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Spinal Injuries

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Introduction

Injury to the spinal cord occurs in approximately 10 to 15 people per million population per year in the UK. Of these, the majority are young healthy males aged between 18 and 35 years (male to female ratio 3:1) (1). The disability, reduced life expectancy and socioeconomic costs associated with spinal injury are so devastating that there is considerable anxiety surrounding both the potential for missed injuries and the pre-hospital management of patients who may have spinal injuries. Current pre-hospital practice is, therefore, to always consider the possibility of spinal injury in all trauma patients and to have a very low threshold for instituting full spinal precautions based on 'high risk' (high energy) mechanisms of injury such as road accidents and falls from height (2). As a result, large numbers of patients without spinal injury arrive in Accident and Emergency (A&E) Departments or other receiving facilities secured to long spine boards or vacuum mattresses with semi-rigid cervical collars and head immobilisation devices in place. While this standard of care is entirely appropriate in many circumstances, it is recognised that some patients may be inappropriately immobilised and that this may result in delays (both at the scene and in the receiving facility) as well as discomfort for the patient (3). Rescue from entrapment may be much quicker if, in appropriate circumstances, full spinal precautions can be safely avoided (Figure 1) (4). Similarly, delayed or prolonged evacuation from remote or operational environments may make spinal immobilisation, particularly if using improvised equipment, impossible to achieve and potentially harmful to the patient and rescuers (Figure 2) (5-7). Unnecessary immobilisation may also impose considerable logistic demands on rescue and transport assets as well as receiving facilities. In addition, there continues to be debate regarding actual immobilisation techniques (2,8-10) and whether there is any evidence to show benefit from pre-hospital spinal immobilisation at all (11).

This article provides guidance on the clinical assessment and management of the patient with potential spinal injury in the pre-hospital environment. It focuses on the acute problems associated with spinal cord injury and the appropriate use of full spinal precautions. It assumes familiarity with the principles of Battlefield Advanced Trauma Life Support and pre-hospital care (4,12-16).

Pathophysiology

Spinal injury is frequently associated with high energy trauma such as occurs in road traffic accidents and falls from height. In the military context, spinal injury following penetrating wounds and blasts is important. In most cases, spinal injury is rarely isolated and many patients will have multi-system injury. There are, however, a number of patients every year who sustain isolated spinal injuries in the context of sports or leisure activities such as gymnastics, rugby, horse riding, swimming (diving), skiing and cycling (17,18). The presence of an obvious 'high risk' (high energy) mechanism of injury in itself has not been shown to be useful in predicting the presence of clinically significant cervical spine injuries (19). Knowledge of the basic clinical anatomy of the spine and an ability to interpret simple clinical findings may provide additional information to guide pre-hospital management and the need for immobilisation.

The term 'spine' encompasses the vertebral column, the spinal canal and the spinal cord. The vertebral column comprises 7 cervical, 12 thoracic, 5 lumbar and 5 sacral vertebral bodies which all articulate. The cervical and lumbar vertebrae are relatively mobile in comparison to the thoracic and sacral vertebrae. Thus the junctions, or 'transition zones' between the relatively more and less mobile parts of the vertebral column (cervico-thoracic, thoraco-lumbar and lumbo-sacral junctions) are prone to injury. Although spinal cord injuries are invariably associated with vertebral fractures the converse is not true. Many vertebral fractures can be regarded as clinically insignificant with respect to stability. The 'stability' of the spine refers to the ability of the damaged vertebral column to withstand mechanical stress without further deformity and/or impingement on the cord. In determining stability after injury, the spine is considered in terms of anterior, middle and posterior columns. The anterior column consists of the anterior longitudinal ligament and the anterior parts of the vertebral body and intervertebral disc. The middle column includes the posterior longitudinal ligament and the posterior parts of the vertebral body

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Fig 1. This truck driver is trapped in the cab by his left leg after colliding with an agricultural vehicle. The left femur is fractured and there is an open displaced fracture of the left tibia and fibula. The left lower leg is trapped in metalwork. He has sternal tenderness and multiple abrasions but no other apparent injuries. He is conscious, calm and alert with a respiratory rate of 20 and a pulse of 130. He resists attempts to hold his head still and is finding the cervical collar uncomfortable. He denies any pain in the neck or back and has no tenderness on palpation or pain on movement. He cannot feel his left foot and there is considerable bleeding from the trapped leg. It was considered that despite the distracting injury, it was appropriate to manipulate the trapped limb under Ketamine sedation and extricate the driver quickly through the open door with careful handling rather than full spinal immobilisation. He had no other injuries. (Reproduced with consent).

Fig 2. In remote or resource limited environments the ability and desirability of spinal immobilisation may be very different from civilian practice. If this injured paratrooper has an open displaced fracture of the right tibia and fibula following a heavy landing, should he be fully immobilised for evacuation? British Army Picture Library Ref: 02700210. Crown Copyright.

and disc. The posterior column consists of the posterior elements and ligamentous complex. In simple terms, spinal stability depends on the integrity of at least two of the three columns. For example, the thoraco-lumbar compression or wedge fracture represents failure of the anterior column with forward flexion / compression but it is usually stable if the middle and posterior columns have remained intact. There is little risk of further injury. The burst fracture, however, results from compression of both the anterior and middle columns and it is often unstable. Although certain mechanisms of injury can be associated with specific stable or unstable fractures, the actual determination of stability in a patient with symptoms of a fracture but no neurological signs requires an experienced clinician and full radiographic examination (including computed tomography). All suspected vertebral fractures should, therefore, be regarded as unstable in the pre-hospital setting. The patient's reliability and symptoms and signs, not the

Box 1. Aide Memoire for Dermatomes and Myotomes.

Segment	Representative Dermatomes	Representative Myotomes
C5	Sensation over deltoid	Deltoid muscle
C6	Sensation over thumb	Wrist extensors
C7	Sensation over middle finger	Elbow extensors
C8	Sensation over little finger	Middle finger flexors
T1	Sensation over inner aspect elbow	Little finger abduction
T4	Sensation around nipple	-
T8	Sensation over xiphisternum	-
T10	Sensation around umbilicus	-
T12	Sensation around symphysis	-
L1	Sensation in inguinal region	-
L2	Sensation anterior upper thigh	Hip flexors
L3	Sensation anterior mid thigh	Knee extensors
L4	Sensation on medial aspect leg	Ankle dorsiflexors
L5	Sensation between 1st and 2nd toes	Long toe extensors
S1	Sensation on lateral border foot	Ankle plantar flexors
S3	Sensation over ischial tuberosity	-
S4/5	Sensation around perineum	-

mechanism of injury, are the key to deciding whether there may be a vertebral fracture (see below) (2,9,20).

All suspected vertebral fractures should be initially treated as unstable

The spinal canal contains the spinal cord, blood vessels and extradural fat. The cord typically extends to the lower margin of the L1 vertebral body in adults. From L1, the canal contains the lumbar, sacral and coccygeal spinal nerves (the cauda equina). The canal is narrowest in the thoracic area. Thoracic vertebral fractures which may be easily missed even in the hospital setting are, therefore, frequently associated with cord damage (21,22). In contrast, there is a large potential space behind the odontoid peg at C1 and fractures of the upper cervical vertebrae may not impinge on the cord at all. The spinal cord is supplied with blood by three longitudinal vessels within the spinal canal: one anterior spinal artery (supplying the anterior two thirds) and two posterior spinal arteries. Numerous radicular arteries along the length of the cord augment these three arteries. Despite this the cord is vulnerable to ischaemic damage at watershed areas in the mid thoracic region. In addition, the centre of the cord is a relative watershed area throughout its entire length. Profound hypotension or arterial damage secondary to primary or secondary injury may thus produce a variety of clinical cord syndromes depending on the vessels involved, the segmental level and the degree of damage in watershed areas.

Primary spinal cord injury (primary neurological damage) results from penetrating or blunt trauma that causes direct mechanical disruption of neural elements within the spinal cord or nerve roots. At the time of injury there is transient or permanent impingement on the cord by bone fragments, haematoma or soft tissue. Nothing can be done to alter this primary injury. Further deterioration in cord function may result from secondary phenomena occurring in the minutes and hours following primary injury. The common preventable causes of secondary injury to the spinal cord are hypoxia, hypotension and further mechanical disruption of the spine (23). Secondary injury results in increased oedema and further reduction in spinal perfusion around the damaged area of cord. The result is further deterioration in function. With high spinal injuries, this progression may lead to respiratory failure.

Secondary injury is caused by hypoxia, hypoperfusion and mechanical disruption

The spinal cord consists of 31 segments each with a pair of anterior (motor) and dorsal (sensory) spinal nerve roots. On each side the anterior and dorsal nerve roots join to form the spinal nerves as they leave the vertebral column. Each segmental nerve root supplies motor innervation to specific muscle groups (myotomes) and sensory innervation to a specific area of skin (dermatomes). Simple clinical tests of motor and sensory function can thus be used to localise a suspected spinal cord injury to the segmental level (Box 1). The segmental or neurological level of injury is defined as the lowest segmental level with normal motor and sensory function. It should be noted, however, that because the cord and the vertebral column are different lengths, segmental neurological levels are not the same as vertebral levels.

The 'level' of spinal injury is defined as the lowest neurologically normal level

The spinal cord is organised anatomically into paired bundles of fibres or 'tracts' that carry motor (descending) and sensory (ascending) information. Within the tracts, the more centrally situated fibres innervate more proximal areas of the body (e.g. the arms) and the more lateral fibres innervate the embryological distal areas (e.g. the sacrum). This arrangement explains the phenomenon of 'sacral sparing'. Patients with apparently complete cord lesions (complete loss of movement and sensation below the injury) may have sparing of perianal sensation, rectal motor function and great toe flexion because the sacral fibres lie away from the central watershed area in the cord. Conversely, the absence of sacral function may be the only neurological deficit on examination of a patient with a cauda equina injury. If there is any sparing of neurological function below the level of the injury then it is described as incomplete. Incomplete injuries may be manifest as any of a variety of patterns of neurological signs that relate to the tracts and segments involved (cord syndromes). Pre-hospital practitioners should be cautious about diagnosing a complete injury even if the patient has no evidence of sparing. Some of these patients may, in fact, have incomplete injuries. This is because of the phenomenon of 'spinal shock': a 24 to 72 hour period of complete loss of all neurological function, including reflexes, rectal tone and autonomic control below the level of the injury. Spinal shock is a neurological, not a cardiovascular, condition and it is reversible.

Spinal shock is a neurological, not cardiovascular condition and results in temporary complete loss of all neurological function below the level of injury

The corticospinal and spinothalamic tracts and the dorsal (or posterior) columns are the most important tracts. Their integrity can be readily assessed on clinical examination in the conscious patient by screening tests for motor power, pain, fine touch and position sense. The corticospinal tracts carry descending motor fibres and are situated anteriorly within the cord. These tracts cross the midline (decussate) in the brain stem and thus injuries to the corticospinal tracts result in muscle weakness on the same side (ipsilateral) as the injury. The dorsal columns carry ascending sensory fibres and are located posteriorly within the cord. They convey light touch, position and vibration sense. They also decussate in the brainstem and produce ipsilateral loss of position and vibration sense when injured. The spinothalamic tracts also carry ascending sensory information. They lie in two areas within the cord. The lateral spinothalamic tracts convey pain and temperature sensation while the anterior spinothalamic tracts convey light touch. In contrast to the corticospinal tracts and dorsal columns, the spinothalamic tracts decussate within three spinal segments (or two vertebral bodies). Injury to any one tract will therefore result in sensory loss on the opposite (contralateral) side. For example, the lateral cord syndrome (Brown-Séquard Syndrome) results from hemi-transection of the spinal cord following penetrating trauma, vascular injury or unilateral vertebral facet fracture or dislocation. There is damage to the spino-thalamic and corticospinal tracts on one side. The resulting cord syndrome manifests as loss of ipsilateral motor and dorsal column function from the level of injury and loss of contralateral pain and temperature sensation with an upper sensory level a few segments below the level of the injury.

In addition to the motor and sensory tracts, fibres from the sympathetic nervous system leave the spinal cord between C7 and L1 and fibres from the parasympathetic system leave between S2 and S4. In general, following injuries at or above T6, there is significant loss of the sympathetic outflow. As a result, vasomotor tone is reduced and, if the injury is high enough, sympathetic innervation of the heart is also reduced. This loss of sympathetic tone results in the neurogenic shock 'triad' of hypotension, bradycardia and peripheral vasodilatation. Progressively higher spinal cord lesions cause increasing degrees of sympathetic autonomic dysfunction while lower cord lesions may cause parasympathetic autonomic dysfunction (priapism and loss of bladder and bowel function).

Neurogenic shock is a cardiovascular phenomenon caused by loss of sympathetic outflow and manifest as bradycardia, hypotension and peripheral vasodilatation

Immediate Care

The immediate care of any trauma patient should follow the conventional ABCDE approach (1,12). Given the pathophysiology of spinal cord injury, the basic principles of immediate care for patients with spinal injury are to maintain the airway, ensure adequate ventilation and prevent hypotension. Throughout attempts to maintain the airway, support ventilation and control haemorrhage, it is essential that the spine is also protected from further mechanical disruption. Thus early immobilisation of the whole spine should be instituted from the outset. In practice, it is the cervical spine that is immediately controlled with manual in-line stabilisation during the primary survey and resuscitation. Application of a cervical collar and restraints early in the assessment of a patient may be appropriate to free up additional personnel but detailed evaluation of the spine and application of full immobilisation can be safely deferred until after immediately life-threatening conditions have been assessed and treated.

The initial priority is spinal immobilisation not spinal assessment

Although mishandling of patients has frequently been cited as a common cause of iatrogenic spinal injury, there have been no reported cases of spinal cord injury developing during rescue, extrication or transport in trauma patients who did not already have a primary neurological injury. Maximum deformity of the vertebral column will occur at the time of injury thus it seems improbable that the actions of rescuers – even if they were to move the spine to a small degree – will cause a patient with an unstable spine to develop a new cord injury. Nevertheless, there are reports of spinal injury resulting from abnormal positioning in uninjured patients so injured patients still require careful handling and care (24).

Manual in-line immobilisation is achieved by simply holding the head in the neutral position. If an unconscious patient's neck is flexed or rotated, it can be gently moved back to the neutral position provided there is no resistance. If resistance is felt, the head and neck should be immobilised in that position (provided the airway is not compromised). If a patient is agitated and combative forced restraint may place them at further risk and, if necessary, they should be allowed to move freely whilst possible underlying causes of their agitation (e.g. hypoxia, hypotension hypoglycaemia) are excluded. Agitated patients often settle in a position of comfort and usually tolerate a semi-rigid cervical collar. Although some ambulatory patients may have an unstable vertebral fracture (25), it may be safer for patient and rescuer not to attempt any further degree of immobilisation while the patient is uncooperative. In patients with an immediate risk to life (e.g. fire), rescue will be associated with some risks to the vertebral column and spinal cord and these must be accepted. All other patients should have manual in-line immobilisation while they are being assessed.

Airway and Breathing

Although hypoxia can result from head, chest and upper airway injuries, spinal injury itself can result in impaired ventilation. With injuries above C5, there is weakness of the diaphragm, an ineffective cough and an 80-90% reduction in tidal volume. These patients will clearly require early ventilatory support to treat respiratory failure and prevent secondary hypoxic damage. Patients with thoracic spine injuries may have a significant, but much less apparent reduction in tidal volume and respiratory function. Their respiratory failure may be insidious. Pre-hospital anaesthesia and tracheal intubation may be required. Although there is considerable anxiety about further exacerbation of spinal injury, there is little evidence that a properly performed orotracheal intubation with manual in-line immobilisation will cause harm (26,27). However, oral suction, laryngoscopy and intubation may precipitate severe bradycardia due to unopposed vagal stimulation in patients with autonomic disruption from cervical or high thoracic spinal cord injury and atropine should be immediately available.

Circulation

Hypotension in acute spinal cord injury may be the result of haemorrhage from other (unidentified) injuries, neurogenic shock or both. Although it is important to consider neurogenic shock in all hypotensive patients, the spinal injury may also prevent patients from becoming tachycardic and vasoconstricted in response to bleeding. Thus persistent hypotension should never be attributed to neurogenic shock until haemorrhage has been actively excluded. Most patients with spinal cord injuries have multiple injuries and occult bleeding may be present in the chest (associated with thoracic spinal injuries), abdomen and pelvis (28). Signs of peritonism (guarding, rigidity and rebound tenderness) may be absent and referred shoulder tip pain may be the only indication of a major intra-abdominal injury. There may be no perception of pain from the pelvis or long bones. A useful clue is that hypotension in the absence of a neurological deficit or with spinal pain below T6 is more likely to indicate bleeding.

It is unlikely that the diagnosis of neurogenic shock will be made with confidence in the pre-hospital phase but if present, the aim of treatment is a systolic blood pressure of 90 to 100 mmHg, a heart rate of 60 to 100 beats per minute and a urine output above 30 ml per hour. Cautious fluid administration and atropine (0.5 to 1mg) may be required to achieve this. In patients with persistent bradycardia, atropine may be given repeatedly until the heart rate is acceptable. If these measures fail, inotropic support will be required.

Disability

The aim of the neurological examination is to determine the presence of any spinal injury, document the deficit and identify the need for full spinal immobilisation for evacuation or transfer. A rapid simple clinical assessment can be made in the conscious patient to determine the presence of any neurological symptoms or signs. Most conscious patients with an acute spinal injury will complain of pain in the region of the injury. If there is no pain in the back or neck, the patient should be asked to cough and have their heels percussed to try and elicit pain. This approach can occasionally reveal a painful area, particularly with respect to compression or wedge fractures and if there are distracting injuries. The patient should then be asked to move each limb in turn, provided that there is no pain or discomfort in the limb or spinal column. Direct questions should be asked regarding absent or abnormal sensation in the limbs or trunk.

Practitioners should be sensitive to the fact that conscious patients often become distressed when they realise that they cannot move or feel parts of their body. The spectrum of symptoms and signs associated with incomplete cord lesions is so varied that any sensory or motor symptoms should be taken seriously. It is not necessary to assess each sensory modality in the pre-hospital phase unless transfer or evacuation is prolonged. At the secondary survey stage, each dermatome should be tested for sensitivity to a sharp object (pain) and cotton wool or gauze (light touch). Co-ordination, tone, power and deep tendon reflexes should all be tested and any abnormality documented. The root values of dermatomes and myotomes must be known in order to interpret the findings (Box 1). Assessment of power should be standardized to allow comparison over time and between limbs (Box 2). In unconscious patients, a careful examination may reveal signs of spinal cord injury (Box 3).

Box 2. Standardised assessment of muscle power.

Score		Interpretation
0	=	no flicker or movement
1	=	a flicker of contraction but no movement
2	=	movement, but not against gravity
3	=	movement against gravity
4	=	movement against resistance
5	=	normal power

Box 3. Signs of spinal cord injury in the unconscious patient.

- Diaphragmatic breathing
- Neurogenic shock (hypotension and bradycardia without hypovolaemia.)
- Flaccid areflexia of the limbs (spinal shock)
- A lax anal sphincter
- Flexed posture in the upper limbs (loss of extensor innervation distal to C5)
- Response to pain above the clavicles only
- Priapism (due to unopposed parasympathetic drive and which may be incomplete)

Spinal immobilisation

A recent systematic review found no randomised-controlled trials comparing pre-hospital spinal immobilisation strategies (including no immobilisation) in patients with suspected spinal cord injury (11). Thus the true effect of spinal immobilisation on mortality, neurological injury, spinal stability and adverse effects in trauma patients remains uncertain. In contrast, a great deal of research into clinical decision rules for spinal radiography once patients have reached A&E has been performed. Historically, most immobilised patients would undergo some form of radiographic imaging. In efforts to reduce unnecessary radiography, numerous studies have been performed to look at the clinical and incident characteristics that are highly sensitive for vertebral injury (29-39). Although there is little evidence that the mechanism of injury in itself is a sensitive predictor of spinal fracture or the need for spinal immobilisation in the pre-hospital setting (20), a clinical decision rule (comprising five key elements) that allows 'clinical' clearance of the spine without radiography has been validated. Its sensitivity for identifying blunt trauma patients who require spinal radiography approaches 100% (38,39). Patients who [1] are alert and co-operative with no alteration in mental status, [2] have no evidence of intoxication, [3] have no neurological symptoms or signs, [4] have no significant distracting injury and [5] have no pain or tenderness do not require radiography of the spine to exclude a fracture (Box 4).

Box 4. Clinical decision rule.

- All trauma patients involved in an incident where spinal injury is possible or where the mechanism of injury is uncertain should be immobilised manually *during initial assessment.*
- Patients who have multiple major injuries, have a reduced level of consciousness or who may be unreliable due to intoxication, altered mental state or distracting injuries should be fully immobilised.
- Alert, fully oriented patients who complain of *midline* pain and/or have bony tenderness and/or abnormal motor or sensory function should be fully immobilised.
- Patients who are cooperative, sober; and alert with no neurological symptoms or signs, no significant distracting injury and no pain or tenderness do not require radiography of the spine to exclude a fracture and, therefore, do not require immobilisation for suspected spinal injury.
- If spinal injury can be localised in the wilderness or operational setting and is limited to a specific area of the spine with a *reliable examination*, then reduction in the degree of immobilisation according to the area of injury can be considered.

It is argued that the decision process regarding whether to undertake radiography (i.e. assessing the risk of clinically significant vertebral fracture) is the same as the decision process regarding whether to immobilise the spine in the pre-hospital phase. Although there have been reports of cases in which there were bony or ligamentous abnormalities discovered in alert, awake patients who were truly asymptomatic, application of the rule is not associated with any clinically significant fractures being missed and there are no reports of asymptomatic patients who suffered cord injury as a result of such bony or ligamentous abnormalities (29,38,39). When applied in the pre-hospital environment, the clinical decision rule has reduced the number of patients who were immobilised and did not result in missed fractures (40,41). The clinical decision rule is now included in the ATLS® Course and is being routinely applied by some pre-hospital services and non-medical staff (9,37). There seems little doubt that it is a safe and reliable means of reducing the need for radiography and thus also full spinal immobilisation.

There are some important caveats to the use of the clinical decision rule in the typical pre-hospital traumatic injury population. Most importantly, there needs to be no barrier to effective communication between the pre-hospital practitioner and the patient (either in terms of language, culture or mental capacity). With respect to a distracting injury, a subjective decision regarding the presence of an injury sufficiently serious to render the patient 'unreliable' is required. In general terms, a significant distracting injury is regarded as a long bone, pelvis or thoracic cage fracture or extensive wounds such as burns. It is well understood that the presence of pain and anxiety (in adults and children) may significantly influence a patient's perception of pain. Pain is a complex phenomenon with physiological, psychological emotional and behavioural components (13). When patients are assessed in the pre-hospital environment immediately following injury, fear, confusion, and multiple or distracting injuries may result in 'masking' of pain and an inaccurate assessment of the presence of midline cervical, thoracic or lumbar spine tenderness. Where scene and transfer times are very short, it may be appropriate for such patients to have immobilisation maintained and be transported quickly and safely to an appropriate receiving facility for further assessment. However, where there is likely to be a significant delay to evacuation or prolonged transport times, there is time to administer analgesia and re-assess the patient over time (13). The need for immobilisation can then be reassessed. Another caveat is the fact that medical and paramedic staff have been shown to be ineffective at judging the degree of intoxication and, therefore, this assessment also remains potentially very subjective (42). Finally, although the rule has not been validated in children, preliminary studies in the alert child have not identified any cervical spine injury in the absence of neck pain, neurological symptoms, distracting injury, or altered mental status (16,43,44). In interpreting the clinical examination in children, practitioners must be confident in their ability to communicate with the child and in the child's ability to identify symptoms.

Patients who do not fulfill the criteria for clinical clearance of the spine require immobilisation. This clearly applies to unconscious patients, those with multiple injuries and conscious patients who can localise pain, identify sensory loss and demonstrate motor weakness.

Conventional practice is that any patient with neurological symptoms or signs must be fully immobilised. If, however, an alert and co-operative patient is complaining of mid thoracic pain, has swelling and deformity in the mid thorax and paraplegia with loss of sensation below the umbilicus do they require cervical spine immobilisation? There is a relatively high incidence (between 5 and 10%) of further non-contiguous vertebral fractures in spinal injury but it is unlikely that these will be asymptomatic in the alert patient (45,46). Careful examination may allow the traditional full spinal immobilisation procedures to be tempered and thus greatly improve patient comfort and safety in the situation where pre-hospital times are prolonged. For example, although lateral movement of the pelvis and legs should be avoided with acute cervical and thoracic spine fractures, limited anterior/ posterior movement of the legs at the hip is not harmful. Similarly, cervical spine immobilisation may not be necessary in patients with well localised lumbo-sacral injury (47).

Where spinal immobilisation is indicated, the full range of immobilisation techniques should be employed. The semi-rigid cervical collar does not adequately immobilise the cervical spine on its own and all patients with suspected spinal injuries should have the entire vertebral column immobilised. There are different patterns of semi-rigid cervical collar but there is no difference in the degree of cervical spine immobilisation provided by them (14). The type chosen (if any) should be compatible with other emergency services and receiving medical facilities. All collars, when correctly applied, can cause a variable rise in intracranial pressure. Patients with a reduced level of consciousness should, therefore, have the collar loosened or removed once they have been adequately immobilised (2,48-50). A cervical collar does not provide any useful additional immobilisation once a patient is secured with a head immobilisation device.

The transfer device used for patients with spinal injuries (or who are unconscious) is important. Where possible, a vacuum mattress should be used. If this is not available then a conforming mattress or stretcher (with appropriate padding if there is vertebral column deformity) can be used. Non-conforming extrication boards are excellent extrication devices but should not be used for prolonged transfers (2). Whatever is used, close attention should be paid to thermoregulation, fluid balance and pressure area care.

Penetrating trauma

Although penetrating wounds to the spine are predominantly stable, gunshot wounds of the trunk or neck that may have traversed the spinal column can produce unstable injuries and full immobilisation is required. In a tactical environment this may simply not be possible and some risk to the spine and cord must be accepted. Observational studies of patients with gunshot wounds to the head indicate that if the wound is limited to the vault of the skull and the bullet does not traverse the neck on clinical examination, then spinal immobilisation is unnecessary. There is no evidence of indirect cervical spine injury in these patients (51,52). Stab wounds may penetrate the cord and cause a direct injury but are more often associated with vascular compromise and hypoperfusion. There is no evidence to support a clinical decision rule for stab injuries.

Steroids

Many centres (and some pre-hospital systems) currently administer methyl-prednisolone 30mg/kg to all patients presenting within 8 hours of an acute (blunt) spinal cord injury However, there remains considerable debate about whether early high dose steroids will reduce the progression of spinal cord injury and provide long term improvement in outcome. Steroids should certainly be avoided in penetrating injuries and it is recommended that the advice of the nearest spinal injuries specialist unit is sought before administration in other circumstances (53).

Summary

The pre-hospital care of patients with suspected spinal injuries involves early immobilisation of the whole spine and the institution of measures to prevent secondary injury from hypoxia, hypoperfusion or further mechanical disruption. Early ventilation and differentiation of haemorrhagic from neurogenic shock are the key elements of pre-hospital resuscitation specific to spinal injuries. Falls from a significant height, high-impact speed road accidents, blast injuries, direct blunt or penetrating injuries near the spine and other high energy injuries should all be regarded as high risk for spinal injury but clinical examination should determine whether the patient requires full, limited or no spinal immobilisation. Although there is little conclusive evidence in the literature that supports pre-hospital clinical clearance of the spine, the similarities between pre-hospital immobilisation decisions and in-hospital radiography decisions are such that it is likely that clinical clearance will be effective for selected patients. This decision can be made at the scene provided the patient has no evidence of:

- Altered level of consciousness or mental status
- Intoxication
- Neurological symptoms or signs
- A distracting painful injury (e.g. chest injuries, long bone fracture)
- Midline spinal pain or tenderness

Where there is evidence to support spinal immobilisation, then the full range of devices and techniques should be considered. In the remote or operational environment where pre-hospital times are prolonged, full immobilisation, analgesia and re-assessment may allow localisation of the injury and a reduction in the degree of immobilisation.

Common reasons for missing significant spinal injuries include failing to consider the possibility of spinal injuries in patients who are either unconscious, intoxicated or uncooperative (54,55). The application of the decision rule discussed here will ensure that no clinically significant spinal injuries are missed in pre-hospital care.

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Spinal Injuries

Commentary

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Spinal Cord injury may follow inappropraite patient handling in the presence of an unstable spinal injury. A policy to collar and board patients based on the mechanism of injury produces significant resource implications for the ambulance service and space, staffing and time issues for the Accident & Emergency Department to say nothing of the discomfort the patient may suffer.

This article is a comprehensive review of the evidence base and includes appropiate sections on the anatomy and pathophysiology of spinal injuries. The article covers both the civilian and military perpective.

It is time to review current practice. The development of the Emergency Care Practitioner (ECP) with supporting clinical competances should permit an immobilisation decision to be based on clinical examination. A word of caution however: the possibility of thoracolumbar injury is often overlooked and the problems of a distracting injury under-emphasised.

Consideration should be given to reviewing the "clinical decision rules" and a timely update of the JRCALC/Faculty of Pre-hospital Care Consensus guidelines.

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