

ACUTE MANAGEMENT OF TRAUMATIC BRAIN INJURY (Clinical aspects of head and cervical spine trauma)

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Management of traumatic brain injury focuses on stabilisation of the patient and prevention of secondary neuronal injury to avoid further loss of neurons. Full neuromonitoring including intracranial pressure measurement are rarely available prior to the patient's arrival in the intensive care unit. Significant neurological damage can occur between the time of injury and CT scanning, accurate measurement of ICP and other parameters. The acute management of these patients is therefore directed towards assuming there is significant intracranial pathology and instituting measures to protect living brain tissue.

ASSESSMENT

Assessment of brain injury hinges on evaluation of the Glasgow Coma Score (GCS) and examination of the pupils. Traditionally a GCS of below 9 is considered to reflect severe brain injury. However with improvements in prehospital care and greater knowledge of brain injury, patients are arriving in emergency departments earlier and their brain injury may still be evolving. Therefore the following measures should be considered and probably instituted in all patients with coma scores of 12 or below.

Hypotension will adversely affect cerebral perfusion and therefore lower the Glasgow Coma Score. However brain injury management should be instituted on the basis of the initial examination and there should be no delay to assess whether the GCS improves with volume resuscitation. It is important to identify signs of impending transtentorial herniation as this will affect the course of the immediate management of these patients. This is identified by unilateral abnormal posturing and/or the presence of a unilateral dilated pupil.

Serial assessment is vital. Patients may arrive with a mildly impaired GCS and rapidly deteriorate due to expanding haematomas or increasing cerebral swelling. Pupils may be initially normal and then dilate as intracranial pressure rises and the brain starts to herniate.

MANAGEMENT

The specific goals in the acute management of severe traumatic brain injury are:

1. Protect the airway & oxygenate
2. Ventilate to normocapnia
3. Correct hypovolaemia and hypotension
4. CT Scan as soon as appropriate
5. Neurosurgery if indicated
6. Intensive Care for further monitoring and management

Hypoxia and hypotension are the greatest threat to functional outcome in brain injury. Early acute control of the above three parameters may have more impact than all other measures subsequently employed. Progressive neuronal loss occurs from the time of injury, not the time of arrival in hospital. Rapid sequence intubation should be used where available to secure the airway, provide adequate oxygenation and control ventilation. Hypovolaemia and hypotension must be corrected early and take priority over other interventions for the brain injury. Other injuries causing haemorrhage must be addressed first (or simultaneously) so that an adequate cerebral perfusion pressure is maintained. Patients should be kept sedated to prevent coughing, Valsalva manoeuvres and from dysynchrony with the ventilator, as these increase intracranial pressure.

Many of the interventions used in the management of intracranial pressure may have a detrimental effect on cardiovascular haemodynamics (eg. mannitol), which in turn will have a detrimental effect on cerebral perfusion. In addition some measures may be counterproductive when used without adequate monitoring (eg. hyperventilation). Thus these further interventions are used without guidance from CT scans or ICP monitoring only when there is evidence of impending brain herniation (unilateral posturing and/or unilateral dilated pupil).

A CT scan of the brain should be obtained when appropriate, as dictated by the presence of other injuries and physiological disturbances. This will delineate the brain injury and determine whether surgery is indicated to remove an intracranial mass lesion (epidural / subdural haematoma), and the degree of diffuse injury and cerebral swelling present.

During this period there is potentially continuing cerebral ischaemia and neuronal death and timeliness is of the essence. There should be no unnecessary investigations or procedures and damage control techniques should be employed as necessary. No spinal or long bone imaging should be undertaken prior to CT scanning as these investigations will not affect the immediate patient management. The haemodynamically unstable patient should have minimum investigations, control of haemorrhage by the simplest means appropriate (and abbreviated surgery if necessary) and then CT scan and treatment of the brain injury.

If there are signs of impending transtentorial herniation (unilateral posturing and/or unilateral dilated pupil) or if there is rapid progressive neurological deterioration (without extracranial cause), then there is significant intracranial hypertension and measures should be instituted to control ICP immediately. Hyperventilation should be instituted to reduce the PaCO₂ to no lower than 3.5kPa (25mmHg) and mannitol should be administered as a bolus. Oxygenation and cerebral perfusion must be maintained. CT scanning is emergent, as is surgery if indicated.

If there are other injuries leading to haemorrhage and hypotension these still take priority. However it may be necessary to consider treatment of the brain injury simultaneously with management of these injuries, even without a CT scan to guide therapy. Blind burr holes to detect extra-axial collections may be appropriate as a last resort in these cases.

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INITIAL MANAGEMENT AND ASSESSMENT OF SPINAL INJURY

SPINAL INJURY

Spinal injury occurs in approximately 2% of the trauma population, and the incidence is higher in severe, multisystem injury. Road traffic incidents are the most common cause of injury, followed by falls and sporting injuries.

Approximately 40% of spinal injuries occur in the cervical spine. Around 5% of unstable spinal injuries are associated with a second, possible non-contiguous injury elsewhere in the spinal column. Up to 2% of unstable spinal injuries are due to soft tissue disruption and have no associated fracture.

The delayed or missed injury rate has been reported as high as 33%, but averages 5%. Delayed or missed diagnosis is usually due to failure to suspect an injury to the cervical spine, or to inadequate cervical spine radiology and incorrect interpretation of radiographs.

INDICATIONS FOR SPINAL IMMOBILISATION

Very few studies define the criteria used to decide who is at risk from cervical spine injury.

Blunt

All patients with sufficient mechanism of injury should be considered to have a spinal injury until proven otherwise.

Penetrating

Gunshot wounds that have traversed the spinal column may produce unstable injuries and caution should be exercised. Gunshot wounds to the cranium alone are not associated with a risk of cervical spine trauma. It is not necessary to immobilise stab injuries. Spinal immobilisation devices may interfere with the recognition and management of life-threatening conditions.

TECHNIQUES OF IMMOBILISATION AND PATIENT HANDLING

The spine should be protected at all times during the management of the multiply injured patient. The ideal position is with the whole spine immobilised in a neutral position on a firm surface. This may be achieved manually or with a combination of semi-rigid cervical collar, side head supports and strapping. Strapping should be applied to the shoulders and pelvis as well as the head to prevent the neck becoming the centre of rotation of the body.

Prehospital concerns

Manual spinal protection should be instituted immediately. The application of definitive immobilisation devices should not take precedence over life-saving procedures.

If the neck is not in the neutral position, an attempt should be made to achieve alignment. If the patient is awake and co-operative, they should actively move their neck into line. If unconscious or unable to co-operate this is done passively. If there is any pain, neurological deterioration or resistance to movement the procedure should be abandoned and the neck splinted in the current position.

Long spine (rescue) boards are valuable primarily for extrication from vehicles. Repeated transfers to and from the board may compromise spinal protection and induce a significant amount of spinal movement. Patients may also be transferred on a scoop stretcher and/or vacuum mattress. There is little place for the short spine board or spinal extrication devices in the prehospital environment.

In-hospital

The spine board should be removed as soon practical once the patient is on a firm trolley. Prolonged use of spine boards can rapidly lead to pressure injuries. Full immobilisation should be maintained. Manual protection should be reinstated if restraints have to be removed for examination or procedures (eg. intubation).

The log-roll is the standard manoeuvre to allow examination of the back and transfer on and off back boards. Four people are required, one holding the head and coordinating the roll, and three to roll the chest, pelvis and limbs (figure?). The number and degree of rolls should be kept to a minimum. Rigid transfer slides (eg. *Patslide*) are useful for transferring the patient from one surface to another (eg CT scanner, operating table).

Patients who are agitated or restless due to shock, hypoxia, head injury or intoxication may be impossible to immobilise adequately. Forced restraints or manual fixation of the head may risk further injury to the spine. It may be necessary to remove immobilisation devices and allow the patient to move unhindered. Anaesthesia may be necessary to allow adequate diagnosis and therapy.

Intubation of the trauma victim is best achieved via rapid sequence induction of anaesthesia and orotracheal intubation, though the technique used should ultimately depend on the skills of the operator. The collar should be removed and manual, in-line protection re-instituted for the

manoeuvre. The routine use of a gum elastic bougie is recommended, minimising cervical movement by allowing intubation with a minimal visualisation of the larynx.

CERVICAL SPINE ASSESSMENT

Spinal immobilisation is a priority in multiple trauma, spinal clearance is not.

The spine should be assessed and cleared when appropriate, given the injury characteristics and physiological state. Imaging the spine does not take precedence over life-saving diagnostic and therapeutic procedures.

Clinical clearance

Numerous large prospective studies have described the large cost and low yield of the indiscriminate use of cervical spine radiology in trauma patients. Although there are case reports of bony or ligamentous injuries in asymptomatic patients, no asymptomatic patient in the literature has had an unstable cervical spine fracture or suffered neurological deterioration due to the injury.

There is no conclusive evidence in the literature that supports clinical clearance of the spine in the prehospital environment. There is enough variation between prehospital and in-hospital assessments to recommend that prehospital removal of spinal immobilisation be avoided.

Mechanism of injury alone does not determine the need for radiological investigation.

The cervical spine may be cleared clinically if the following preconditions are met:

- Fully alert and orientated
- No head injury
- No drugs or alcohol
- No neck pain
- No abnormal neurology
- No significant other 'distracting' injury

The neck may then be examined. If there is no bruising or deformity, no tenderness and a pain free range of **active** movements, the cervical spine can be cleared. Radiographic studies of the cervical spine are not indicated.

Radiology

Radiological evaluation of the cervical spine is indicated for all patients who do not meet the criteria for clinical clearance as described above. Imaging studies should be technically adequate and interpreted by experienced clinicians.

Plain Film Radiology

The standard 3 view plain film series is the lateral, antero-posterior and open-mouth view.

The lateral cervical spine film must include the base of the occiput and the top of the first thoracic vertebra. The lateral view alone is inadequate and will miss up to 15% of cervical spine injuries. The lower cervical spine may be difficult to examine and caudal traction on the arms or a swimmer's view may be of value. However repeated attempts at plain radiography are usually unsuccessful and a CT scan of the region is indicated.

The antero-posterior view must include the spinous processes of all the cervical vertebrae from C2 to T1.

The open-mouth view should visualise the lateral masses of C1 and the entire odontoid peg. Bite blocks may improve the open-mouth view. In the unconscious, intubated patient the open mouth view is inadequate and should be replaced by a CT scan from the occiput to C2.

The addition of two oblique views to the standard 3-view series does not increase the sensitivity of plain film evaluation. Some centres use two supine or trauma-oblique views to replace the antero-posterior view. These views can provide excellent visualisation of the posterior elements of the cervical spine and provide significantly more information than the antero-posterior view.

CT Scanning

Thin-cut (2mm) axial CT scanning on specific bone windows, with sagittal and coronal reconstruction should be used to evaluate abnormal, suspicious or poorly visualised areas on plain radiology. CT scanning of the occiput to C2 should replace the open-mouth radiograph in unconscious, intubated patients.

With technically adequate studies and experienced interpretation, the combination of plain radiology and directed CT scanning provides a false negative rate of less than 0.1%. There is currently

insufficient evidence to support primary helical CT scanning of the entire cervical spine without initial plain film radiology.

Assessment of soft tissue injury in the awake patient

The patient with normal radiological evaluation as described above who has persistent symptoms requires an evaluation of soft tissue injury with static flexion and extension imaging of the neck at the extremes of the **active** range of motion.

Pure disc or ligamentous disruption can produce unstable cervical spine injuries and will usually be detected by such imaging. The movements are safe provided the patient performs them actively and halts if there is an increase in pain or neurological symptoms.

Assessment of soft tissue injury in the comatose patient

Patients who are unconscious and intubated are unable to describe symptoms of neck pain or neurology. Despite normal plain films or CT scan there may be an occult disc, ligament, cord or nerve root injury (approximately 1-2% of spine injuries). If these patients are expected to regain consciousness within 24 hours spinal immobilisation may be left in place and the patient clinically assessed when fully awake.

Prolonged spinal immobilisation in critically ill patients leads to decubitus ulcers and deep venous thromboses while compromising nursing care, respiratory support and the management of traumatic brain injury. A semi-rigid collar is not necessary in the adequately sedated, ventilated patient. A soft collar may provide a visual clue to remind carers that the spine is not cleared.

There are three radiological options in the patient who will remain unconscious for a prolonged period – magnetic resonance imaging, dynamic flexion/extension fluoroscopy and whole cervical spine CT. There is currently insufficient evidence to support one modality over the other. However CT scanning of the whole neck is rapidly being adopted as the most appropriate solution for these patients. Patients who will not regain consciousness quickly should be cared for in facilities where one of these modalities is available to avoid prolonged immobilisation and its sequelae.

Magnetic Resonance Imaging (MRI)

MRI is extremely sensitive at detecting soft tissue injuries without stressing the cervical spine. However the significance of such injuries with regards to the clinical stability of the spine is not clear. MRI of ventilated patients is a significant undertaking requiring special non-ferromagnetic equipment. However the increasing use of MRI for critically ill patients is making this equipment cheaper and more widely available.

Dynamic Flexion/Extension Fluoroscopy

Passive dynamic flexion/extension stressing of the cervical spine, performed by an experienced clinician, should reveal most significant ligamentous injuries. Several studies have reported its safety and efficacy although false negative studies have been reported. Further rigorous investigation into its application is necessary before it can be fully recommended.

Helical CT scanning

In recent years, the concept of full cervical spine CT for assessment of spinal injury has emerged. There are several studies that have demonstrated the robustness of the full CT scan, with sagittal and coronal reconstructions, for the exclusion of significant spinal injury.

Widening, slippage or rotational abnormalities of the cervical vertebrae suggest soft tissue injury. An absence of such signs appears to exclude significant instability. Abnormal findings on the CT scan are evaluated by a spinal surgeon and additional modalities, such as MRI, can be employed. No study has missed a cervical spine injury, and no study has identified an injury on plain films that was not apparent on the CT scan.

Assessment of the patient with abnormal neurological examination

All patients with an abnormal neurological examination should be evaluated in a specialist unit and have an MRI scan of the spine.

Patients who report transient neurological symptoms (the ‘stinger’ or ‘burner’) but who have a normal exam should also undergo an MRI assessment of their spinal cord.

Paediatric

Spinal evaluation in the paediatric population is similar to those in adults. However there is little evidence on the validity of clinical clearance of the cervical spine in this age group. Clinical and radiological evaluation of the immature anatomy requires particular care, with attention paid to the X-ray variants of pseudo-subluxation and anterior translation. Spinal cord injury without radiographic plain film abnormality may be more common in this age group and a thorough neurological examination is important.

Thoracolumbar spine assessment

Thoracolumbar spine imaging is indicated if there is pain, bruising, swelling, deformity or abnormal neurology attributable to the thoracic or lumbar spinal regions. Unconscious patients who cannot be assessed clinically also require radiological clearance of the whole spine.

Patients with one fracture of the spine have a 5% chance of a second fracture, which may be non-contiguous. Detection of one injury should prompt a full spinal evaluation.

The basic investigation is antero-posterior and lateral plain films of the thoracic and lumbar spine. These are supplemented with CT scanning of abnormal areas or those difficult to visualise (especially the upper thoracic spine).

Transfer to a specialist unit

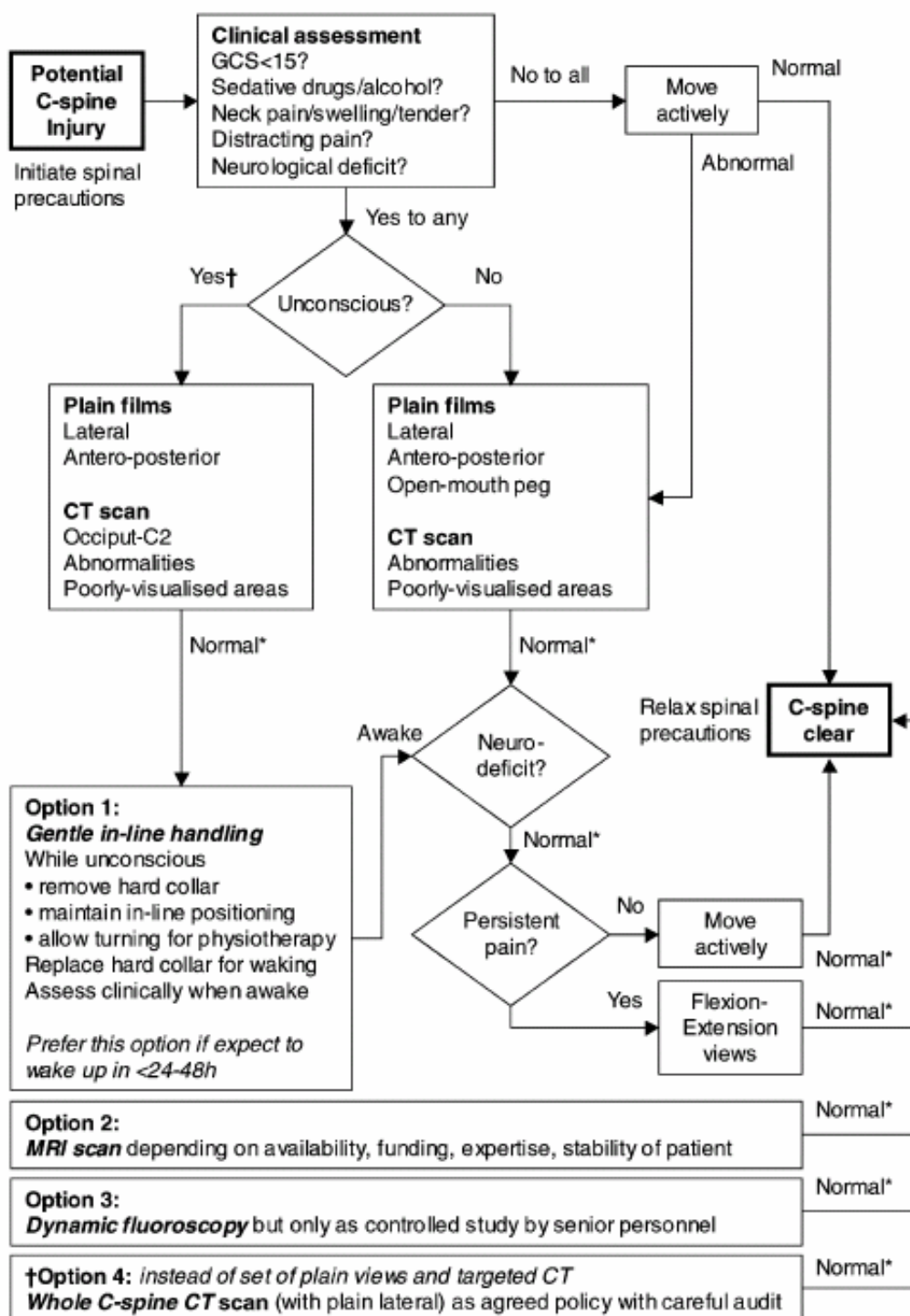
Consultation with a specialist spinal unit is indicated if:

- There is uncertainty in interpretation of spine radiology
- Appropriate imaging technologies are not available
- A spine or spinal cord injury is identified

Patients may require transfer to other units for definitive care of other injuries such as head or pelvic trauma. There should be no unnecessary delays in the transport of these patients. Transfer should not wait for unnecessary diagnostic procedures that will not alter management. This includes radiological imaging of the spine. The spine should be immobilised and protected for the transfer as detailed above.

Algorithm for spinal clearance

Cervical Spinal Clearance Algorithm

* If Abnormal, refer to **Specialist in Spinal Injury**

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