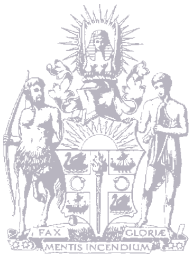
The Neurosurgical Society of Australasia

THE MANAGEMENT OF ACUTE NEUROTRAUMA IN RURAL AND REMOTE LOCATIONS

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



The Royal Australasian College of Surgeons

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FOREWORD – FIRST EDITION

These Guidelines for the Recognition and Management of Acute Neurotrauma will be of immense help to Surgeons and General Practitioners alike, in remote areas.

Both the Neurosurgical Society of Australasia and the Royal Australasian College of Surgeons are committed to improving the skills of medical personnel who have committed their professional life to the care of people in remote and rural areas. Both organisations, amongst others, recognise the extra training required by these doctors, and the sense of professional inadequacy and lack of support which has deterred many of their colleagues from practising in these locations.

Help is now being provided, by guidelines such as these, and measures such as early management of severe trauma (EMST) courses, being run by the Australasian College of Surgeons. Improved training programmes are being developed and instituted for such doctors, and these programmes are supported by both the Neurosurgical Society and the college.

The beneficiaries are the patients. Despite an apparent widespread access to retrieval of severely injured people to road, helicopter and fixed wing transport, delays can be frequent. In neurotrauma, time is critical. These guidelines will help doctors make the right decision at the right time, and save lives which might otherwise be lost or irretrievably impaired.

JC Hanrahan
President
Royal Australasian College of Surgeons

FOREWORD – SECOND EDITION

These revised guidelines produced by the Trauma Committees of the Neurosurgical Society of Australasia and the Royal Australasian College of Surgeons include the most relevant and contemporary information using an evidence based approach to the management of neurotrauma which is the major cause of death in road traffic injury. The guide is provided to all who provide care in rural and remote locations and will increase confidence that trauma occurring in more isolated areas will be assessed and treated appropriately thus reducing the chance of a poor result. These guidelines give clear and concise advice allowing accurate assessment and minimal delay in instituting effective treatment. A further reduction in trauma morbidity and mortality can be achieved by the wide dissemination and use of these guidelines. It must be noted that greater compliance with preventative measures such as a reduction in driver fatigue, reduced speed, less alcohol use, plus the regular use of seatbelts and helmets must continue to be supported if we are to achieve maximal possible improvement in death and disability rates.

Bruce H Barraclough
President
Royal Australasian College of Surgeons

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PREFACE – FIRST EDITION

The Neurosurgical Society of Australasia through its Trauma Committee has a long involvement in the problem of neurotrauma. The management of acute neurotrauma in rural and remote locations is of particular interest and is part of a general policy which includes education, prevention, organisation of an integrated neurotrauma system and support for the Early Management of Severe Trauma (EMST) programme instituted by the Royal Australasian College of Surgeons.

The management of acute neurotrauma requires a consultative approach especially in the multiple injured patient and where transfer or retrieval is necessary. Adequate cerebral perfusion, oxygenation and control of intracranial pressure are essential for normal brain function. Airway control, treatment of hypovolaemic shock, minimising delay from the accident site to definitive care, the development of effective communication, transport and retrieval systems and an appreciation of the mechanism of head injury should contribute to an improved outcome in the neurotrauma patient.

As acute neurotrauma may present to general practitioners, rural surgeons or Emergency Departments in country hospitals, a set of guidelines has been developed to assist in the early management of acute neurotrauma throughout Australasia. It would be usual practice that operations and procedures for acute neurosurgical conditions normally would be performed by trained Specialist Surgeons. On occasions these operations and procedures may need to be performed by General Practitioners who have been trained appropriately. It is recognised that distance, geography, local demography and facilities available may make a particular guideline inapplicable in some instances.

These guidelines are a continuing medical education publication for the Neurosurgical Society of Australasia and the Royal Australasian College of Surgeons. They have been extensively used since 1992 by rural health and distance education groups, Royal Flying Doctors' course, Emergency Management of Severe Trauma Course of the Royal Australasian College of Surgeons and by overseas education programs for neurotrauma care.

Ray Newcombe *Chairman, Trauma Committee*
Neurosurgical Society of Australasia

Glen Merry *Chairman, Trauma Committee*
Royal Australasian College of Surgeons

PREFACE – SECOND EDITION

The first edition of "Guidelines" has proven very effective. This new edition incorporates changes in management derived from Evidence Based Guidelines published in recent years. A slightly abbreviated version has been published in the Journal of Clinical Neurosciences* and placed on the website of Neurosurgical Society of Australasia. It is hoped that the present publication will continue to be of assistance to those engaged in the early management of acute neurotrauma.

Peter L Reilly *Chairman, Trauma Committee*
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Incidence

Neurotrauma is responsible for 70% of all road fatalities and 50% of trauma deaths. Road crashes cause 50–60% of all head injuries. Accidental injury is the third highest cause of death in motorised countries. The highest incidence for hospital admission in persons under 45 years of age is from trauma.

Factors in the Rural Environment

The following factors are significant in rural trauma: isolation and distance, medical facilities, delay in definitive care, rural crash profiles, eg incidence of 40% fatality on admission, more severe injuries, multiple injuries, higher incidence of single vehicle crashes, road and environmental conditions, driver competence and fatigue and compliance with preventative measures such as alcohol, seatbelts, helmets and speed.

NEUROTRAUMA
Clinical factors adversely influencing outcome (death and disability)

- Severity of primary injury.
- Intracranial complications.
- Hypoxaemia.
- Hypercarbia.
- Hypotension.
- Anaemia.
- Multiple injuries, proportional to injury severity score (ISS).
- Age.
- Prolonged prehospital time.
- Admission to inappropriate hospital.
- Delayed or inappropriate interhospital transfer/ retrieval.
- Delay in definitive surgical treatment.

COMMENT

- PREVENTABLE OR AVOIDABLE CAUSES OF DEATH OR DISABILITY INCLUDE:
- DELAY IN INSTITUTING PRIMARY RESUSCITATION for hypoxia, hypercarbia and hypotension.
- DELAY IN INITIATING DEFINITIVE NEUROSURGICAL CARE especially for the rapidly developing intracranial haematoma. This involves diagnosis, communication and transportation.
- Failure to prevent craniocerebral infections.

Abnormal neurological signs involving level of consciousness, pupillary size and reaction to light, brain stem reflexes and motor response, indicate the severity of cerebral dysfunction. Children and elderly patients generally react particularly adversely to trauma. Persons over 50 years of age can develop intracranial complications from an apparently minor head injury such as a fall.

From ambulance officers, police and eyewitnesses, and from clinical examination, one can deduce

- The anatomical area involved.
- The type of injury.
- The pathology of injury.
- The evolution of the injury.

ANATOMICAL AREA

The outcome and complications of frontal, lateral and occipital impacts are to some extent dictated by the local anatomy, eg. presence of air sinuses, large blood vessels, etc.

TYPE OF INJURY

Injury forces applied to particular anatomical areas produce a pattern of injury for the individual, eg:

Acceleration/Deceleration
- applied to the entire head, evident as disordered consciousness from the time of impact resulting from concussion, often with diffuse axonal injury and/or cerebral contusions (coup or contrecoup).

Local impact
- coup injuries to scalp, skull, meninges, brain.

Penetrating
- pathway of injury
- velocity and nature of projectile.

Crush injury
- scalp, skull and cranial nerve injuries.

PATHOLOGY OF HEAD INJURY

i) Primary

Scalp	– contusion, abrasion, laceration.
Skull fracture	– open, closed (note – includes compound base of skull fracture without a scalp laceration). – linear, depressed, comminuted.
Meningeal injury	– dural tear.
Brain injury	– concussion. – diffuse axonal. – focal contusion. – laceration and penetration.

ii) Secondary

Intracranial haemorrhage.

Cerebral hypoxia.

Cerebral swelling.

CSF leakage and pneumocephalus.

Metabolic disorders.

Infection.

Epilepsy.

EVOLUTION OF INJURY

The rate of deterioration will influence the time available for specific treatment.

Factors influencing outcome

The following factors require attention –

- airway
- breathing
- control of haemorrhage
- prevention and treatment of shock
- factors which can either precipitate or aggravate raised intracranial pressure (the head-down position, hypoxia, hypercarbia, vomiting)
- serious associated injuries especially spinal injury
- effective communications and transport.

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

Position of the unconscious patient

The LATERAL position is indicated for airway control. This applies in a patient with a suspected spinal injury but taking care to maintain spinal alignment (see Spinal Injury, Prehospital Management, page 20). In the lateral position the unconscious victim lies on one side with the weight supported by the under 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.

Tracheal Intubation

In certain circumstances, tracheal intubation may be needed if the airway is inadequate. Tracheal intubation should only be performed by a competent medical practitioner or by an ambulance officer specially trained and certified in this potentially dangerous procedure.

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 20).

EARLY MANAGEMENT OF SEVERE TRAUMA

The management plan is based on:

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

1 PRIMARY SURVEY

(i) Airway with cervical spine immobilised in neutral position.

(ii) Breathing pattern and adequacy.

(iii) Circulation and haemorrhage.

(iv) Disability – rapid neurological examination

A rapid examination based on the AVPU scale is helpful (Alert, responding to Voice only, responding to Pain only, Unresponsive). Check pupils.

(v) Exposure: completely expose the patient for an adequate examination but protect against hypothermia.

2 RESUSCITATION

(i) Airway – ensure patent airway
- in an unconscious patient: intubate if skilled
  N.B. Maintain cervical spine immobilisation until radiological examination excludes spinal injury.

(ii) Breathing and oxygenation
- ensure adequate ventilation,
- mechanically ventilate if intubated,
- give supplemental oxygen initially.

(iii) Circulation support and control of haemorrhage
- treat shock aggressively to improve tissue perfusion,
- stop external haemorrhage.

(iv) Assess response to resuscitation using physiological parameters:
pulse, blood pressure, skin colour, capillary refill and urine output.

(v) Nasogastric tube and urinary catheter unless contraindicated.

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

COMMENT

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

3 SECONDARY SURVEY

(i) Special neurosurgical assessment including GLASGOW COMA SCORE (GCS) and EXTERNAL SIGNS OF INJURY TO THE HEAD.

(ii) Record the pulse, blood pressure, respiratory rate and temperature.

(iii) Systematically examine each region of the body, ie, head-to-toe examination – establish an injury list.

(iv) Connect to monitors as available.

(v) Re-evaluate the Glasgow Coma Score.

(vi) Radiological examination – lateral xray spine, chest, pelvis, other areas as indicated, skull xray and CT head scan – see guidelines.

SPECIAL NEUROSURGICAL ASSESSMENT

Clinical

1. History

(i) Cause of injury. This will help in determining the mechanism and pattern of head injury.

(ii) 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 eg hypoxia, hypotension, intracranial haematoma.

(iii) Pupillary response

Were the pupils equal or unequal at the injury site? Initial equality with change to inequality suggests a lateralised mass lesion.

(iv) Cardiorespiratory status and response to resuscitation at the injury site.

(v) History of drugs or alcohol, prior to, and at the time of injury.

(vi) Other medical disease, previous head injury or ocular conditions.

2. CNS Examination

(i) Glasgow Coma Score.

(ii) Pupillary responses

Are they equal or unequal? Were the pupils equal at the time of the incident (report from ambulance officer) and have they the same response now?

(iii) Motor pattern,

Hemiparesis, quadriparesis,

Flexion or extension to pain (from supraorbital, sternal or fingernail bed pressure) see page 10,

(iv) Inspection of the face and scalp.

(v) Palpation of the face and scalp and any laceration for a depressed fracture.

(vi) Palpation of the spine for tenderness and deformity.

COMMENT

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

Using the Glasgow Coma Scale (GCS)

This scale examines three areas of behaviour: Eye Opening, Best Verbal Response and Best Motor Response.

The Response. 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 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. 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. NB. In general it is better to describe a patient's state in verbal terms eg "eye opening to pain, incomprehensible sounds, localises pain" rather than "GCS = 9".

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*. Each side is tested, but only the better score recorded.

Side to side differences in the motor response. The purpose of the Glasgow Coma Scale 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 pulls away from the stimulus.

M3. ***Flexion – abnormal*** – After painful stimulus to the nail bed:

(a) there is extension at first followed by flexion, or else

(b) two of the following:–

(i) stereotyped flexion posture,
(ii) extreme wrist flexion,
(iii) abduction 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.

M1. ***None.***

Coma Score (E + V + M) = 3 – 15

COMMENT

A 14 point scale is used in some Units. This recognises no difference between abnormal flexion and withdrawal to pain. The best motor response is assessed on a 5 point scale.

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

CLINICAL CLASSIFICATION

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 – 4
	localises – abnormal flexion	3 – 5

Mild Head Injury GCS 14 – 15

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

CT HEAD SCAN GUIDELINES

1. **GCS <9 AFTER RESUSCITATION.**
2. **NEUROLOGICAL DETERIORATION i.e. 2 or more points on the GCS, hemiparesis, squint.**
3. **DROWSINESS OR CONFUSION (GCS 9–13 persisting >2 hours).**
4. **PERSISTENT HEADACHE, VOMITING.**
5. **FOCAL NEUROLOGICAL SIGNS.**
6. **FRACTURE – known or suspected.**
7. **PENETRATING INJURY – known or suspected.**
8. **AGE – over 50 years of age.**
9. **POST-OPERATIVE ASSESSMENT.**

COMMENT

A CT scan is the investigation of choice where available. EXCEPT FOR AN UNCOMPLICATED MINOR HEAD INJURY, ALL PATIENTS SHOULD IDEALLY HAVE A CT SCAN. This may involve a transfer.

Rapid deterioration may require an immediate operation rather than risk delay in performing a CT scan.

As lesions may develop after an initial normal scan, repeat CT scans may be required should neurological deterioration occur.

A post-operative scan will demonstrate adequate removal of the haematoma, re-accumulation or the development of a new lesion.

SKULL XRAY GUIDELINES

In rural areas where a CT scan is not available or readily accessible, a plain skull xray can provide useful information. The pictures required are AP, lateral, Towne's view and tangential to the point of impact for demonstrating a depressed fracture.

Indications

1. **LOSS OF CONSCIOUSNESS, AMNESIA.**
2. **PERSISTING HEADACHE.**
3. **FOCAL NEUROLOGICAL SIGNS.**
4. **SCALP INJURY.**
5. **SUSPECTED PENETRATING INJURY.**
6. **CSF OR BLOOD FROM NOSE OR EAR.**
7. **PALPABLE OR VISIBLE SKULL DEFORMITY.**
8. **DIFFICULTY IN CLINICAL ASSESSMENT**
   – alcohol or drug intoxication,
   – epilepsy, children.
9. **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.**

COMMENT

A skull xray is useful in triage assessment. The presence of a skull fracture may influence treatment:

1. A skull fracture is associated with an increased risk of intracranial haemorrhage and a CT scan is indicated.
2. A compound fracture, including fractures of the base of skull, is associated with an increased risk of infection.
3. A depressed fracture is associated with an increased risk of epilepsy especially if associated with dural penetration.
4. A fracture indicates the site for surgery particularly in a rapidly deteriorating patient in whom an extradural haematoma is suspected.
5. Pneumocephalus – the presence and volume is a consideration in aerial transport.

4. DEFINITIVE CARE

This is the stage for comprehensive management and includes fracture stabilisation and consideration for transfer: control of internal haemorrhage from the abdominal or thoracic cavities may be required before transfer.

CRITERIA FOR ADMISSION TO HOSPITAL

1. CONFUSION OR ANY OTHER DECREASED LEVEL OF CONSCIOUSNESS.
2. NEUROLOGICAL SYMPTOMS OR SIGNS – including persistent headache, vomiting.
3. DIFFICULTY IN CLINICAL ASSESSMENT – eg alcohol, epilepsy.
4. OTHER MEDICAL CONDITIONS – eg coagulation defects, diabetes mellitus.
5. SKULL FRACTURE.
6. ABNORMAL CT BRAIN SCAN.
7. RESPONSIBLE OBSERVATION NOT AVAILABLE OUTSIDE THE HOSPITAL.
8. AGE – patients over 50 years of age.
9. CHILDREN – see Paediatric Head Injury, page 18.

COMMENT

A person whose loss of consciousness was brief (less than 5 minutes) and who does not exhibit any of the listed criteria need not be admitted, if a period of more than 4 hours has elapsed since impact. However, this supposes that the patient can be observed at home by someone able to detect increasing headache and/or drowsiness, and act responsibly by arranging urgent re-admission. All discharged head injuries must be given appropriate written discharge instructions.

CRITERIA FOR NEUROSURGICAL CONSULTATION

1. SKULL FRACTURE + confusion, decreased level of consciousness, epilepsy, focal neurological signs, and any other neurological symptoms or signs.
2. COMA CONTINUES AFTER RESUSCITATION (GCS <9).
3. DETERIORATION IN NEUROLOGICAL STATUS eg worsening in conscious state (2+ points on GCS) fits, increasing headache, new CNS signs.
4. CONFUSION OR OTHER NEUROLOGICAL DISTURBANCE (GCS 9–13) > 2 hours: no fracture.
5. COMPOUND DEPRESSED SKULL FRACTURE.
6. SUSPECTED BASE OF SKULL FRACTURE eg blood and/or clear fluid from nose or ear, periorbital haematoma, mastoid bruising.
6. PENETRATING INJURY – KNOWN OR SUSPECTED.
8. ABNORMAL FINDING ON CT SCAN.

NEUROSURGICAL INDICATIONS FOR TRANSFER

1. GCS <9.
2. DETERIORATION IN GCS OF 2 OR MORE POINTS.
3. FOCAL NEUROLOGICAL SIGNS.
4. PENETRATING INJURY.
5. DEPRESSED FRACTURE.
6. COMPOUND FRACTURE.
7. PERSISTENCE OF: headache, vomiting, confusion (GCS 9–13) > 2 hours post admission.

COMMENT

Consultation with a neurosurgeon will determine the need to transfer to a regional neurosurgical unit.

NEUROSURGICAL CONSULTATION INFORMATION FOR TRANSFER

What the neurosurgeon will need to know.

1. NAME AND AGE OF PATIENT.
2. MECHANISM + TIME OF INJURY.
3. CARDIORESPIRATORY STATUS
   – blood pressure, pulse rate
   – respiratory rate
   – oxygenation saturation (if available).
4. GLASGOW COMA SCORE
   (or detailed description of responses).
5. PUPILLARY RESPONSE.
6. MOTOR PATTERN.
7. ALTERATION IN BASELINE OBSERVATIONS.
8. NON CEREBRAL INJURIES.
9. RESULTS OF INVESTIGATIONS.
10. RELEVANT PREVIOUS MEDICAL CONDITIONS, MEDICATIONS, ALLERGIES.
11. REFERRING DOCTOR, LOCATION AND RETURN PHONE NUMBER.

TRANSPORT AND RETRIEVAL

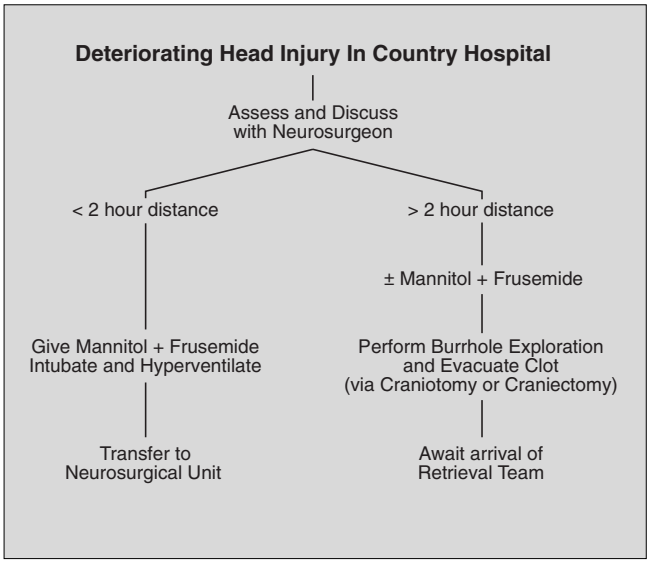
The indications and timing for admission to a Neurosurgical Unit is a neurosurgical decision taken in the light of any injury to other systems and with particular attention to cardiopulmonary stabilisation. The method of transfer, personnel and equipment required are arranged through the integrated transport and retrieval system developed for a particular location. This section should be read in conjunction with the document "MINIMUM STANDARDS FOR TRANSPORT OF THE CRITICALLY ILL" published by the Australian and New Zealand College of Anaesthetists and The Australasian College for Emergency Medicine.

Management options for intracranial haemorrhage include:

1. Rapid transfer under intensive care ± mannitol or frusemide.
2. Immediate on-the-spot operation with neurosurgical support.

The decision should be made with a neurosurgical consultation and is based on:

1. Transfer time > 2 hrs.
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.



Reference: Extradural haemorrhage: strategies for management in remote places, Simpson et al – Injury (1988)19, 307–312.

COMMENT

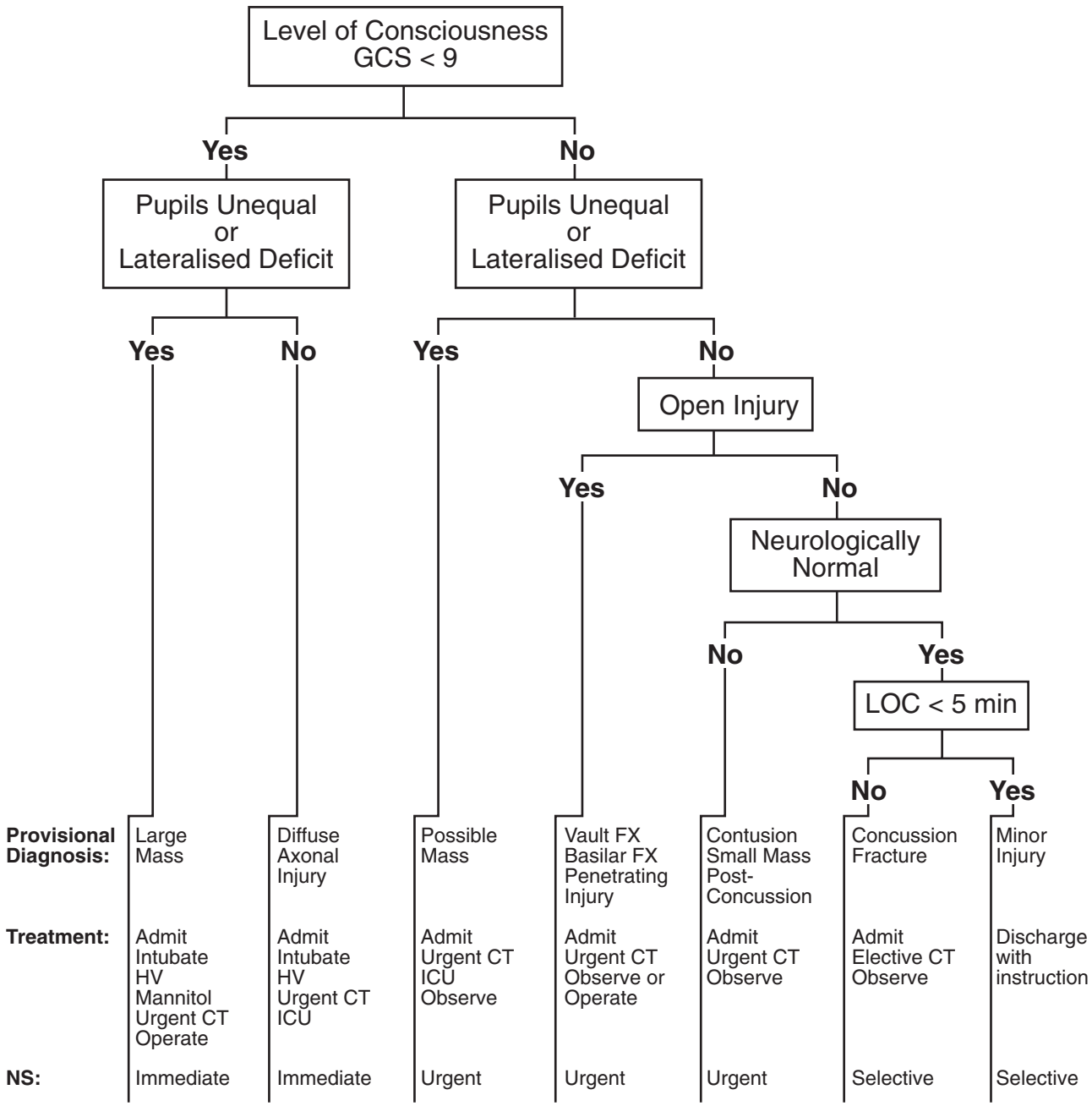
Intubate and ventilate if GCS < 9.

Be aware of pneumocephalus, pneumothorax and epilepsy.

Should emergency on-the-spot operation be indicated, see guidelines on Emergency Surgical Treatment, page 15.

HEAD INJURY TRIAGE SCHEME

This scheme is based on level of consciousness (GCS), size of pupils and a lateralised neurologicl deficit.



NS = Neurosurgical Consultation
GCS = Glasgow Coma Score
FX = Fracture
LOC = Loss of Consciousness
HV = Hyperventilate
ICU = Intensive Care or Neurosurgical Unit

Reference– modified from: Triage of Head-Injured Patients – Chapter Author: Gennarelli, T. in "Current Therapy of Trauma – 2", Trunkey, D. and Lewis, F. eds – B.C. Decker Inc. toronto. 1986

COMMENT

The risk of intracranial haemorrhage is increased in the presence of a fracture and and in a patient over 50 years of age. Note guidelines for xray of skull.

The need for transfer/retrieval will follow consultation.

The condition of extradural haematoma (EDH) is surgically remediable but the diagnosis may be difficult. The so-called classical picture of delayed deterioration after initial lucidity only occurs in less than 50% of cases: some patients are unconscious from the time of injury and others never lose consciousness.

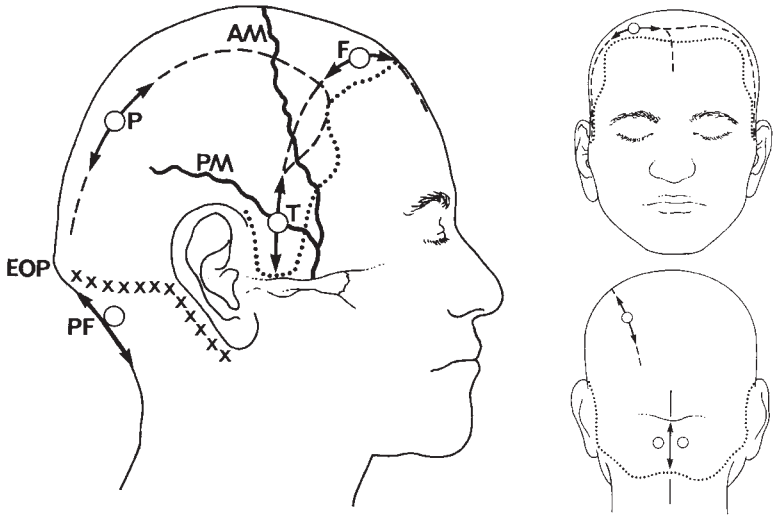
Deterioration is evident if the patient's GCS declines by 2 or more points, or if pupillary enlargement develops. Two courses of action are possible in this situation if CT scanning is unavailable.

1. If transfer to a neurosurgeon can be achieved within two hours, stabilise the airway and administer IV Mannitol, 20% solution, (1 Gm/kg body weight) and IV Frusemide 80mg.
2. Burrhole exploration by the country practitioner if transfer will take longer than two hours.

Both these management strategies can succeed, and the choice between them is made in a telephone dialogue between the country practitioner and the city neurosurgeon. CT scanning makes diagnosis easy and exact, but of course CT scanning may not be available.

If on-the-spot surgery does proceed, the following points should be considered:

1. The site of the extradural haematoma will often be indicated by bogginess of the overlying scalp, local scalp injury or by a fracture (if a skull xray picture was obtained).
2. Pupillary dilatation occurs ipsilateral to the haematoma. If present, it should be the most important guide to the side of surgery: it is preferable to diagnose EDH before this (usually) late sign.
3. Scalp infiltration with 0.5% solution Lignocaine and 1:200,000 Adrenaline is useful, but not essential.
4. 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 in the temple, and 11% are frontal or subfrontal. Therefore the first burr hole, 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 burr hole should be made. If again negative, the other side should be explored.



SURGERY FOR EXTRADURAL HAEMATOMA

○ – Temporal (T), Frontal (F), Parietal (P), and Posterior Fossa (PF) burr hole sites.

– – – – Optional skin incisions for conversion to craniotomy.

AM, PM – Anterior and posterior branches of middle meningeal artery.

EOP – External occipital protuberance.

xxx – Transverse and sigmoid sinuses.

····· – Hair line

5. The temporalis muscle lies beneath the scalp. This is incised with cutting diathermy and held open with a self retaining retractor. The skull is perforated with a perforator and enlarged with a burr.
6. If the extradural haematoma is a solid clot, and a burr hole is insufficient to evacuate it surgically, the bone overlying the haematoma has to be removed (ie unroofed) by nibbling it away. The haematoma can then be removed by suction under vision.
7. If the surgeon's skills extend to turning a flap, this is the preferred method of exposure, rather than a craniectomy (ie the procedure outlined in paragraph 6).
8. The dura should be seen coming up to the skull in each aspect of the wound. Bleeding points on the dura are coagulated with diathermy. (Bipolar is preferred, if available).
9. Oozing from the dura can be controlled by "tenting" the dura to temporalis muscle. If bleeding remains a problem, leave the wound open with a pack. It can be closed later after the patient has been evacuated to the neurosurgical centre.
10. Liaison with a neurosurgeon is important and, in some situations, it may be possible to arrange for a neurosurgeon to travel with a retrieval team to complete the operation.

Non deteriorating patients with depressed and compound skull fractures do not require urgent on-the-spot surgery. They can be transferred to a neurosurgeon in the usual way.

COMMENT

An acute subdural haematoma, or an intracerebral haematoma suitable for surgical evacuation, requires neurosurgical experience, as 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 involves removing more bone by nibbling or turning a flap, and by making multiple 1 cm dural incisions through which blood usually can be drained to avoid the difficult situation of a bulging brain.

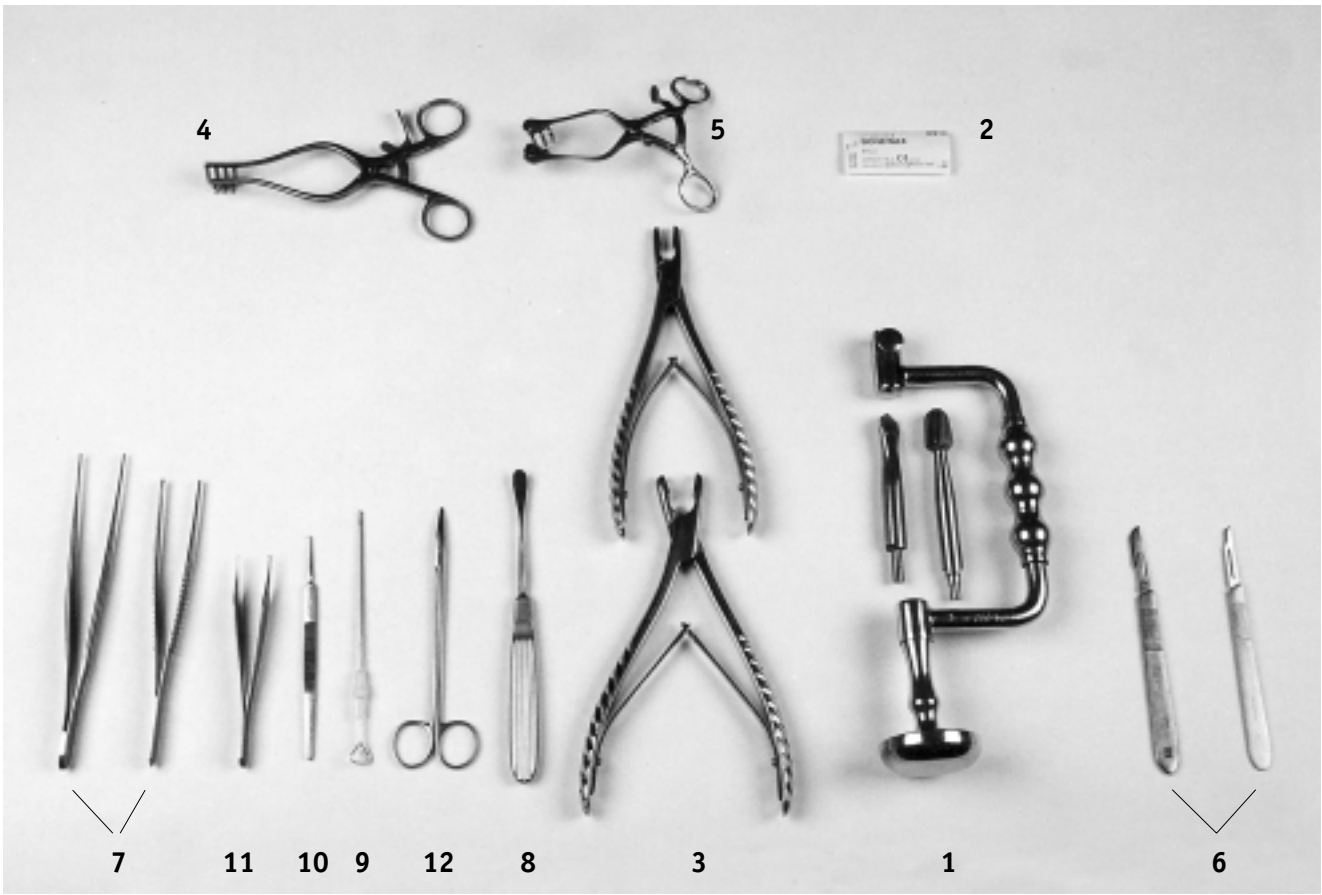
If following EDH evacuation, bleeding is well controlled, there is no significant brain swelling, and a bone flap has been cut, the bone may be replaced with several dural hitching stitches through its centre. If any uncertainties persist, leave the bone plate out and transfer it in a sterile container of antibiotic solution (eg flucloxacillin 1 Gm/litre) with the patient.

A tension pneumocephalus is an unusual outcome. It is relieved by aspiration through a burr hole.

INSTRUMENTATION

Adequate illumination, suction and diathermy are required.
Instruments required:

1. Hudson brace, perforator and burr.
2. Bone wax.
3. Bone nibblers: Horsley and Pennybacker.
4. Medium straight retractor.
5. Ventricular retractor.
6. Scalpels with No.10 & 15 blades.
7. Forceps: plain dissecting, toothed.
8. Periosteal elevator.
9. Brain needle with stillette.
10. Sharp dural hook.
11. Adson's forceps.
12. Dural scissors (fine, curved tips).



COMA MANAGEMENT – RAISED INTRACRANIAL PRESSURE

1 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. Ventilation parameters should be based on blood gas analysis when available and/ or pulse oximetry.

2 CEREBRAL PERFUSION
Hypotension (systolic blood pressure <90mmHg) must be avoided. A mean arterial pressure >90mmHg should be achieved as soon as possible.

3. INTRAVENOUS FLUID AND ELECTROLYTES
Normovolaemia is the goal. Maintenance fluids should replace pathological losses. Avoid dehydration or over hydration. Serum electrolyte measurements should be undertaken early.

4. ACTIVE TREATMENT OF INTRACRANIAL PRESSURE.
This should only be undertaken if there is evidence of neurological deterioration due to intracranial causes eg pupillary dilatation or deteriorating motor function.

(a) Hyperventilation. Hyperventilation to 30mmHg $PaCO_2$ or less should be instituted.

(b) Intravenous 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.
N.B. Mannitol should be avoided unless adequate volume resuscitation has already occurred.

5. HEAD POSTURE
The head should be elevated to 20° provided the patient is adequately volume resuscitated.

6. CORTICOSTEROIDS
These are not recommended.

7. 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 variations both to the head and in general and the response of the child's brain to a traumatic insult.

Points of relevance are as follows:

1. In the young child it is not possible to employ the Glasgow Coma Scale as for adults. A modified scale is adopted for infants and small children. Fluctuation in the responses is more marked in children and an isolated recording on the chart is very often misleading.

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

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

4. An epileptic fit is not uncommon in children after what appears to be 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. Such a patient should have a CT scan to ensure that there is no intracranial haemorrhage.

5. 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.

6. The thinness of the scalp and skull in a young child increases the risk of damage of the brain by penetration by objects which in an older child or adult would not so penetrate. Any puncture wound over a child's head must be treated with suspicion concerning the likelihood of direct injury to the underlying brain. The entry wound must be carefully inspected for signs of fracture, discharge of CSF or cerebral tissue. If doubt remains, 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.

7. 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 and the acceleration effects on the brain may be minimised. The lack of a history of loss of consciousness does not exclude the presence of a severe focal injury. A plain skull xray, particularly a tangential view, may reveal the extent of the bone injury while a CT scan will show more clearly the same aspects, and, in addition, demonstrate whether or not there is injury to the underlying brain.
8. Because of the elasticity of the small child's skull considerable deformation may take place after impact without there being a fracture. Such deformity may be associated with local injury to the brain or injury to the meninges resulting in the development of an extradural haematoma. The absence of a fracture certainly does not exclude a haemorrhage of that type in a child.
9. Blood loss is of considerable importance as regards the assessment of head injuries in small children including infants. A dramatic decline in circulating blood volume may result from bleeding from a wound, a scalp haematoma (particularly if subgaleal) and/or intracranial haematoma. In small infants because of compensatory mechanisms intracranial haematomas may be extremely large. It is particularly important to realise that the blood pressure may be maintained as a reflection of raised intracranial pressure and distortion. With relief by surgery the 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.
10. The small child's brain is more likely to swell following blunt trauma and it is imperative not to over infuse such a patient. As in adults intravenous fluids are not required except to replace estimated existing losses which as indicated above may under certain circumstances be of relevance. Delayed brain swelling may cause sudden unexpected deterioration and observation of the young child in hospital for 24hrs after minor injury is advisable.
11. In infancy the fontanelle is a most useful guide in assessing the absence or otherwise of raised intracranial pressure. The state of the fontanelle gives information which would be of assistance to the assessing neurosurgeon.
12. In the community there is a significant incidence of non-accidental injury. It is important to understand that the history provided may often be incorrect and mislead the assessing surgeon as regards the severity or otherwise of an intracranial insult. The presence of retinal haemorrhages, subdural haemorrhage(s) and bilateral skull fractures suggests a non-accidental injury.
13. The restless head injured small child may be difficult to scan. An appropriate G.A. is preferable to sedation in the acute situation.

COMMENT

The assessment of small children with head injury is generally more difficult than in an older patient and consultation with a neurosurgeon is recommended at an early stage. The Algorithm described on page 13 is applicable to children. The deteriorating patient requiring transfer to the neurosurgical centre must be intubated by a person experienced in this technique in that age group. Overhydration 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 utilised if a shock state develops following evacuation. After such surgery the child should be transferred to a neurosurgical unit by an appropriate retrieval team.

PREHOSPITAL MANAGEMENT

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

(ii) Rapid clinical assessment:
  (a) Respiratory pattern – is the breathing only diaphragmatic?
  (b) Voluntary movement and sensation in the limbs.

(iii) Extrication from vehicle
  (a) Maintain spinal alignment, especially avoiding flexion or rotation.
  (b) Avoid movements which increase pain.
  (c) If cervical injury suspected apply cervical collar or substitute (eg rolled up jacket).

(iv) Transport to primary hospital:
  (a) Immobilisation
    – rigid cervical collar,
    – sandbags and straps as needed,
    – spine board,
    – log roll for turns,

  If necessary, CPR takes precedence.

  (b) Position
    – if conscious, place supine,
    – if unconscious, clear and control airway. Place in lateral position with neck immobilised. Protect airway from obstruction and inhalation.

  (d) Give supplemental oxygen.

PRIMARY HOSPITAL MANAGEMENT

(i) Continue immobilisation.

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

(iii) More detailed neurological evaluation:
  (a) History (mechanism of injury) and neurological symptoms,
  (b) Palpation of spine for tenderness or step,
  (c) Motor level assessment
    – voluntary limb muscle groups,
    – rectal examination – voluntary and reflex sphincter contraction.
  (d) Sensory level assessment.
  (e) Evaluation of reflexes
    – muscle stretch reflexes,
    – abdominal cutaneous reflexes – cremasteric,
    – bulbocavernosus,
    – anal cutaneous.
  (f) Evaluation of autonomic dysfunction
    – altered perspiration below lesion,
    – priapism,
    – urinary retention.

(iv) Radiographic evaluation (see below).

(v) Methylprednisolone

  NASCIS trials reported benefit for both complete and incomplete cord injuries with a methylprednisolone regimen, if given within 8 hours of injury.

  Not all "improvements" may have been of functional significance, but the use of methylprednisolone is currently recommended.

  Regimen
  30 mg/kg bolus over 15 minutes
  45 minute pause
  5·4 mg/kg/hr continuous infusion for 23 hours.

Reference– The Second National Acute Spinal Injury Study. Young W, Bracken MB. J. Neurotrauma 1992, 9 (Suppl 1): S397 – 405.

(vi) Nasogastric tube.

(vii) Urinary catheter.

(viii) Maintain normothermia (temperature regulation may be lost).

(ix) Lift or log roll two hourly to avoid pressure areas.

(x) Suspect other injuries, eg:
  (a) Head injury.
  (b) Haemopneumothorax or ruptured aorta with thoracic spine injury.
  (c) Ruptured abdominal viscus with thoracolumbar injury. Particularly consider duodenal or other retroperitoneal injury with 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

(i) Unconscious patient:
- (a) lateral cervical spine must visualise to T1/T2. "Swimmer's" view may be necessary, or
- (b) CT scan of any remaining vertebrae not clearly seen on plain films, and/or cervical segments seen to be fractured on plain films.
- (c) Careful dynamic views if instability suspected and fracture not demonstrated, with medical supervision.
- (d) Thoraco-lumbar spine AP and lateral, depending on mechanism of injury.

(ii) Conscious patient complaining of neck pain:
- (a) AP, lateral, oblique and odontoid views. MUST VISUALISE TO T1/T2. "Swimmer's" view or CT scan may be necessary in some patients,
- (b) Dynamic (lateral flexion/extension) if static Xray appears normal, with medical supervision, to exclude ligamentous injury,
- (c) Repeat (a) and (b) if patient continues to complain of neck pain over subsequent days/weeks, especially if muscle spasm restricts movement on initial Xrays,
- (d) CT of injured segments.

(iii) Conscious patient complaining of back pain:
- (a) AP and lateral Xrays of the thoracolumbar spine and pelvis,
- (b) CT scan of burst fractures or other fractures where compromise of the spinal canal is suspected,
- (c) Consider oral contrast CT of upper gastrointestinal tract if duodenal injury is suspected.

ADMISSION CRITERIA

All patients with proven or potential spinal injury.

MOST APPROPRIATE HOSPITAL FOR ADMISSION

(i) Local/district hospital – pain from soft tissue injury ± uncomplicated spinal fracture.

(ii) Major neurosurgical/orthopaedic referral centre – minor spinal cord or nerve root injury, or complex spinal fracture, with sphincter function preserved.

(iii) Dedicated Spinal Injury Unit – significant or deteriorating spinal cord, cauda equina or nerve root injury, or with sphincter disturbance.

CRITERIA FOR CONSULTATION

Spinal Injury Unit should be contacted if there is:

(i) Evidence of spinal cord or nerve root damage.

(ii) Concern regarding spinal stability.

MANAGEMENT FOR 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 require admission to hospital.

- All patients who sustain a moderate head injury should, where possible, undergo an urgent CT scan of the brain.
- Particular attention needs to be directed to patients with multiple system trauma and/or age > 40 years.

1. PRIMARY SURVEY

A Airway.

B Breathing.

C Circulation.

D Disability: neurological.

E Exposure.

2. RESUSCITATION

Management of life-threatening conditions.

3. SECONDARY SURVEY

- Initial sign assessment.
- 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.
- Operations.
- Stabilise for transfer.

DEFINITIVE NEUROSURGICAL MANAGEMENT

A. CT SCAN AVAILABLE

a) Normal scan

Continue regular observations.

Repeat the CT scan for clinical indications.

b) Abnormal scan

i) Neurosurgical consultation, using teleradiology if available.

ii) Haematoma or other surgical condition – operating theatre or transfer to neurosurgical unit.

iii) Not requiring surgery
- repeat scan between 24 and 36 hours to exclude delayed intracranial haematoma,
- treat other injuries as prioritised.

i) Consider ICP monitoring if:
- prolonged anaesthesia necessary,
- ventilation necessary for any cause eg multitrauma,
- CT scan worsening,
- after drainage of intracranial haematoma, eg intra operative swelling, or post operative confusion.

B. CT SCAN NOT READILY AVAILABLE (Rural or remote location)

a) Skull xray – presence of a fracture increases the probability of intracranial pathology, particularly a haematoma.

b) Neurosurgical consultation and/or transfer if:
- No improvement in the neurological level 4 – 6 hours after establishment of the post-resuscitation GCS.
- Deterioration of post-resuscitation GCS by 2 or more points at any time.

Modified after the Early Management of Severe Trauma Manual, National Road Trauma Committee, Royal Australasian College of Surgeons, AH Massma & Co, Melbourne, 1989.

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 – antibiotic therapy.
3. Penetrating craniocerebral injury – early neurosurgical repair and antibiotic therapy.

COMMENT

The indication for prophylactic antibiotic therapy is controversial.

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 requiring pain relief (not 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.

The value for prophylactic anti-convulsant therapy beyond the first week is controversial. A neurosurgical consultation is indicated both for the cause of the epilepsy and for consideration for anti-convulsant therapy.

COMMENT

If prophylactic anti-convulsant therapy is given one approach is

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

In the unconscious patient, intravenous phenytoin 1 Gm is given (<50 mg/min), and 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.
2. Support 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

1. Shave at least 3cms around the wound.
2. Gently palpate the laceration with a gloved finger. This may provide information regarding an underlying fracture.
3. If a fracture is found unexpectedly, do not remove bone fragments: contact your neurosurgeon at once.
4. Scalp wounds may bleed profusely and cause hypotension. Secure haemostasis by pressure or suturing early.
5. If the wound edges are badly torn, excise non-viable scalp and where possible suture the scalp in two layers.

MINOR HEAD INJURY

1. A minor head injury is defined as one where the Glasgow Coma Score is 14 – 15.
2. Admit and observe the patient if:
   (a) there has been loss of consciousness or a period of post-traumatic amnesia – see comment below,
   (b) the patient remains confused,
   (c) the patient is under 5 or over 50 years of age,
   (d) focal neurological signs,
   (e) severe headache with or without vomiting.

DISCHARGE OF A MINOR HEAD INJURY PATIENT

Criteria:

1. Orientated in time and place.
2. No focal neurological signs.
3. No headache or vomiting.
4. No skull fracture.
5. A responsible person is available to continue observation of the patient.
6. Discharge check list – advise to report back to hospital immediately if:
   (a) vomiting,
   (b) complains of severe headache or dizziness,
   (c) becomes restless, drowsy or unconscious,
   (d) 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 in 6 above are present after observation for 4 hours in the Emergency Department.

PRIMARY SURVEY

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

NURSING 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:
   – Insert urinary catheter, unless contraindicated. Check with medical officer if a pelvic or urethral injury is suspected,
   – 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 15° – 30° once hypotension has been treated,
   – Unconscious, unintubated patients in whom a spinal injury has been excluded are nursed in the lateral position.
7. Confused patients:
   – Give oxygen therapy,
   – Avoid sedation as this will mask neurological changes,
   – Close supervision is essential.
8. Management of CSF leaks, 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.**

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 >4 hours after arrival at the major trauma centre.

  (Exclusions are: ICP Monitoring or clinical decision by the surgical team to defer).
- Patient transferred from initial major trauma centre to an equivalent service in another hospital within 12 hours of 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.