including neurointensive care
  - Neurorehabilitation

1. **Neurotrauma prevention**
   In developed countries there has been a steady fall in TBI on the road and in the work place for some decades and this can be attributed to strategies aimed at preventing accidents and at reducing the severity of injury when accidents happen. Neurosurgeons have played an important role in injury prevention by promoting preventative measures to the public and through government agencies. Injury prevention requires the active participation of government to establish standards and ensure compliance.

2. **Education** (to be expanded).
   Medical
   Paramedical
   Community

3. **Trauma systems**
   Many studies support the benefits of an established system of trauma management which extends from the prehospital stage to rehabilitation.

   A trauma system includes:

   - Prehospital care
     i. Management at the accident site
     ii. Transport to initial hospital including type of transport and equipment

iii. Management during transport

- Management at the hospital of first admission
- Consultation with trauma centre/ neurosurgeon
- Transfer to a trauma centre with neurosurgical facilities
- Trauma centre assessment and management
- Rehabilitation and follow up

General principles underlying neurotrauma management

A. The causes of death after trauma

Seconds to minutes	Brain
	Brain Stem
	High spinal cord
	Heart +/or major vessels
Minutes to hour	Intracranial clot
	Haemopneumothorax
	Ruptured spleen
	Lacerations liver
	Pelvic fracture
Days to weeks	Sepsis Multiple organ system failure

B. Factors adversely influencing outcome from neurotrauma

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.

C. Avoidable causes of death or disability

The following are avoidable causes of death and disability:

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

D. Clinical Indicators of a major trauma service

The efficiency of a trauma service may be assessed by setting practice standards such as:

1. Time to CT Head Scan - 2 hours
2. Craniotomy for acute intracranial haematoma - 4 hours
3. Transfer time between major equivalent centres - 12 hours
4. Unplanned return to O.T. - 7 days
5. Transfer from Ward to ICU
6. Cardiac or respiratory arrest (after initial resuscitation)
7. Unplanned readmission – 28 days
8. Death

4. Medical management

Management phases from the accident site to the major trauma centre

- **At the accident site and during transport**

Particular attention must be taken to:

- Airway
- Breathing
- Controlling haemorrhage
- Preventing and treating shock
- Preventing hypothermia
- Avoiding factors which can either cause or further increase intracranial pressure (such as the head-down position, hypoxia, hypercarbia, vomiting or fitting)
- Identifying serious associated injuries especially spinal injury

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

(See Early Management of Severe Trauma (EMST) protocols for primary survey and resuscitation).

Important prehospital issues

1. **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. The patient is log rolled on to one side with the neck in a collar and supported throughout the maneuver. 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.

2. **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.

3. **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

4. **Prehospital immobilization & transport**.
   Expeditious & careful transport is essential. Combination of rigid cervical collar and supportive blocks on back board is effective.

- **Management at the hospital of first admission**

The stages of management are:

- Primary Survey
- Resuscitation
- Secondary Survey
- Definitive Care

The tasks to be undertaken during these phases are set out in the ATLS guidelines

Investigations

CT head scan

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

Indications:

- 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

Note in particular

- 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.

Skull xray

When a CT scanner is not readily accessible, a plain skull xray can provide important information. The Xray views required are lateral, anteroposterior, 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.

Benefits of a skull xray.

- 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.

Admission to a peripheral 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

Care at a hospital without neurosurgical services

Following resuscitation and full assessment the priorities of care are established and definite treatment undertaken. This stage may require transfer to a major trauma service.
Before transfer fractures should be stabilised and any internal haemorrhage from the abdominal or thoracic cavities should be controlled.

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.

- **Consultation with the trauma centre/neurosurgeon**

If there is no neurosurgical service at the hospital of initial admission a neurosurgeon or neurosurgical service should be consulted for the following reasons:

- 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

- **Transfer to a trauma centre with neurosurgical facilities**

This decision should made in consultation with the neurosurgical service

- 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

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:

A. Transfer to a neurosurgeon within two hours, stabilising the airway and administering IV Mannitol, 20% solution, (1 Gm/kg body weight) or hypertonic saline.

B. If transfer will take longer than two hours burr hole exploration on site by the medical practitioner or general surgeon in a hospital where neurosurgery is not available.

The decision to operate at a hospital without neurosurgical expertise should be made by telephone consultation with a neurosurgeon.

The decision is based on:

- Estimated transfer time
- Clinical state – determined by the level of consciousness and pupillary size and reaction
- Rate of deterioration
- CT scan (if available) or x-ray of skull
- Level of surgical experience and range of neurosurgical equipment available at the regional hospital

Ct images should be sent to the neurosurgeon being consulted. This may be done by mobile phone, by camera image in a JPEG format via the internet or by teleradiology.

Indications for intubation and ventilation

Intubate and ventilate with a Glasgow Coma Score <9.

- It is most important to avoid hypoxia and hypercarbia.
- $PaCO_2$ should be maintained at 35-40 mmHg
- Hyperventilation to a $PaCO_2$ below 30 mmHg should be avoided.
- Ventilation parameters should be based on blood gas analysis when available or by 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

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

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

Intravenous fluids and electrolytes

- Maintenance fluids should replace pathological losses avoiding both dehydration and over hydration. Normovolaemia is the goal

- 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 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 for raised intracranial pressure

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

2. Intravenous 20% mannitol or hypertonic saline.
   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.

   Mannitol dose: 0.5 to 1gm/kg body weight over 20 minutes. Fluid loss through diuresis should be replaced concurrently.

   Hypertonic saline may be used instead of 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.

Management at a hospital with neurosurgical services

The principles of management have been set out in various Guidelines (see below).
These guidelines depend on the availability of
ICU with staff and facilities for controlled ventilation, continuous arterial BP, ICP and blood gases
CT scanning

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**
   Note:
   - 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 (such as a rolled up jacket).

3. Transport to primary hospital

- Cardio pulmonary resuscitation 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 prefered if possible.
Avoid hypotension. Maintain systolic BP >90mm Hg. Distinguish 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 a step.
Neck control, if conscious, tested 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 suspected of injury.
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.

4. **Conscious patient, no pain or limitation of mobility** – no radiological exam need.

NB: MR is performed in the specialist spinal injuries centre when fractures are seen on CT. It is used to help decide 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 or 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 with the acute spinal service

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

Reduction by cervical traction

- Early reduction is recommended
- MRI before reduction not recommended
- Initial closed reduction of cervical fracture dislocation is safe & effective with 80% success

  -permanent neurological injury due to cervical traction is very rare (1%)

  -safer than manipulation under anesthesia
- traction weight: initial 3 pounds per body level
  maximum 5 (-10) pounds per body level
  increase 5-10
  10 lb after reduction achieved
- -Stop point of cervical traction
  1. Pain
  2. Neurologic status worsens
  3. Overdistraction

SPECIAL GROUPS

1. **Paediatric head injury**

The principles of management of head injuries in children are similar to those of adults but there are important differences relating 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 apply the Glasgow Coma Scale designed for adults. A modified scale should be adopted for infants and small children in which the vocal responses appropriate to age are recorded. Fluctuation in 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 noticed by observers.

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

4. Blunt injury head in a young child may be followed within a short time or up to 24 hrs by acute brain swelling, sometimes after apparently minor head injury. This may lead to sudden and unexpected decline in the conscious state. Acute brain swelling can only be diagnosed and a mass lesion excluded by a CT scan. Brain swelling is treated by a period of ventilation and often ICP monitoring. It is imperative not to over infuse such a patient. As in adults intravenous fluids should replace estimated existing losses. Usually full recovery occurs. Because of this risk observation of a young child in hospital for 24hrs after minor injury is advisable.

5. An epileptic fit is more common in children than in adults after a relatively minor head injury. The immediate decline in the conscious state 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 penetration. With any puncture wound over a child's head the likelihood of penetration to the underlying brain needs to be considered. The entry wound must be carefully inspected for signs of fracture, CSF or brain tissue. If there is doubt a CT scan must be undertaken. The child should be sent to a neurosurgeon for repair of any defect. Penetration of the brain through the orbital roof or nose of the child may easily be overlooked.

8. 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 by the malleable skull, reducing the acceleration effects on the brain. Even without loss of consciousness there may be severe local injury. A plain skull xray, particularly a tangential view, may show the bone injury and a CT scan will show 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 a serious risk 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 expansible skulls, intracranial haematomas may become extremely large. The blood pressure may be maintained in response to raised intracranial pressure. A sudden reduction of raised intracranial pressure when a clot is removed at surgery may cause blood pressure to fall rapidly. It is essential when planning surgery in a young child to obtain blood for transfusion. Blood transfusion should be in place at the time of operation. In an emergency O-Negative blood may be necessary

11. In infancy the fontanelle is a most useful guide in assessing the intracranial pressure. The state of the fontanelle should be carefully noted.

12. There is a significant incidence of non-accidental injury. It is important to be aware that in such circumstances the history provided may be incorrect and mislead the assessing surgeon as to 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 are also suspicious signs.

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

Special note

The assessment of small children with head injury is often difficult, Consultation with a neurosurgeon is recommended at an early stage. The deteriorating child who requires 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.

2. 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

Primary Survey

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

Resuscitation

Management of life-threatening conditions

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

Definitive Care

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

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 above.
- 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

- 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 recording a post resuscitation GCS

  - Deterioration of post resuscitation GCS by 2 or more points at any time

3. 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
- 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 still present after observation for 4 hours in the Emergency Department.

4. Head injury in the elderly

The elderly, defined as those over 65 years, are the fastest growing segment of most populations. Trauma is the fifth leading cause of death in the elderly, with head injury as one of the commonest forms of trauma. Mortality and morbidity after acute head injury is significantly higher in the elderly and older patients tend to remain in hospital longer.

Special aspects

- Mechanisms of injury. Falls and pedestrian accidents are more common
- Patterns of pathological changes following acute head injury. More susceptible to cerebral ischaemia. Higher incidence of intracranial haematoma.
- Systemic responses to injury. The elderly may have weak protective airway reflexes. The baseline arterial oxygen tension is reduced, increasing the risk of hypoxia. Cardiovascular and pulmonary changes of aging result in a reduced physiological tolerance and reserve. Hence the elderly have limited ability to respond to the stress of injury and the deleterious effects of secondary insults may be magnified.
- Increased prevalence of comorbidities, particularly:
    - cerebral pathology (cerebrovascular disease, degenerative disease, normal pressure hydrocephalus)
    - lung disease with increased risk of hypoxia
    - cardiac disease, hypertension, diabetes mellitus, coagulopathy
- Medications frequently prescribed for elderly patients which may affect management

Management

Prehospital

The primary survey and resuscitation with stabilization of airway, breathing, and circulation should be performed rapidly and the patient transported without delay. Avoid hypothermia.

Airway

Respiratory responses to hypoxia and hypercapnia are reduced. Weakened intercostal and accessory muscles of respiration may reduce vital capacity. Coexisting lung disease may add to respiratory dysfunction due to trauma.

Careful clinical assessment**, c**ontinuous pulse oximetry and arterial blood gas assessments are essential to detect respiratory failure early.

Positioning

Standard positioning with a backboard and cervical collar to maintain spinal immobilization can impede ventilation in a patient with kyphosis or lordosis.

History

i) **The circumstances of the injury** - The circumstances of the injury should be carefully sought. Cardiac or neurologic events may precipitate falls or motor vehicle collisions. If such disease is left undiagnosed, serious morbidity or mortality can result.

ii) **Past history** - Impairment of mental status or residual neurological deficits after cerebrovascular accidents that may have been present before the injury and can confound neurological assessment. A history of previous injury is significant. For example, a slowly developing subdural haematoma due to a previous injury may be responsible for a subsequent injury.

iii) **Co-morbid disease** - Concomitant medical conditions are common (see above).

iv) **Medications** - Medications taken prior to injury such as beta-blockers, calcium channel blockers and anticoagulants. An event such as a myocardial infarction, a transient ischemic attack, or hypoglycaemia may precipitate a head injury. Undiagnosed underlying events can result in serious morbidity and mortality.

Neurological Examination

- A focal neurologic deficit or a GCS less than 15 significantly increases the probability of intracranial injury on a CT scan and the need for neurosurgical intervention.
- Conversely elderly patients may be relatively intact on neurological evaluation and yet harbour significant intracranial pathology.
- Shock, hypoxia and concurrent illness may result in a confusional state.
- Mental status deterioration can also be secondary to prescription medications which can reach toxic levels due to hepatic or renal dysfunction.
- In the absence of a clear history of injury, it may be difficult to differentiate a confusional state after acute head injury from delirium secondary to metabolic encephalopathy, dehydration or sepsis.

Ventilation

- An edentulous patient may be difficult to ventilate with a bag-valve-mask device
- Respiratory insufficiency must be treated promptly.
- The benefits and risks of intubation and mechanical ventilation in the elderly head injured patient who is breathing spontaneously need to be carefully weighed.
- Intubation may be difficult as mouth opening and cervical spine mobility may be reduced making visualization of the glottis difficult or impossible.
- The trachea is brittle in the elderly.
- To minimize the risk of cardiac depression and hypotension, the doses of preintubation sedation/analgesia drugs may need to be reduced by 20% to 40% of the standard dose for adults.
- The risks of barotrauma, nosocomial pneumonia, prolonged ventilation and difficult weaning are significantly higher.

Occult cardiogenic shock

- Elderly patients may appear to be clinically stable in the immediate post –injury period and yet be in a low output state due to occult cardiogenic shock.
- Such "clinically stable" patients may suddenly develop overt shock.
- Evidence of tissue hypoxia in the form of increased lactate levels or evidence of metabolic acidosis on blood gas analysis, may indicate occult cardiogenic shock.
- Early and close monitoring is recommended for elderly patients with potentially survivable injury.

Fluid Resuscitation

- Changes in vital signs may not be reliable early indicators of haemorrhagic shock. A tachycardic response to hypovolaemia and stress may not occur due to cardiac changes associated with age or use of medications.
- Blood pressure readings may be misleading due to baseline systolic hypertension.
- Targeted mean arterial blood pressure should be based on probable normal range for that patient, as autoregulation will be maintained only within that range.
- Elderly patients may be dehydrated on admission if there has been a delay in detecting the injury, especially if they are living alone.
- Suspected hypovolaemia should be treated with 1 to 2 L of crystalloid given initially in boluses of about 250 ml. Volume overload must be avoided.
- Where facilities are available, insertion of a central venous line or a pulmonary artery catheter will help to guide fluid therapy.
- Ringer's lactate is preferable to Normal Saline which may cause hyperchloremic acidosis if renal function is impaired.
- Infusion fluids should be warmed prior to administration.
- The urine output may not be a reliable guide for fluid administration as impaired renal function may reduce the ability to concentrate urine. In addition, the elderly may be less sensitive to antidiuretic hormone (ADH), resulting in a less concentrated urine.

- If the patient is still hypotensive after adequate volume replacement, inotropic support should be instituted.

Spinal Injury in the elderly

The elderly are at particular risk of spinal injury due to

- Falls being a common mechanism of injury
- Spinal immobility due to degenerative disease
- Senile osteoporosis leading to fractures of the spine with minimal force

Degenerative changes in the vertebral bodies may interfere with radiographic evaluation of the spine.

Central cord syndrome occurs more frequently because of degenerative narrowing of the cervical canal. CT or MRI may be needed to exclude spinal injury.

Control of the agitated or violent elderly patient

Short-acting agents are preferred. Lorazepam (0.5 mg intravenously, intramuscularly or orally) may be used initially. Haloperidol (2.5-5.0 mg intravenously, intramuscularly) may be used when stronger tranquilization is required. Haloperidol can be given in combination with Lorazepam. Cardiac and respiratory function must be monitored during CT scanning under sedation/tranquilization.

Radiological investigation

Special indications for Cranial CT scan

- The elderly patient with mild head injury should be considered at “High Risk” for intracranial complications.
- Lack of a clear history
- Any changes in cognition and memory
- Anticoagulation

Intravenous Mannitol

Mannitol should be used with caution in the elderly:

- the elderly patient may already be dehydrated, hence there is a risk of renal failure with further dehydration
- pre-existing electrolyte abnormalities may be exacerbated. Patients on diuretic therapy for hypertension may already have hyponatraemia or hypokalaemia
- a sudden increase of circulating blood volume risks cardiac failure

Indications for referral to a neurosurgical centre

This decision may be based on adverse prognostic features

- Age > 75 years
- Comorbidity - especially significant cerebrovascular disease and dementia
- Social circumstances - lack of family support, wishes of family, stated wishes of the injured prior to the injury
- GCS - GCS ≤ 8) from the time of injury has a worse prognosis than one who deteriorates from a higher GCS score
- Duration of unconscious state - GCS ≤ 8 for more than 6 hours (and certainly if the coma persists for 24 hours)
- Signs of brain stem compression/herniation (pupillary dilatation)
- Multisystem injury
- Extent of possible neurosurgical procedure required - Outcome is very poor after craniotomy for an acute subdural haematoma in those over the age of 75 years. Decompressive craniectomy or extensive lobar resection are not reasonable options in this age group
- Need for prolonged intensive care – eg prolonged ventilation with prolonged osmotherapy or certainly metabolic suppression, are usually not reasonable options in elderly

REHABILITATION

- A comprehensive trauma care system for head injury includes rehabilitation services
- Rehabilitation aims to minimize disability and maximize functional recovery.
- Neurological rehabilitation has a long time profile and consists of several stages.
    - The acute phase actively involves specialists in rehabilitation medicine and the family of the head-injured patient.
    - Sub-acute programs are designed for 'slower stream' patients who remain in coma or post-traumatic amnesia (PTA) and consist of coma management and neurobehavioral therapy.
    - After PTA resolves individual programs provide for transitional living, day care and activities, and supported or sheltered employment.

SPECIAL ISSUES IN NEUROTRAUMA

1. **Intracranial infection**

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

Immediate management

- CSF rhinorrhoea or otorrhoea – swab for culture and sensitivity and observe.
- Intracranial aerocele - observe unless marked brain displacement and impaired conscious level.

- 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.

2. 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 a patient with multiple injured 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.

3. 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 necessary beyond the first week. A neurosurgical consultation is indicated if fits occur and for general advice about prophylactic anticonvulsant therapy.

Prophylactic anti-convulsant therapy:

- In the conscious patient, oral phenytoin 400mg as a stat dose, 400mg in 12 hours followed by 300mg nocte, monitored by serum phenytoin level.

- 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.

Management

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

Comment

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

For the treatment of scalp wounds:

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

4. 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.

5. Nursing management

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

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

Oxygen

Treat hypotension

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

Fluid management

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

Intra-gastric tube

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

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

Confused patients

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

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.

SUMMARY OF ACUTE 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 coordinated, comprehensive trauma system which delivers timely advanced trauma care lowers mortality following trauma.
- 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.

- 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.

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

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