SPINAL CORD INJURY: ACUTE CARE MANAGEMENT

In the third and final part of his series on spinal cord injury, FINTAN SHEERIN describes the pre-hospital and emergency department management of patients.

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The first two articles in this series described the anatomy and physiology of the vertebral column and spinal cord, and examined the aetiology and pathophysiology of spinal cord injuries (Sheerin 2004, 2005). These provide a basis for understanding the presentation and management of spinal cord injuries.

It is difficult to be prescriptive about care because spinal cord injuries can present in various ways. Sensory and motor loss can be total below the injury level, perhaps involving segments S4 and S5, or there may be varying degrees, and indeed types, of neurological loss, with sacral function remaining (Sheerin 2005).

Good initial and acute management is crucial however, whatever the degree of damage (Campagnolo and Heary 2002, Sheerin and Gillick 2004).

This article, therefore, focuses on the principles of acute care for patients with suspected or confirmed cervical spinal cord injuries before admission to specialised spinal units. Care of those patients with lower, less widespread spinal cord injuries may be extrapolated from this.

PRE-HOSPITAL CARE
Spinal cord injury can be described as a multifaceted condition that demands a multifaceted approach that takes account of the multi-system effects of spinal and neurogenic shock (Zejdlik 1992).

Spinal shock, a transient loss of somatic and autonomic reflex activity below the level of neurological damage, can affect every system of the body (Sheerin 2005), while neurogenic shock leads to the classic triad of signs: bradycardia, hypotension and loss of thermoregulation, typically hypothermia (Campagnolo and Merli 2002).

These effects, along with respiratory sequelae, present a challenging scenario for pre-hospital and emergency department staff.

The central objective of pre-hospital management is ‘to prevent further neurologic insult and maintain remaining neurologic function’ (Prendergast and Sullivan 2000).

To achieve this, the generic ‘airway, breathing and circulation’ (ABC) assessment is used, but within the context of spinal immobilisation (Burney et al 1989, Campagnolo and Heary 2002, Chiles and Cooper 1996, Young and Shea 1998).

Spinal immobilisation
Chiles and Cooper (1996) suggest that ‘spinal injury should be suspected in patients with severe systemic trauma, patients with minor trauma who report spinal pain or have sensory or motor symptoms, and patients with an impaired level of consciousness after trauma’.

The decision whether or not to immobilise the spine is made by paramedics and determined by standard operating procedures (Department of Health and Children 1999).

These conform to internationally accepted principles of in-line head and neck stabilisation and take account of such factors as mechanism of injury, location of the casualty, and the presentation of such signs and symptoms as level of consciousness, reported neurological loss and anatomical irregularities.

In-line stabilisation of the neck, also termed ‘neutral alignment’, is usually enhanced by using immobilisation blocks and straps that fix the patient’s head and neck to a spinal board.
There is some controversy however over whether spinal boards, though recommended in the standard operating procedures, will achieve neutral positioning of the neck.

Schriger et al (1991) find that, in 98 per cent of their study subjects, immobilisation on a spinal board places the neck in ‘relative cervical extension’, thus failing to achieve the required neutral position.

Immobilisation of young children requires particular comment. The relative head-to-torso size is larger in children than in adults, so immobilisation on a flat spinal board results in flexion of the child’s neck rather than neutral alignment (Fielding 1984, Walker 1998).

This can be remedied by using a paediatric spinal board or by placing a folded blanket on the normal spinal board under the torso (Fielding 1984, Walker 1998).

Airway and circulation
Spinal immobilisation is a key component of management but it does not take precedence over airway or circulatory management if either one is compromised.

The airway has to be kept patent using the jaw thrust approach rather than the chin lift, which can cause extension of the neck (Campagnolo and Heary 2002, Prendergast and Sullivan 2000, Young and Shea 1996).

A patent airway allows administration of high flow supplemental oxygen (Gardner and Kluger 2004), which can prevent secondary cord injury by correcting hypoxia (Belanger and Levi 2000).

Insertion of pharyngeal or endotracheal tubes should be done with caution. Stimulation of the airway can cause bradyarrhythmas or cardiac arrest in patients who may already have neurogenic shock induced bradycardia (Gardner and Kluger 2004).

Campagnolo and Merli (2002) report however that this type of bradycardia is most marked two to three weeks after injury.

Hypotension during the pre-hospital phase can be caused by unopposed vagal stimulation coupled with loss of sympathetic vascular tone, or active blood loss (Karlet 2001).

Differentiating between these causes can be difficult, so there should be a conservative approach to fluid replacement to avoid fluid overload and pulmonary oedema (Timothy et al 2004, Young and Shea 1998).

If fluid replacement is required, but there is no proven haemorrhage, recommended treatment is a fluid bolus of between 200 and 500ml of IV crystalloid (Gardner and Kluger 2004).

INITIAL EMERGENCY DEPARTMENT MANAGEMENT AND DIAGNOSTIC EVALUATION

Initial management

Initial management and evaluation, however, normally takes place in emergency departments, which suggests that emergency department staff should have basic skills in managing patients with acute spinal cord injuries.

It is vital that, following initial assessment, the patient is removed from the spinal board (Hickey 2003, Porter and Allison 2003) and nursed on an emergency trolley with head immobilisation and straps applied.

This should minimise the pressure ulcer formation that is so prevalent in patients with spinal cord injury (Byrne and Salzberg 1996, Mawson et al 1988, Sheerin and Gillick 2004). This also results in the removal of the patient from a device that is designed for extrication and not hospital purposes.

For similar reasons, hard cervical extrication collars should be changed to a semi-rigid model on admission to A&E (Chendrasekhar et al 1998, Plaiser et al 1994).

Diagnostic evaluation
Diagnosis is based on physical examination, neurological assessment and radiographic imaging (Berlinger and Levi 2000).

Physical examination includes visual inspection and palpation of the neck and back to help localise vertebral column trauma, and is supported by information from the pre-hospital team about mechanism of injury, direction of forces applied to the spine, anatomical point of impact and presence of concomitant injuries.
Any report of altered neurological function is corroborated by thorough neurological assessment, focusing on the spinal cord and its peripheral distribution. There are various scales designed to assess sensory and motor function, of which the most widely used is the American Spinal Injury Association (ASIA) International Standards for Neurological Classification of Spinal Cord Injury (ASIA 2002) (Fig. 1).

The ASIA assessment involves assessment of sensory input, namely pin prick and light touch, in 28 paired dermatomes, defined areas of skin that provides sensory input to the dorsal roots of specific spinal nerves. It also involves assessing the motor output to ten paired myotomes, groups of muscles innervated by the neurones from single spinal segments.

Assessment of the integrity of segments S4 and S5 is by digital rectal examination. This can localise the neurological, sensory and motor levels, as well as the completeness of injury (Table 1).

Radiography is initially used to assess the alignment of the vertebrae and identify fractures (Chiles and Cooper 1996).

Anterior-posterior (A-P) and lateral-cervical spine X-rays should be taken and must include views of the junction between C7 and T1, a region that is particularly susceptible to injury (Prendergast and Sullivan 2000, Richards 2005).

The odontoid process of C2 should be visualised through open mouth views (Belanger and Levi 2000, Timothy et al 2004), and A-P and lateral views of the thoracic and lumbosacral spine should be taken to assess for further, lower spinal injuries (Lee and Green 2001).

More detailed assessment of fractures and bone fragment displacement can be obtained from computed tomography (CT) imaging, which can give various cross sectional and reconstructed views of the bony injury site (Belanger and Levi 2000, Richards 2005).

While X-rays and CT imaging can provide information on bony injury, they give limited detail about soft tissue injury to the cord, ligaments and intervertebral discs (Richards 2005).

Soft tissues can be assessed for diagnosis and prognosis however by magnetic resonance imaging (MRI) (Belanger and Levi 2000, Richards 2005).

**Methylprednisolone**

There is considerable debate in the professional literature about the pharmacological management of patients with acute spinal cord injury.

Much of this focuses on the administration of the corticosteroid, methylprednisolone, which, according to some researchers, results in neurological improvement if started soon enough after spinal cord injury (Bracken et al 1990, 1997).

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**Table 1. Characteristics of neurological impairment identified by the ASIA assessment**

<table>
<thead>
<tr>
<th>Sensory level</th>
<th>Motor level</th>
<th>Neurological level</th>
<th>Complete sacral cord integrity</th>
<th>Incomplete sacral cord integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lowest segment of the spinal cord with normal sensory function on both sides of the body</td>
<td>The lowest segment of the spinal cord with normal motor function on both sides of the body</td>
<td>The lowest segment of the spinal cord with normal sensory and motor function on both sides of the body</td>
<td>Absence of sensory or motor function in the lowest sacral cord segments</td>
<td>Preservation of motor and/or sensory function below the neurological level including function in the lowest sacral cord segments</td>
</tr>
</tbody>
</table>

(ASIA 2002)

Methylprednisolone acts on the inflammatory process by restoring extracellular calcium ion concentration, inhibiting tissue lipid peroxidation and inhibiting arachidonic acid release, all of which contribute to cell death.

It is used in many countries, including the USA and Ireland.

Gardener and Kluger (2004) report that the ‘majority view in the UK is that methylprednisolone should not be given’, suggesting that the benefits of administration do not outweigh the potential side effects of sepsis, pneumonia and possible gastrointestinal complications.

ONGOING EMERGENCY DEPARTMENT MANAGEMENT

In-line immobilisation

In-line head and neck immobilisation is important during pre-hospital care and remains an important part of care in hospitals.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Desired outcome</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ineffective airway clearance related to increased secretions and muscle weakness</td>
<td>Airway clearance Recovery of secretions</td>
<td>Humidified oxygen at lowest appropriate concentration Nebulised bronchodilators Cautious suctioning of secretions Incentive spirometry Assisted coughing Changing position regularly</td>
</tr>
<tr>
<td>High risk of respiratory complications</td>
<td>Respiratory complications prevented, identified and or managed</td>
<td>Respiratory assessment Observation for signs of infection, noting culture and sensitivity of sputum sample Assessing the effectiveness of antimicrobial therapy</td>
</tr>
<tr>
<td>Risk of pulmonary oedema related to aggressive fluid therapy secondary to neurogenic shock related hypotension</td>
<td>Episodes of pulmonary oedema identified, and minimised or managed</td>
<td>Monitoring for signs of pulmonary oedema Cautious use of fluid therapy</td>
</tr>
</tbody>
</table>

(McCloskey and Bulechek 1996, North American Nursing Diagnosis Association 1999)
Patients need to be turned onto their sides however so that they can be taken off spinal boards and examined, and pressure on them can be relieved regularly. This must be done in a controlled, supporting manner.

A full cervical spine (c-spine) turn should be performed each time the patient needs to be moved.

The turn involves four competent handlers as well as the person examining the patient, and the log rolling of the patient onto their side. One handler supports the head and c-spine, and three support the body.

The person at the head, who is the most experienced handler and usually a nurse or a doctor, assumes charge for the procedure.

There are various approaches to c-spine turns and thoracolumbar log rolls for thoracolumbar injuries (American College of Surgeons 1997, Emergency Nurses Association 2001, National Association of Emergency Medical Technicians 2002), but each hospital should adopt an approach that has been standardised within the hospital and that achieves c-spine, thoracic and lumbosacral immobilisation.

**Respiratory management**

High level spinal cord injury can have a drastic effect on the patient’s respiratory function and vital capacity (Fig. 2).

The increase of secretions in narrowed airways, caused by parasympathetic presentation, is complicated by the patient’s inability to expectorate due to loss of abdominal musculature innervation (Cook 2003, Karlet 2001, Urdaneta and Layon 2003).

Involvement of cord segments C3, C4 and C5 leads to progressive loss of diaphragmatic innervation because the nerve roots here give rise to the phrenic nerve. This further complicates respiratory function.

Pulmonary complications are responsible for most deaths in the pre-hospital and emergency management of patients with high cervical cord lesions (Guin 2001, Roth et al 1997), so airway patency should be a nursing priority (Table 2).

The interventions outlined in Table 2 may minimise such complications but, as previously discussed, the patient’s heart should be monitored during endotracheal suctioning because vagal stimulation can compound presenting bradycardia and lead to asystole (Buglass 1999).

Respiratory interventions can improve air entry and control, leading to more effective breathing and increased tissue perfusion, and prevent complications such as atelectasis and pneumonia (Peterson and Kirschblum 2002).

Inappropriate fluid replacement can also compromise respiratory ability. Aggressive fluid management based on the assumption that the patient’s hypotension is caused by hypovolaemia, for example, can lead to pulmonary oedema, and the introduction of glucose containing solutions can aggravate the neurological injury (Urdaneta and Layon 2002).

It is therefore advised that colloidal solutions are used and titrated against pulmonary capillary pressure or pulmonary wedge pressure (Campagnolo and Merli 2002). This is achieved through the use of Swan-Ganz catheterisation (Timothy et al 2004, Young and Shea 1998).

**Cardiovascular management**

The mechanism of cardiovascular complications soon after spinal cord injury is described in detail in the second article of this series (Sheerin 2005) and summarised in Fig. 3.

While hypotension in uncomplicated cases is usually due to neurogenic shock, haemorrhage must be excluded through careful medical assessment (Campagnolo and Merli 2002).

Blood pressure should be monitored to ensure that mean arterial pressure remains above 85mmHg, a level suggested to be associated with good neurological outcomes (Vale et al 1997).

Severe hypotension can be treated with a vasopressor such as dopamine (Guin 2001).

Along with hypotension, bradycardia is a sign of neurogenic shock. Bradycardia and associated dysrrhythmias in acute spinal injuries are related to the interruption of the sympathetic autonomic nervous system and cardioaccelerator reflexes.

The vagal presentation that results is susceptible to further bradycardia during specific interventions such as tracheal suctioning (Campagnolo and Merli 2002, Guin 2001, Karlet 2001).
It is important, therefore, to maintain cardiac monitoring during these activities and, in some cases, treat the patient with atropine in advance (Campagnolo and Merli 2002).

Patients also require cardiac monitoring during turning. In the UK, patients with spinal cord injuries are usually managed on specialised turning beds (Grundy and Swain 2002).

In Ireland, however, it is normal practice during early management to use Stryker wedge turning frames, which permit the turning of patients from supine to prone by ‘sandwiching’ them between two pallets and removing the upper pallet following the turn.

Schneiber (1990) and Coppola (1977) report instances of cardiac arrest in patients during prone lying on Stryker frames due to brainstem ischaemia caused by neck hyperextension. This can be compounded by the bradyarrhythmia induced during the turning process, which is why monitoring is vital. Bradycardias may be managed by the use of atropine.

Interventions to prevent complications such as the development of deep vein thromboses (DVTs) can be started during...

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**Table 3. Managing cardiovascular problems**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Desired outcome</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased cardiac output and altered tissue perfusion related to hypotension secondary to neurogenic shock</td>
<td>Haemodynamic stability</td>
<td>Monitoring of blood pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maintaining mean arterial blood pressure of more than 85mmHg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fluid replacement with IV colloids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maintaining urinary output of greater than 30ml per hour (Carpenito 1995)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consider vasopressor therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Promote venous return to increase cardiac preload</td>
</tr>
<tr>
<td>Risk of bradyarrhythmias related to sympathetic and cardioaccelerator depression secondary to neurogenic or spinal shock</td>
<td>Haemodynamic stability</td>
<td>Cardiac monitoring during tracheal suctioning, belching and positional changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pre-treatment with IV atropine before susceptible activities</td>
</tr>
<tr>
<td>Risk of bradyarrhythmias and cardiac arrest related to brainstem hypoxia secondary to prone lying on Stryker wedge turning frame</td>
<td>Haemodynamic stability</td>
<td>Cardiac and oxygen saturation monitoring before and after turning patient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Careful monitoring while patient is prone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If there are cardiac anomalies, return patient to supine position</td>
</tr>
</tbody>
</table>

(Zejdlik 1992)
The management of cardiovascular problems is outlined in Table 3.

**Gastrointestinal management**

The gastrointestinal (GI) sequelae of spinal cord injury derive from the autonomic imbalance but may also be related to high dose methylprednisolone administration. Outcomes can be widespread (Fig. 4) and have long term consequences, but the principle issues in the context of acute management relate to gastric ulceration and paralytic ileus (Fig. 4).

Nasogastric tubes are often inserted soon after injury and put on intermittent suctioning to decompress the stomach and reduce the potential for vomiting and aspiration (Hickey 2003, Prendergast and Sullivan 2000).

Gastritis and peptic ulcer disease are associated with high c-spine injuries (Berlly and Wilmot 1984), possibly due to unopposed parasympathetic activity and stress (Hickey 2003).

Prophylactic use of histamine (H\textsubscript{2}) antagonists is the usual intervention (Prendergast and Sullivan 2000), but it has also been suggested that early initiation of nutritional support can prevent peptic ulcer disease (Kuric et al 1989).

Paralytic ileus is a common GI complication after spinal cord injury (Chen and Nussbaum 2002). It usually resolves after between 48 and 72 hours and is managed by nasogastric decompression and maintaining a nil-by-mouth regimen. During paralytic ileus, there is no active defaecatory reflexes. This persists during spinal shock. It is important therefore to

![Table 4. Managing gastrointestinal problems](image)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Desired outcome</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk of gastric ulceration related to vagal stimulation</td>
<td>Gastric ulceration prevented or managed</td>
<td>Routine use of H\textsubscript{2} antagonists or H\textsubscript{2} pump inhibitors</td>
</tr>
<tr>
<td>Reduced colonic motility related to paralytic ileus secondary to spinal shock</td>
<td>Complications of paralytic ileus managed or minimised</td>
<td>Monitoring for signs of gastric bleeding</td>
</tr>
</tbody>
</table>

(Please note: The Table 4 content is not fully visible in the image provided.)
CONCLUSION
The imminent arrival of a spinal cord injured patient at the emergency department need not be a source of fear for clinicians. It has been seen that, in the early stages of spinal cord injury, nursing management is multifaceted chiefly because of the presence of spinal and neurogenic shock. But adherence to the key tenets of care encompassed within the three articles of this series should minimise the potential for further complications and should lead to more positive outcomes for patients. The role of pre-hospital and emergency carers is crucial to achieving this high quality approach.

In this series of articles, the author has attempted to provide emergency nurses with a concise source of information on the anatomical and physiological bases for, and consequences of, spinal cord injury. It is acknowledged that approaches to the management of spinal cord injury vary from country to country, and that this author has approached care from the interventional perspective that is current in the Republic of Ireland.

Unfortunately, it has not been possible to cover all issues relating to the management of spinal cord injury. Readers are therefore encouraged to consult the references that have accompanied these articles for greater detail.

References


