Management of acute cervical spine injury

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INTRODUCTION

Between 2 and 5% of patients suffering from blunt polytrauma have a cervical spine injury. Cervical spine injuries tend to occur between 15 and 45 years and are seen more commonly in males (7:3). The most common level of fracture is C2 whereas dislocations occur most commonly at the C5/6 and C6/7 levels.[1]

The initial management of the polytrauma patient follows the Advanced Trauma Life Support (ATLS) practice of airway and cervical spine control, breathing and circulation. Assessment of injuries takes place initially in the form of a primary survey, during which time life-threatening injuries are excluded. This is followed by a secondary survey when a more detailed assessment of injuries is carried out, including spinal injuries. All polytrauma patients should be assumed to have a cervical spinal injury until proven otherwise; precautionary cervical spine immobilisation should be instigated for all patients at the scene of the injury by pre-hospital staff. By immobilising the spine immediately, major injuries can be treated at the scene, or on arrival at hospital, without the risk of disrupting an unstable cervical spine injury and causing secondary neurological injury.[2]

IMMOBILISATION OF THE SPINE

Until spinal injuries can be excluded or 'cleared' the spine must be immobilised and this can be achieved in a number of ways. However, all methods continue to allow varying degrees of movement. Soft cervical collars are the most inefficient and provide very little stability and therefore should not be used. Whereas the application of Gardner-Wells forceps can be considered the most effective technique it is rarely a practical solution in the acute setting. Two methods are in common use, compromising between simplicity of application and effectiveness: these are semi-rigid collars and manual in-line stabilisation (MILS). In the prehospital setting, MILS should be applied as an initial manoeuvre as the patient's airway is assessed and then, when available, a semi-rigid collar should be applied. Further stability is achieved by using sandbags or blocks on either side of the head, with two non-elastic self adhesive tapes strapped across the head and on to a rigid spinal board. Users should be aware of the disadvantages of semi-rigid collars (Table 1).

Laryngoscopy is more difficult with a semi-rigid collar in place. If laryngoscopy and intubation is urgently indicated the collar should be removed and MILS applied instead (Figure 1). During laryngoscopy MILS reduces cervical spine movement by up to 60%. An assistant squatting behind the patient applies MILS by placing his or her fingers on the mastoid processes and the thumbs on the temporoparietal area of the skull. The hands are then pressed against the spinal board and act to oppose movements of the head caused by the anaesthetist. Axial traction should not be applied because of the risk of exacerbating cervical spinal injuries. Until the spine is 'cleared' a log roll should be performed for any movement or transfer of the patient.[3, 4]

Table 1. *Disadvantages of semi-rigid collars*

Total immobilisation is not achieved
Increases the chance of difficult laryngoscopy
Can exacerbate cervical spinal injuries
Can cause airway obstruction
Can increase intracranial pressure (ICP)
Increases risk of aspiration
Increases risk of deep vein thrombosis (DVT)
May cause significant decubitus ulcers

Summary

This article covers the aspects of acute cervical spine injury that are relevant to anaesthetists. The anaesthetist's involvement will range from participating in the resuscitation of patients with polytrauma to the provision of safe anaesthesia to allow surgical treatment for cervical spine or other injuries. The importance of early immobilisation is emphasised and strategies used to 'clear' the cervical spine are described.

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Clearing the cervical spine

The exclusion of spinal injuries or 'clearance' requires the exclusion of both bony and ligamentous injuries, and ideally requires a combination of clinical assessment and radiological investigation. Clinical clearance of cervical spine injury is difficult or impossible in patients who are unconscious (due to sedation, anaesthesia or head injury) or have distracting injuries to other parts of the body. Anaesthetists should understand the principles of clearing the cervical spine, since a proportion of patients cannot be clinically cleared for several days and prolonged cervical spine immobilisation (with its inherent risks) may be necessary.

Figure 1. *(A) Application of manual in-line stabilisation (MILS). (B) Bimanual application of cricoid pressure*

Two sets of screening clinical criteria have been proposed prior to imaging the cervical spine, in an attempt to reduce the number of unnecessary X-rays. These are the Canadian C-spine rule and the National Emergency X-radiography Utilisation Study (NEXUS) criteria. Both are sensitive tools.[1] The NEXUS criteria include 'no evidence of posterior cervical tenderness', 'no history of intoxication', 'an alert patient', 'no focal neurological deficit' and 'no painful distracting injuries'. If all the criteria are fulfilled then the cervical spine can be cleared without the need for imaging.

If these screening tests indicate that radiological imaging is required, the strategy needed to clear the cervical spine differs depending on whether the patient is awake or unconscious. In the alert patient it is generally agreed that clearing the spine requires a 3-view plain X-ray series (lateral and AP cervical spine views with a 'peg view'), with a computerised tomogram (CT) for areas that cannot be visualised or are suspicious. If these are normal, but the patient is complaining of neck pain, a lateral cervical spine X-ray should then be performed in flexion and extension.

In the unconscious, since ligamentous injuries are difficult to exclude with accuracy using radiography, there is less agreement on the best method. Three options are available:

1. The cervical spine is left uncleared and the spine kept immobilised until the patient is fully conscious. Inherent with this method are the complications of immobilisation for any long duration, particularly decubitus ulcers.

2. Alternatively the patient has a combination of plain X-rays and CT scans to exclude bony injuries and, where available, this should be followed by magnetic resonance imaging (MRI) or fluoroscopy to exclude ligamentous injuries.

3. MRI may not be available and there are considerable practical difficulties associated with its use in unconscious critically-ill patients. A thin-cut CT scan is an alternative, including coronal and sagittal reconstruction of the entire cervical spine. Although less sensitive than MRI for the detection of ligamentous injury, CT is more practical and the number of unstable ligamentous injuries missed is extremely small.[1,3,5] It is worth remembering that the incidence of ligamentous injury without bony injury in blunt trauma is 0.02%.

Figure 2. *Lateral cervical spine X-ray, showing fracture-dislocation of C4 (A) on C5 (B)*

AIRWAY MANAGEMENT

Patients may require airway instrumentation as an emergency (for airway obstruction, respiratory failure or as part of the management of a severe head injury) or later in their management as part of anaesthesia for surgical management of other injuries.

The extent to which the injured cervical spine can be safely moved is unknown. Therefore the main aim during management of the airway, in patients with potential cervical spine injuries, is to cause the least amount of movement possible. All airway manoeuvres will produce some degree of movement of the cervical spine, including jaw thrust, chin lift

and insertion of oral pharyngeal airways. Mask ventilation is known to produce more movement than direct laryngoscopy.

Most anaesthetists are comfortable with direct laryngoscopy and oral intubation and it is therefore the obvious first choice in establishing a definitive airway in the polytrauma setting. During direct laryngoscopy, significant movement occurs at the occipito-atlanto-axial joint. Manual in-line stabilisation (MILS) is used to minimise this movement. Previous anecdotal reports of the spinal cord being damaged following direct laryngoscopy in patients with unstable cervical spine injuries were based on weak coincidental evidence.[6] Therefore the technique of direct laryngoscopy with MILS is now an accepted safe technique for managing the airway in patients with potential cervical spine injuries. In addition the gum elastic bougie is a useful adjunct during direct laryngoscopy. It allows the anaesthetist to accept inferior views of the vocal cords thereby limiting the forces transmitted to the cervical spine and therefore movement. No particular laryngoscope blade has shown a superior benefit except the McCoy levering laryngoscope which will improve the view at laryngoscopy by up to 50% in simulated cervical spinal injuries. The McCoy is therefore an alternative to the Macintosh for those experienced in its use (Figure 4).

The laryngeal mask airway (LMA) or intubating laryngeal mask airway are both extremely useful in the failed or difficult intubation. The forces applied during insertion can cause posterior displacement of the cervical spine but the movement is less than that seen in direct laryngoscopy. In the 'can't intubate, can't ventilate' scenario there should be early consideration of the surgical airway or cricothyroidotomy. These techniques can produce posterior displacement of the cervical spine but this should not prevent the use of this life-saving procedure.

Nasal intubation has formerly been included in the Advanced Trauma Life Support course airway algorithm. However, the low success rate and high incidence of epistaxis and layngospasm has resulted in this technique been superseded. Awake fibreoptic intubation has consistently produced the least amount of movement of the cervical spine in comparative studies. However in the acute trauma setting, blood or vomit in the airway may make the technique impossible. Further disadvantages include a relatively prolonged time to intubation,
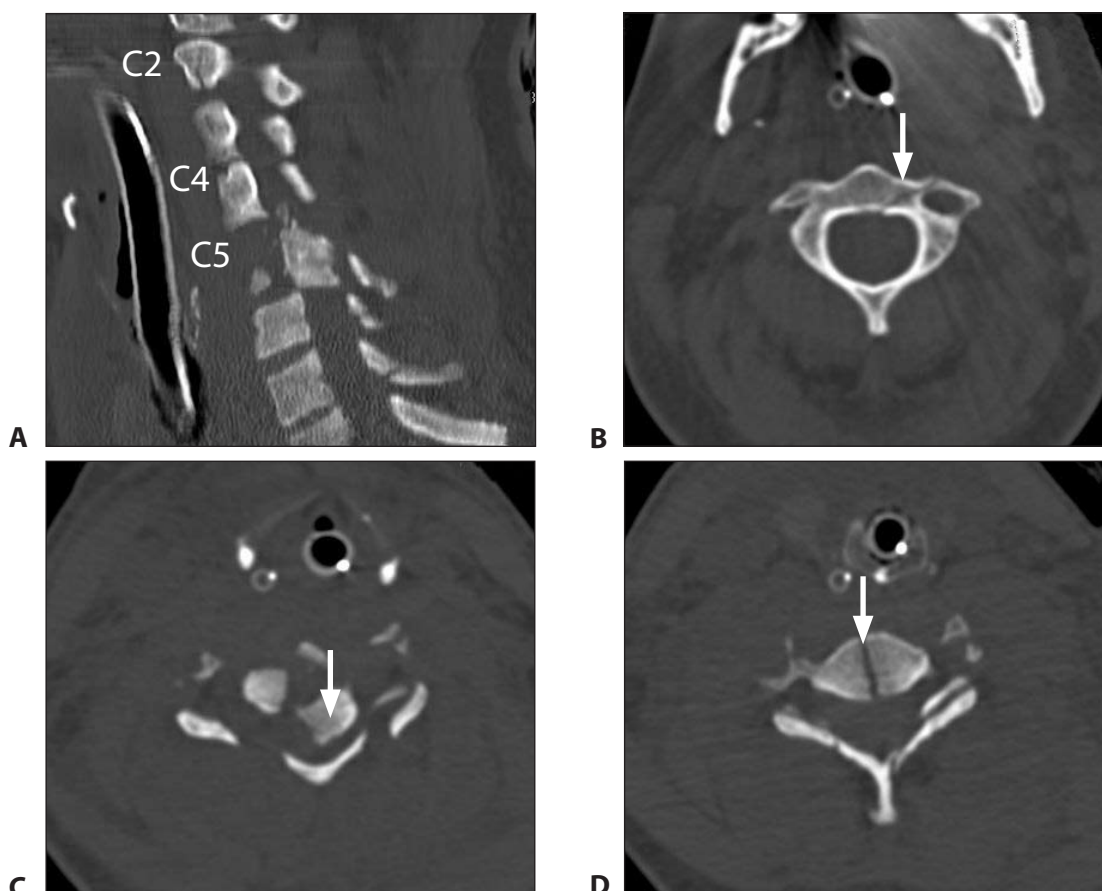
Figure 3. *Computed Tomography (CT) of the cervical spine. (A) sagittal reconstruction showing fractures at multiple levels; (B) transverse section fracture through the vertebral body of C2 to the left of the dens (arrowed); (C) transverse section - comminuted fracture with displacement of the left hemi-body of C5 into the spinal canal (arrow), presumably compressing the cord; (D) transverse section - midline fracture through the vertebral body of C6 (arrow), with bilateral fractures of the laminae of the vertebral arch*

risk of aspiration and, if gagging or coughing occur, an increase in the intracranial pressure (ICP). Despite theses concerns, for those anaesthetists with sufficient expertise and in the appropriately chosen patient, awake fibreoptic intubation is an option.[1,4]

Suxamethonium is safe to use in the first 72 hours and after 9 months following the injury. In the intervening period there is a risk of suxamethonium-induced hyperkalaemia due to denervation hypersensitivity and therefore should be avoided.

Spinal cord injury results in important pathophysiological consequences in various systems of the body that require appropriate treatment.

RESPIRATORY MANAGEMENT

Respiratory failure is common and pulmonary complications are the leading cause of death. The diaphragm (C3-C5) and intercostals (T1-T11) are the main inspiratory muscles. The accessory inspiratory muscles consist of sternocleidomastoid, trapezius (both 11th cranial nerve), and the scalene muscles (C3-C8). Expiration is a passive process but forced expiration requires the abdominal musculature (T6-T12). The abdominal muscles are therefore important for coughing and clearing respiratory secretions.

The severity of respiratory failure depends on the level and completeness of the injury. Complete dissection of the spinal cord above C3 will cause apnoea and death unless the patient receives immediate ventilatory support. For lesions between C3 to C5 the degree of respiratory failure is variable and the vital capacity can be reduced to 15% of normal. These patients are at risk of increasing diaphragmatic fatigue due to slowly progressive ascending injury resulting from cord oedema. This commonly results in retention of secretions and decompensation around day 4 post-injury, and intubation and ventilation is required. Where facilities are available some would electively intubate and ventilate patients in this group.

Initially the intercostal muscles are flaccid, allowing in-drawing of the chest during inspiration with a consequential compromise in respiratory

Figure 4. *The McCoy levering laryngoscope*

function. This gives the characteristic appearance of 'paradoxical breathing' – on inspiration the diaphragm moves down, pushing the abdominal wall out and drawing the chest wall inwards. As the muscles become spastic, respiratory function improves, allowing potential weaning of the patient from the ventilator. It is important to remember that paralysis of the abdominal musculature means that in the upright position the diaphragm works in a lower and less effective position and so a supine position is preferred. Abdominal binders are an alterative. Patients with high cervical spine lesions have increased bronchial secretions, possibly due to altered neuronal control of mucous glands.

In general, the decision to intubate depends on several factors, including:[7,8]

- loss of innervation of the diaphragm,
- fatigue of innervated muscles of respiration,
- failure to clear secretions,
- history of aspiration,
- presence of other injuries e.g. head and chest injuries,
- premorbid conditions, especially respiratory disease.

CARDIOVASCULAR MANAGEMENT

Cardiovascular instability is particularly seen with high cervical cord injuries. At the time of injury there is an initial brief period of increased sympathetic activity resulting in hypertension, an increased risk of subendocardial infarction and arrhythmias. This is followed by a more sustained period of neurogenic shock, resulting from loss of sympathetic outflow from the spinal cord, which may last up to eight weeks. This is characterised by vasodilatation and bradycardia and tends to be seen only in lesions above T6. Bradycardia is caused by loss of cardiac sympathetic afferents and unopposed vagal activity and may lead to asystole. This can be treated with atropine.

Hypotension is due to the loss of peripheral vasoconstriction. The loss of sympathetic innervation to the heart means that increases in cardiac output are primarily achieved by increases in stroke volume. The initial treatment of hypotension involves intravenous fluid administration. Once preload responsiveness is lost, (i.e. the stroke volume cannot be increased further), then vasopressors will need to be commenced using either dopamine or norepinephrine, which are both α- and β_2-receptor agonists, thereby providing vasoconstriction, chronotropic and inotropic support to the heart.[7, 8]

The end-point of resuscitation is controversial. There is evidence that ongoing ischaemia and secondary spinal cord damage is successfully treated by raising the mean arterial pressure to 85mmHg for up to seven days.[9]

AUTONOMIC DYSREFLEXIA

This complication does not occur during the acute phase of spinal injury but is mentioned here for completeness. The condition can be triggered by various stimuli including surgery, bladder distension, bowel distension and cutaneous stimuli. Severe signs are seen with higher lesions, and it is rarely seen in patients with cord lesions below T10. The symptoms may start weeks to years following the spinal injury and include paroxysmal hypertension, headaches and bradycardia. Below the lesion cutaneous vasoconstriction, piloerection and bladder spasm may be seen. Above the lesion there may be flushing, sweating, nasal congestion and conjunctival congestion. The patient may complain of blurred vision and nausea.

If left untreated, complications include stroke, encephalopathy, seizures, myocardial infarction, arrhythmias and death. Management options include removal and avoidance of triggers such as the insertion of a urinary catheter. If surgery is planned, consider the use of spinal anaesthesia as this reliably prevents the symptom complex. Other options include increased depth of anaesthesia and vasodilators for the treatment of hypertension.[8]

VENOUS THROMBOSIS

The incidence is 40 to 100% in untreated patients with a spinal injury and pulmonary embolism is one of the leading causes of death in this group of patients. Prophylaxis must be started as soon as possible although there is no consensus as to exactly when or how this should be initiated. Treatment can be divided into two clear groups, pharmacological and non-pharmacological. Low-molecular-weight heparin is effective in preventing deep vein thrombosis (DVT), but is associated with an increased risk of haemorrhage within the injured spinal cord if given acutely. Therefore mechanical compression devices and graduated elastic stockings are often applied for the first 72 hours when the risk of DVT is low and anticoagulants considered thereafter. Prophylaxis should be continued for at least eight weeks.[7]

GASTROINTESTINAL MANAGEMENT

Bleeding due to stress ulceration should be prevented with an H_2 receptor antagonist such as ranitidine. Ileus and gastric distention can be treated with nasogastric suctioning and prokinetic drugs, e.g. metoclopramide or erythromycin.[8]

SPECIFIC TREATMENT

Different therapies have been tried, attempting to reduce the secondary neuronal injury due to cord ischaemia and inflammation. Although some have shown potential in animal studies most have not shown significant benefit in clinical studies. Only methylprednislone has shown any promise.

There have been four randomised, controlled trials involving high dose methylprednisolone. The most discussed are the three National Acute Spinal Injury Studies (NASCIS), showing that administration of methylprednisolone in the acute phase showed a slight but significant benefit. However, this was at the cost of increases in the incidence of pneumonia and sepsis and the trials were criticised on several levels. Therefore methylprednislone is only a treatment option and cannot be considered a standard of care.

Early surgical decompression has been shown to be benefit in animal models of spinal cord injury. To date the evidence in humans is lacking, and the timing of surgical decompression remains a topic of debate and ongoing research.[10]

SUMMARY

The initial management of patients involved in blunt trauma follows the ATLS principle of airway and cervical spine control, breathing and circulation. The spine is immobilised as soon as possible to prevent secondary neurological injury. However, extrication collars should be removed and MILS applied prior to establishing a definitive airway, where this is indicated. Despite movement at the occipito-atlanto-axial joint, direct laryngoscopy with MILS is an accepted safe method to manage the airway in patients with potential cervical spine injuries. The gum elastic bougie and the McCoy laryngoscope are useful tools in this context. A cervical spine injury is likely to result in respiratory failure and cardiovascular instability, which may require ventilatory and/or inotropic support.

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