Guidelines for the Management of Acute Spinal Cord Injury

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I. Introduction

a. Background

i. Trauma is the leading cause of death and disability among Americans less than 45 years of age, and is the fourth leading cause of death overall. Although spinal cord injuries (SCI) account for a small proportion of those injuries, some result in death and many result in severe disability and prolonged medical treatment.

ii. In the United States, the annual incidence rate of spinal cord injury including prehospital fatalities is estimated to range from 43-55 per million per year. Based on perhaps the most accurate state wide surveillance system in the country, Mississippi reports an average of almost 200 SCI per year which represents a higher per capita rate than the rest of the US.\textsuperscript{1,2} These differences may be explained by several factors including predominance of rural highways, low rate of safety belt usage, and completeness of data collection.

iii. Despite the relative low incidence of SCI, it was estimated in 1990 that the cost of caring for American with SCI was $4 billion annually (Stripling, 1990 “Clinician’s view”)

iv. In Mississippi as elsewhere, SCI is a primarily a disease of the young males, with the highest occurrence among men 20-24 years of age. The leading cause of SCI is motor vehicle collisions followed by violence (such as gunshot wounds) and falls. Among persons sustaining SCI from vehicular collisions at least 75% were determined to be unrestrained by safety belts and alcohol consumption is frequently associated. Approximately half of patients surviving with SCI are quadriplegic and half paraplegic.

v. Spinal cord injury is defined by the American Spinal Injury Association (ASIA) as impairment or loss of motor and/or sensory function due to damage of neural element within the spinal canal to include the conus and cauda equina.

vi. Spinal cord injury results in an alteration of spinal cord physiology which may be amenable to interventions directed at limiting the injury cascade and, therefore, secondary injury.

vii. Spinal cord injury is often a catastrophic injury to the central nervous system that secondarily affects all other systems of the human body including cardiovascular, pulmonary, genitourinary, intestinal, and integument systems. (review systems of the body) These secondary alterations in systems may become problematic threatening the life and recovery of the victim following SCI. These secondary effects are collectively known as secondary complications of SCI. Much of the post injury management of SCI is directed towards the prevention and management of secondary complications.

viii. ASCI care will be based on evidence based medicine guidelines and established institutional protocols. The Guidelines for the
Management of Acute Cervical Spine and Spinal Cord Injuries (© 2001 The Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons.) were used.

B. Purpose

1. The purpose of this document is to provide standardized guidelines for the management of the acute spinal cord injured (ASCI) patient at University Mississippi Medical Center.
2. These guidelines are based on Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injuries modified and expanded to address issues specific to University Mississippi Medical Center and also reflect approaches to certain issues not addressed in the guidelines.
3. These guidelines do not replace the physician’s judgment in individual cases, but may be considered reasonable and current approaches to the management of the critically ill ASCI patient.
4. These guidelines are intended to foster a coordinated, cooperative environment among the multidisciplinary team caring for ASCI patients, which includes, but is not limited to, Emergency Medicine, Neurosurgery, Orthopedics, Trauma Surgery, and Critical Care Nursing.
II. **Table of Contents**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>III. Immobilization and Transport</td>
<td>5</td>
</tr>
<tr>
<td>IV. Clinical Assessment Following Acute Spinal Cord Injury</td>
<td>6</td>
</tr>
<tr>
<td>V. Radiographic Assessment of the Cervical Spine</td>
<td>8</td>
</tr>
<tr>
<td>VI. Clearance of the Cervical Spine Following Trauma</td>
<td>9</td>
</tr>
<tr>
<td>VII. Initial Closed Reduction of Cervical Spinal Fracture-Dislocation Injuries</td>
<td>10</td>
</tr>
<tr>
<td>VIII. Management in an Intensive Care Unit</td>
<td>11</td>
</tr>
<tr>
<td>Management of GU and GI systems</td>
<td></td>
</tr>
<tr>
<td>Prevention of Decubitus Ulcers</td>
<td></td>
</tr>
<tr>
<td>Nutritional Support After Spinal Cord Injury</td>
<td></td>
</tr>
<tr>
<td>Prevention of Deep Venous Thrombosis and Thromboembolism</td>
<td></td>
</tr>
<tr>
<td>IX. Blood Pressure Management Following Acute Spinal Cord Injury</td>
<td>13</td>
</tr>
<tr>
<td>X. Pharmacological Therapy Following Acute Cervical Spinal Cord Injury</td>
<td>14</td>
</tr>
<tr>
<td>XI. Prevention and Management of Pulmonary complications</td>
<td>15</td>
</tr>
<tr>
<td>Ventilator dependent patients</td>
<td></td>
</tr>
<tr>
<td>Non intubated patients</td>
<td></td>
</tr>
<tr>
<td>XII. References</td>
<td>17</td>
</tr>
</tbody>
</table>
III. Immobilization and transport  
  a. Background  
  i. It is estimated that 3% to 25% of spinal cord injuries occur after the initial traumatic insult, either during transit or early in the course of management. Furthermore, as many as 20% of spinal column injuries involve multiple non-continuous vertebral levels, therefore the entire spinal column is potentially at risk. Proper immobilization and transportation will limit the risk of secondary spinal cord injury. Immobilization may be temporary in the form of a removable external orthosis, spine board, skeletal traction, etc. or permanent in the form of fixed external orthosis (halo brace) or surgical stabilization.  
  ii. Decubitus ulcers develop in anesthetic skin after just a few hours of sustained pressure. The initial tissue injury is subcutaneous and may not be apparent for days after the insult. The length of time on a rigid spine board has been shown to be associated with the development of decubitus ulcers within 8 days of injury. Removing patients from spine boards expediently will reduce the risk of decubitus formation.  
  b. Goals of Therapy  
  i. To avoid secondary spinal cord injury  
  ii. To allow for safe transport of ASCI patients to appropriate areas within the hospital and discharge facilities  
  iii. To prevent decubitus ulcer formation resulting from prolonged immobilization on a spine board.  
  c. Guidelines  
  i. Appropriately fitting cervical collars should be applied to all trauma patients suspected of having a cervical spine injury. The collar should be maintained until the spine is cleared (See guidelines on clearance of cervical spine fractures for guidelines on removal of cervical collars) or until more permanent immobilization is applied.  
  ii. Patients with suspected spinal injury should be moved within a hospital bed or stretcher using the log rolling technique.  
  iii. Trauma patients should be removed from spine boards as soon as possible after resuscitation and initial evaluation in the Emergency Department (ED). Patients with paralysis should be repositioned in bed or on the stretcher every 2 hours by log rolling.  
  iv. Transfers from ED stretcher to the x-ray table or hospital bed should be performed with care, attempting to maintain spinal alignment at all times.
IV. Clinical Assessment Following Acute Spinal Cord Injury

a. Background
   i. A variety of assessment systems are available for the
documentation of neurological status of patients following ASCI. They include the Frankel Scale, the modified Frankel Scale, Lucas and Ducker's Neurotrauma Motor Index, the Sunnybrook, the Botsford, and the Yale scales, the NASCIS scale, the ASIA scale and the ASIA/International Medical Society of Paraplegia international standards for neurological and functional classification of spinal cord injury scale. The latter is the most uniformly accepted classification scale, it is recommended as the preferred neurological examination tool by the Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injuries, and is currently used at UMMC.
   
   ii. According to the AISA International standards, an SCI is classified as tetraplegia (quadriplegia) if it involves a cervical spinal segment or paraplegia if it involves a thoracic, lumbar, or sacral spinal segment. An SCI is further identified as being complete (absence of all motor or sensory function at the lowest sacral level) or incomplete (at least some preservation of motor or sensory function below the level of the injury, including the lowest sacral level). The classification scheme further outlines a method for quantifying both motor and sensory function that produces a motor score and independent sensory scores for light touch and pin prick sensation. Finally, a scale is included that quantifies the degree of impairment the patient experiences as a result of the injury (ASIA Impairment Scale).

b. Goals of Therapy
   i. To provide neurologic assessment data that can be readily
interpreted by any clinician, even though the assessment may have
been performed by another examiner
   
   ii. To provide data that can be used for standardized data analysis
among different institutions. Spinal injuries often show some
improvement over time so the outcome measures (ASIA motor
score, sensory scores, and impairment scale) accurately quantify
changes in spinal function
   
   iii. To allow the accumulation of data from a large number of SCI
patients over time that can be used to generate comparative
statistics.

c. Guidelines
   i. All patients with an ASCI or suspected ASCI will be examined by
a physician upon admission. The neurologic exam will be
documented according to the ASIA standards (and a form
completed).
      1. The injury will be classified as complete or incomplete.
2. The injury will be classified as paraplegia or quadriplegia (tetraplegia).
3. The motor and sensory level for each side will be documented.
4. Motor scores for each myotome level will be indicated for each side of the body.
5. Sensory scores for pin prick and soft touch will be indicated for each side of the body.
6. Total motor and sensory scores for each side of the body will be calculated.
7. Impairment will be rated based upon the ASIA Impairment Scale.
   ii. Patients will be re-examined on a daily basis as a minimum and any changes in the neurologic exam noted.
   iii. Patients will be re-examined following any significant intervention such as surgery and any changes in the neurologic exam noted.
V. Radiographic Assessment of the Cervical Spine

a. Background

   i. Spinal cord injury is a potentially devastating consequence of acute trauma. The diagnosis of spinal fractures relies partly on the physical and neurological examinations and partly on diagnostic imaging. Patients may present with spinal fractures in the absence of spinal cord injury. Furthermore, 20 percent of spinal fractures are associated with fractures elsewhere in the spine. Failure to recognize spine fractures may lead to catastrophic spinal cord injury.

b. Goals of Therapy

   i. Avoid unnecessary radiographic imaging whenever possible.
   ii. Identify any and all fractures of the spine following trauma.
   iii. Fully characterize any spinal fracture with appropriate imaging techniques to aid in treatment and subsequent follow up.
   iv. Document any spinal cord trauma that may be visible on MRI.

c. Guidelines

   i. Radiographic assessment of the spine is not recommended in trauma patients who are awake, alert, and not intoxicated, who are without spine pain or tenderness, and who do not have significant associated injuries that detract from their general evaluation.
   ii. Any patient with significant head trauma or blunt trauma to the thorax should be suspected of having a spine fracture and examined accordingly.
   iii. Any patient with a neurologic deficit consistent with a SCI should have a thorough radiographic examination.
   iv. A three view cervical spine series (AP, lateral, and odontoid views) is recommended for radiographic evaluation of the cervical spine in patients who are symptomatic (complaints of neck pain or tenderness on examination) following traumatic injury. This should be supplemented with computed tomography to further define areas that are suspicious or not well visualized on the plain cervical x-rays.
   v. AP and lateral views of the thoracic, lumbar and sacral spine should be performed when fractures are suspected below the cervical spine. This should be supplemented with computed tomography to further define areas that are suspicious or not well visualized on the plain x-rays.
   vi. An MRI scan of the spine should be obtained in patients with known spinal cord injuries.
   vii. An MRI scan of the cervical spine should be obtained in patients with cervical fracture dislocations prior to undergoing unsupervised closed reduction or posterior open reduction.
VI. Clearance of the Cervical Spine Following Trauma

a. Background
   i. Spinal cord injury is a potentially devastating consequence of acute trauma and can occur with improper immobilization of an unstable cervical spine fracture. Immobilization of an injury victim’s cervical spine following trauma is now standard care for Mississippi Emergency Medical Services. Immobilization of the cervical spine is maintained until spinal cord or spinal column injury is ruled out by clinical assessment and/or radiographic survey. Prolonged cervical immobilization can result in injury to underlying skin and interfere with patient care.

b. Goals of Therapy
   i. Avoid unnecessary cervical immobilization whenever possible.
   ii. Avoid secondary spinal cord injury in an unrecognized cervical spine fracture.

c. Guidelines
   i. Cervical spine immobilization in awake patients with neck pain or tenderness and normal cervical spine x-rays (including supplemental CT as necessary) be discontinued following either:
      1. Normal and adequate dynamic flexion/extension radiographs; or
      2. Normal MRI study obtained within 48 hours of injury.
   ii. Cervical spine immobilization of obtunded patients with normal cervical spine x-rays (including supplemental CT as necessary) may be discontinued:
      1. Following dynamic flexion/extension studies performed under fluoroscopic guidance; or
      2. Following a normal MRI study obtained within 48 hours of injury; or
      3. At the discretion of the treating physician
VII. Initial Closed Reduction of Cervical Spinal Fracture-Dislocation Injuries

a. Background
i. Spinal cord injury is frequently associated with cervical spine fractures and cervical facet dislocation injuries. Reduction of the deformity helps to restore the diameter of the bony canal and eliminates bony compression of the spinal cord due to the vertebral fracture and/or subluxation. Theoretically, early decompression of the spinal cord after injury may lead to improved neurological outcome. Several large series of patients describe excellent results with closed reduction of cervical fractures and facet subluxations. However, descriptive series using pre-reduction MRI have reported a high incidence of cervical disc herniation in the facet dislocation patient population. Furthermore, case reports and small series of patients who worsened neurologically following closed cervical spinal reduction exist. Several of these reports implicate ventral compression of the spinal cord by displaced disc material.

b. Goals of therapy
i. Rapid but safe reduction of cervical spine fractures and fracture dislocations.
ii. Identify patients at risk for cord compression due to disc herniation following cervical spine fracture.

c. Guidelines
i. Cranio-cervical traction is an option for early closed reduction of cervical spinal fracture-dislocation injuries for the restoration of anatomic alignment of the cervical spine in awake patients.
   1. If cranio-cervical traction is utilized, Gardner-Wells tongs will be applied using sterile technique and appropriate analgesia.
   2. If cranio-cervical traction is utilized for closed reduction, it will be done as rapidly as possible under direct physician supervision performing frequent neurologic examinations and x-ray confirmation following the addition of weight.
   3. Once a patient has been immobilized in cranio-cervical traction the patient can be log rolled to protect the skin.

ii. Patients with cervical spinal fracture dislocation injuries who are not able to be examined during attempted closed reduction, or prior to open posterior reduction, should undergo MRI prior to attempted reduction. The presence of a significant disc herniation in this setting is a relative indication for a ventral decompression prior to reduction.
VIII. Management in an Intensive Care Unit

a. Background
   i. Many patients with acute spinal cord injury are critically ill and therefore have multiple issues related to general critical care management. These include, but are not limited to, respiration, neurogenic shock and blood pressure support, nutrition, prevention of deep venous thrombosis, prevention of decubitus ulcers, and routine monitoring. The Neuroscience Intensive Care Unit (NSICU) is particularly well suited for management of ASCI.

b. Goals of therapy
   i. Prevention of secondary tissue injury following ASCI.
   ii. Prevention of secondary complications following ASCI.
   iii. To provide specialize care in a systematic fashion by personnel well acquainted with the care of a paralyzed patient.

c. Guidelines
   i. Cardiac, hemodynamic, and respiratory monitoring devices will be used to detect cardiovascular dysfunction and respiratory insufficiency in patients following ASCI.
   ii. Nutritional Support (please see nutritional guidelines)
      1. Enteral feeding will commence as early as feasible, preferably within 24 hours post-trauma. 140% of resting metabolism for most patients; 100% of resting metabolism for patients receiving neuromuscular blockade.
      2. Duodenal feedings are preferred over stomach feedings.
      3. For patients who cannot receive enteral feeding, TPN will be provided.
   iii. Ulcer Prophylaxis
      1. An H2-blocker or proton pump inhibitor will be initiated at time of ICU admission.
      2. Sucralfate or omeprazole are alternatives.
   iv. Fluids
      1. All infusions will be mixed in 0.9% NS.
      2. An even or slightly positive (~500-1000 cc) daily fluid balance will be maintained.
      3. Hyponatremia will be aggressively avoided and treated.
      4. For Na < 135, 3% NaCl administration will be considered.
      5. Severe fluid restriction will not be undertaken, as hypovolemia is to be avoided in patients with ASCI.
   v. Hematology
      1. In the absence of bleeding, CBC/plts, PT/PTT will be checked daily.
      2. Platelet count will maintained above 100,000 at the discretion of the Neurosurgery Attending.
   vi. DVT Prophylaxis and Surveillance
      1. Sequential compression devices (SCDs) will be the preferred method of DVT prophylaxis and will be initiated,
2. Low molecular weight heparin will be administered when complete reduction and stabilization of the fracture is achieved.
3. DVT prophylaxis will continue for 3 months post injury.
4. In acute bedridden patients lower extremity doppler studies should be performed initially within 5 days of admission and then once a week thereafter.

vii. Neurogenic bladders will be managed with a foley catheter until the patient is no longer receiving IV fluids at which point intermittent catheterization q 4 to 6 hours to maintain bladder volumes in the range 500 to 700 cc.
IX. Blood Pressure Management
   a. Background
      i. Acute traumatic spinal cord injury is frequently associated with systemic hypotension. Hypotension may be due to associated traumatic injuries with hypovolemia, direct severe spinal cord trauma itself (neurogenic shock), or a combination. Persistent hypotension may contribute to secondary tissue injury as a result of inadequate perfusion of the ischemic penumbra of the injured spinal cord.
   b. Goals of therapy
      i. Assure adequate perfusion pressure thereby preventing or limiting secondary spinal cord tissue injury.
      ii. Avoid injury to vital organs due to hypoperfusion.
   c. Guidelines
      i. Mean arterial blood pressure will be maintained between 85 – 90 mm Hg for the first seven days following acute SCI to improve spinal cord perfusion is recommended.
         1. First line therapy will be fluid resuscitation taking care to avoid fluid overload.
         2. Second line therapy will rely on improving venous return with TED hose, abdominal binders and elevation of the legs.
         3. Third line therapy will consist of vasopressors such as Neo-Synephrine or Dopamine.
      ii. In otherwise medically stable patients, every effort should be made to wean ASCI patients from intravenous third line therapy as quickly as possible in order to avoid prolonged ICU stay.
X. Pharmacological Therapy
   a. Background
      i. Class 1 data exists that supports its use. Furthermore, the NASCIS II protocol has been routinely used since 1992. This protocol has been demonstrated to improve functional outcomes following ASCI if administered within 8 hours of the initial injury.
      ii. The NASCIS II and III studies have generated significant controversy. Several peer reviewed critiques of the data, experimental design, data analysis, conclusions and dissemination have been published. Until further studies or clarification of existing studies is available, the validity of the NASCIS studies is considered questionable.
   b. Goals of therapy
      i. To prevent secondary spinal cord injury
   c. Guidelines
      i. The primary treating physician should make the determination whether or not high dose steroids are used and which dosing regimen is most appropriate.
      ii. NASCIS II protocol: Within 8 hours post injury, Methylprednisolone will be administered as a 30mg/kg bolus over 15 minutes followed by a continuous infusion of 5.4 mg/kg/hr for 23 hours.
      iii. NASCIS III protocol: (may be used as an alternative to NASCIS II protocol.)
         1. Within 3 hours post injury, Methylprednisolone will be administered as a 30 mg/kg bolus over 15 minutes followed by a continuous infusion of 5.4 mg/kg/hr for 23 hours.
         2. Between 3 and 8 hours post injury, Methylprednisolone will be administered as a 30 mg/kg bolus over 15 minutes followed by a continuous infusion of 5.4 mg/kg/hr for 24 hours.
      iv. Pregnant patients and patients with penetrating SCI should be excluded. Patients under the age of 16 have not been studied.
      v. Possible medical contraindications should be weighed against the potential benefits of high dose corticosteroids.
XI. Prevention and Management of Pulmonary complications

a. Background
   i. Ventilatory inspiration is primarily the function of the diaphragm, innervated by C3-C5 spinal segments and intercostals muscles, innervated by the 12 thoracic nerves. Very high cervical ASCI may result in the complete loss of inspiratory capacity thereby necessitating mechanical ventilation to sustain life. Mid to lower cervical injuries spare diaphragmatic function but impairs intercostal function. These patients are still able to breath adequately at the outset, but may subsequently develop respiratory failure. This is due, in part, to decreased inspiratory capability but also due to an inability to cough. Normal ventilatory expiration is passive but a cough requires forceful contraction of abdominal muscles, which are impaired in SCI patients. Prevention of secondary respiratory failure following cervical or high thoracic ASCI is paramount. This can be achieved with vigorous pulmonary hygiene consisting primarily of lung volume expansion and assisted cough.

b. Goals of therapy
   i. Provide respiratory support for ventilator dependent patients
   ii. Prevent respiratory failure through aggressive pulmonary toilet

c. Guidelines
   i. Ventilator dependent patients (high cervical cord injury or those with respiratory failure despite preventative measures)
      1. Early placement of a tracheostomy is recommended unless duration of ventilator support is expected to be less than 5 days. Timing and approach of surgical stabilization should be considered prior to performing tracheostomy. The Neurosurgical Attending should be consulted prior to performance of the tracheostomy.
      2. The initial goal in all patients will be normoventilation maintaining a PaO2 of 100 mmHg.
      3. Initial ventilator settings will involve volume-controlled ventilation (AC or SIMV) with PEEP of 5.

   ii. Non-ventilated patients
      1. Volume expansion will be maintained either through incentive spirometry or intermittent positive pressure breathing (IPPB). Acutely injured patients frequently have very weak inspiratory function and will be unable to maintain adequate volume expansion without the assistance of IPPB. The frequency of respiratory sessions will be determined by need but may be as frequent as q 2 hours or as infrequent as q 12 hours.
      2. Target volumes for IPPB will be 75% of predicted vital capacity.
      3. Once the spinal fracture is adequately stabilized, assisted cough may be added to help the patient clear lung
secrections (assuming the absence of other injuries that preclude assisted cough).

4. Chest percussion and other mechanical or medical means for mobilizing lung secretions may be used at the discretion of the treating physician.

5. NT suction may be used to assist with the removal of lung secretions. However, it should be remembered that although NT stimulation may initiate a cough reflex, an effective cough will not ensue unless residual abdominal motor function exists.
XII. Radiographic Assessment of the Thoracic and Lumbar Spine
   a. Background
      i. Spinal cord injury is a potentially devastating consequence of acute trauma. Fractures of the thoracic and lumbar spine and the thoracolumbar junction in particular, are frequently associated with blunt trauma to the thorax. The diagnosis of spinal fractures relies partly on the physical and neurological examinations and partly on diagnostic imaging. Patients may present with spinal fractures in the absence of spinal cord injury. Furthermore, 20 percent of spinal fractures are associated with fractures elsewhere in the spine. Failure to recognize spine fractures may lead to catastrophic spinal cord injury.
   b. Goals of Therapy
      i. Avoid unnecessary radiographic imaging whenever possible.
      ii. Identify any and all fractures of the spine following trauma.
      iii. Fully characterize any spinal fracture with appropriate imaging techniques to aid in treatment and subsequent follow up.
      iv. Document any spinal cord trauma that may be visible on MRI
   c. Guidelines
      i. Radiographic assessment of the spine is not recommended in trauma patients who are awake, alert, and not intoxicated, who are without spine pain or tenderness, and who do not have significant associated injuries that detract from their general evaluation.
      ii. Any patient with significant head trauma or blunt trauma to the thorax should be suspected of having a spine fracture and examined accordingly.
      iii. Any patient with a neurologic deficit consistent with a SCI should have a thorough radiographic examination.
      iv. An AP and lateral view of the thoracic spine is recommended for radiographic evaluation in patients who are symptomatic (complaints of spine pain or tenderness on examination) following traumatic injury. This should be supplemented with computed tomography to further define areas that are suspicious or not well visualized on the plain cervical x-rays.
      v. An MRI scan of the spine should be obtained in patients with known spinal cord injuries.
XIII. References

Guidelines for the Management of Acute Cervical Spine and Spinal cord Injuries. 
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