Commentary

Emergency Management of Spinal Trauma

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Introduction

Spinal cord injury (SCI) causes temporary or permanent loss of motor, sensory and autonomic functions [1]. This health problem affecting the population in productive age causes physical, psychosocial and economic losses in patients [2]. For these reasons, SCI is a serious health problem. The fact that the neural plasticity and regeneration capacity of the spinal cord and the effects of existing medical practices on decreasing morbidity and mortality are limited increases the value of promising positive results that will be obtained from new studies to be conducted.

Epidemiology and Etiology

Epidemiological data about SCI can differ from country to country and even from region to region within a country. While motor vehicle accidents rank the first in the etiology of traumatic SCI in developed countries, falling from high is the main reason in developing countries [3]. In the USA, SCI incidence is 54/1.000.000 and about 17.000 new cases are seen annually. About 80% of the cases are men. The reasons which play a role in the etiology are traffic accidents with a rate of 38%, falls with a rate of 30.5%, violence with a rate of 13.5%, sport injuries with a rate of 9%, medical/surgical complications with a rate of 5% and other reasons with a rate of 4%. Other reasons are described as avalanche, being trapped under a landslide, jumping off a vehicle and all unclassified injuries [4]. In general, traumatic SCI incidence in the whole world differs between 10.4 and 83 years [3,5].

Diagnostic Assessment and Clinical Features of Spinal Cord Injuries

The patients with a suspicion of SCI or those who have SCI should undergo a primary assessment. The patient's airway manoeuvre should be provided-maintained, respiratory and circulatory parameters should be controlled and required interventions should be made. In the secondary assessment, the whole body should be examined. The patients with a suspicion of SCI or those who have SCI should be transferred with back boards after cervical immobilization is maintained. SCI presence should be doubted in patients who have the clinical features presented in Table 1 [6].

Table 1: Clinical features of suspected spinal cord injury [6].

Clinical Features
Neck and back pain
Sensorial loss in hands and feet
Loss of strength or paralysis in upper and/or lower extremities
Paradoxical movement of chest wall
Priapism
Neurogenic shock findings characterized by hypotension and bradycardia

ASIA impairment scale (AIS)-ASIA defined by ASIA- American Spinal Cord Injury Association is as a standard examination and classification method for patients with spinal cord injury (Table 2) [7,8].

Table 2: ASIA Impairment Scale [7,8].

ASIA Impairment Scale
A-Complete: No sensory or motor function is preserved in the sacral segments S4-5.
B-Sensory Incomplete: Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5 (light touch or pin prick at S4-5 or deep anal pressure) and no motor function is preserved more than three levels below the motor level on either side of the body.
C-Motor Incomplete: Motor function is preserved at the most caudal sacral segments for voluntary anal contraction (VAC) or the patient meets the criteria for sensory incomplete status (sensory function preserved at the most caudal sacral segments (S4-S5) by LT, PP or DAP), and has some sparing of motor function more than three levels below the ipsilateral motor level on either side of the body.
(This includes key or non-key muscle functions to determine motor incomplete status.) For AIS C – less than half of key muscle functions below the single NLI have a muscle grade ≥ 3.
D-Motor Incomplete: Motor incomplete status as defined above, with at least half (half or more) of key muscle functions below the single NLI having a muscle grade ≥ 3.
E-Normal: If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.

PP: Partial preservation; DAP: Deep Anal Pressure; NLI: Neurological level of injury; ISNCSCI: International Standards for Neurological Classification of Spinal Cord Injury

Spinal Radiological Examinations

The purpose of neurological examination is to find out the existing neurological state, to find out the possible lesion level and to choose the radiological examination to be conducted. A suitable radiological examination for the lesion is needed so that the patient can receive the suitable treatment [9]. It is recommended for imaging to be used wisely to avoid unnecessary expenses and to prevent patients from being exposed to unnecessary ionized radiation exposure. Most common imaging methods are conventional direct radiography, computerized tomography (CT) and magnetic resonance imaging (MRI) which does not include ionized radiation [9].

Cervical Imaging

Cervical Imaging Criteria

In patients with a head and/or cervical trauma history and those with a Glasgow Coma Scale (GCS) score of <15, cervical vertebra imaging should be conducted [9]. In the prevention of unnecessary radiological examination in patients who are stable with alert trauma and no neurological deficit, two clinical studies are guiding. One of these was put forward by NEXUS (National Emergency X-Radiography Utilization Study) which consists of five criteria and prevents unnecessary direct radiographic examination in patients who do not meet any of the criteria [10]. NEXUS criteria have 99.6% sensitivity, 12.9% selectivity and 99.9% negative predictive value in detecting cervical spinal injuries (Table 3) [11,12]. Another criterion that helps in preventing unnecessary cervical imaging is Canada Cervical Spinal Rules (CCR) for direct radiography. Canada Rules consist of three questions for assessment. Direct radiography is asked in case of getting the answer "no" to any of these. Canada Cervical Spinal Rules have 100% sensitivity and 42.5% selectivity in the detection of clinically significant cervical vertebra injuries (Table 4) [13,14].

Table 3: NEXUS Criteria [11,12].

NEXUS Criteria
1- No posterior midline cervical-spine tenderness
2- No evidence of intoxication
3- A normal level of alertness (score of 15 on the Glasgow Coma Scale)
4- No focal neurologic deficit and consciousness
5- No painful distracting injuries

Table 4: Canadian Cervical Spine Rule for Radiography [13,14].

Assessment	**Definitions**
Assessment 1: There are no high-risk factors that mandate radiography.	High-risk factors include: Age 65 years or older A dangerous mechanism of injury* The presence of paresthesias in the extremities
Assessment 2: There are low-risk factors that allow a safe assessment of range of motion.	Low-risk factors include: Simple rear-end motor vehicle crashes Patient able to sit up in the ED Patient ambulatory at any time Delayed onset of neck pain Absence of midline cervical tenderness
Assessment 3: The patient is able to actively rotate his/her neck (regardless of pain).	Can rotate neck 45 degrees to the left and to the right

*Defined as fall from a height of >3 feet; an axial loading injury; high-speed motor vehicle crash, rollover, or ejection; motorized recreational vehicle or bicycle collision

Cervical Vertebra Direct Radiography

In vertebral colon injuries, direct radiography is the first step. It is a technically easy and cheap imaging method. It can be taken at bedside and the patient is exposed to low dose ionized radiation. Cervical traumas are routinely assessed with anteroposterior (AP), lateral and open mouth odontoid (dens) radiography. In direct radiography, in addition to seven cervical spine, the upper boundary of thoracic spine should be included in the imaging area considering the possibility of injury in the cervicothoracic intersection. If the cervicothoracic intersection cannot be visualized enough, the patient is brought to a position called swimmer position by lifting the arm at the side of the cassette up, pulling down the arm on the opposite side and turning the shoulders slightly. In the lateral radiography, occipital condyle fractures, first cervical spinal lateral mass and atlantooccipital joint cannot be assessed. These can be assessed better with mouth open odontoid radiography.

Computerized Tomography in Cervical Vertebra Traumas

A great number of trauma centres use computerized tomography (CT) as the initial imaging method to assess cervical vertebra. Eastern Trauma Surgery Association recommends CT as the primary diagnostic tool in patients with a suspicion of cervical vertebra injury [15]. CT is especially useful in the imaging of craniocervical and cervicothoracic areas where sensitivity of radiography is low. Each case who has pain and sensitivity in the cervical area should be assessed with CT even if the direct radiography is normal. In cervical CT examinations, it is recommended to obtain sagittal and coronal images with thin section axial images and to examine in both soft tissue and bone window. Fractured lines in corpus and posterior bone structure and deterioration and stability in vertebra sequencing should be assessed with CT. At the same time, bone pieces and foreign materials that can be inside the spinal canal should also be assessed [16].

Magnetic Resonance Imaging in Cervical Vertebra Traumas

In case of insistent neck pain, midline tenderness, extremity paresthaesia and/or focal neurological findings in the patient despite normal direct radiography and CT, ligament injury and instability should be suspected. If there is a variational suspicion about instability, a newly formed or progressive neurological deficit, cord damage or bone structure, assessment can be made with magnetic resonance imaging (MRI). MRI is superior in the assessment of bone marrow edema, soft tissue injury, spinal cord contusion and hemorrhage, epidural hemorrhage, disc herniation and ligament injuries. Vascular assessment can be made with MRI angiography [17]. In spite of these, restrictions which limit clinical use such as the fact that the patient has to be stable, accessibility, cost and the patient's tolerance to the method are disadvantages. At the same time, other disadvantages are not being able to take images in patients who have magnetic active implant such as cardiac pacemaker and old bone structure instrument.

Thoracolumbar Imaging

Eastern Trauma Surgery Association has an application guideline for imaging in blunt trauma patients who have a suspicion of thoracolumbar injury (Table 5) [18].

Table 5: Eastern Association for the Surgery of Trauma Guidelines for Thoracic and Lumbar Imaging after Trauma [18].

Level I (convincingly justifiable based on scientific evidence)
When imaging is deemed necessary, CT scans with axial collimation should be used to screen for and diagnose injury, because CT scans are superior to plain films in identifying thoracolumbar spine fractures.
Level II (reasonably justifiable based on scientific evidence and expert opinion)
Patients with back pain, thoracolumbar spine tenderness on examination, neurologic deficits referable to the thoracolumbar spine, altered mental status, intoxication, distracting injuries, or known or suspected high-energy mechanisms should be screened for thoracolumbar spine injury with CT scan. In blunt trauma patients with a known or suspected injury to the cervical spine, or any other region of the spine, thorough evaluation of the entire spine by CT scan should be strongly considered due to a high incidence of spinal injury at multiple levels within this population. Patients without complaints of thoracolumbar spine pain who have normal mental status, as well as normal neurologic and physical examinations, may be excluded from thoracolumbar spine injury by clinical examination alone, without radiographic imaging, provided that there is no suspicion of high energy mechanism or intoxication with alcohol or drugs.
Level III (supported by available data, but scientific evidence lacking)
MRI should be considered in consultation with the spine service for CT findings suggestive of neurologic involvement and of gross neurologic deficits.

CT: Computed Tomography

Direct Radioraphy in Thoracolumbar Vertebra Traumas

The primary screening method is anteroposterior (AP) and lateral direct radiography. With lateral radiography, subluxation, decrease in vertebra corpus height, enlargement at interspinous distance and the pressure of bone structures to spinal canal can be seen. In AP radiography, lateral wedge fractures, lateral translation, rotation and enlargement at interpedicular distance in burst fractures can be detected.

Computerized Tomography in Thoracolumbar Vertebra Traumas

In patients with thoracolumbar injury, CT has replaced direct radiography to a great extent. In patients with severe trauma and/or multiple trauma CT can be the primary diagnostic method. In patients with neurological deficit whose direct radiography does not show an obvious anomaly, in patients who have thoracic and lumbar spinal and even intense pain even though there is not pathology found in direct radiography in sublocations and in patients who have been found to have fracture in direct radiography, CT is indicated for advanced examination [19,20]. CT can detect lamina fracture that shows assessment of mid colon integrity and posterior colon deficiency, pars interarticularis fracture, fracture and/or disintegration that can occur in facet joint. Comorbid intraabdominal and/or retroperitoneal injuries can also be detected with CT.

Magnetic Resonance Imaging in Thoracolumbar Vertebra Traumas

This is a perfect method to detect nerve, muscle and soft tissue damage. Disc herniation, SCI and contusion can be defined with MRI. In patients whose direct radiography and CT do not show pathological finding but who have abnormal neurological findings, MRI is indicated [21].

Emergency Approach to Patients with Spinal Trauma

Pre-hospital care

The purpose is to decrease neurological damage and to prevent the additional neurological functioning losses that may occur. Pre-hospital management includes a quick primary assessment of the patient, a detailed secondary assessment following the resuscitation of vital functions and transfer to a trauma center with transportation [22].

In the primary assessment of the patient, airway, breathing and circulation should be assessed and stabilization should be provided and/or maintained suitably [22]. In the secondary assessment, a complete body control from head to toe should be conducted. In patients who have neck and/or back pain, who are found to have sensitivity with palpation on spinal axis, who have muscle weakness, paralysis, paresthaesia and incontinence symptoms and/or priapism, care should be taken in terms of SCI [22]. Patients who are drunk, who have loss of consciousness, paradoxical respiration, low body temperature and high skin temperature and level of sweating should be accepted as spinal cord injury unless proven otherwise.

Transferring the patient to a center that can diagnose and treat fast is important to optimize the results following SCI. The transfer is generally made by providing immobilization through rigid cervical collars and long back boards. Rigid cervical collars and spinal trauma boards can cause pressure sores, decrease in the patient's comfort and difficulty in breathing [23-26].

Stabilization in the Emergency Service

In the emergency service, a primary assessment following the plan Airway (A), Breathing (B), Circulation (C), Disability-abbreviated neurological examination (D) and Exposure-completely disrobing the patient and control the environment (E) should be made by paying attention to the patient's stabilization.

Airway

In a potential SCI patient, the first priority is airway safety. If spinal injury level is high, early airway safety becomes more important. In patients with unstable spinal lesion over cervical 3 (C3), respiration may arrest. The lesions affecting C3-5 also affect the phrenic nerve and diaphragm function is disrupted. For this reason, some experts recommend airway safety through endotracheal intubation in patients with a lesion of C5 and over. In patients with high level of cervical lesion, one should be alert in terms of respiratory failure [27]. The patients whose general condition is good can be given oxygen with nasal cannula or mask. In cases when intubation is indicated, orotracheal or nasotracheal intubation should be applied. An abbreviated neurological examination should be made before sedation-paralysis and intubation if the patient's existing state allows. Spinal stabilization is very important during intubation. The movement of unstable cervical vertebra can cause spinal cord injury or can worsen the existing injury. Video assisted intubation has a greater chance of success when compared with direct laryngoscopy [28]. In patients with spinal cord injury, arterial oxygenization should be followed and supported when necessary, since hypoxia will negatively influence the results.

Hypotension

Hypotension can occur due to loss of blood, cardiac injury, tension pneumothorax and/or other injuries. The loss of sympathetic tonus as a result of autonomous nerve system damage causes the ponding of blood in extremities. As a result of this event called neurogenic shock, the patient may develop hypotension. Although hypotension and bradycardia are neurogenic shock symptoms, bradycardia can also be associated with intraperitoneal hemorrhage and use of beta blocker or calcium canal blocker. For this reason, the presence of blood loss should be considered as the reason for hypotension, unless proven otherwise.

Sufficient tissue perfusion should be provided to prevent secondary damage development. The treatment includes trendelenburg position, crystalloid and/or colloid solutions, blood and blood products, use of vasospressor and positive inotropic effective agents [22,29]. Guidelines currently recommend maintaining mean arterial pressures of at least 85 to 90 mmHg [30,31]. Care should be taken since giving too much liquid for therapeutical purposes can cause lung edema. Atropine can be used in the presence of hypotension and bradycardia.

Neurological Examination

First of all, the patient's state of consciousness should be assessed. An unconscious patient is accepted to have spinal trauma until proven otherwise. Following the neurological examination, muscle strength and anal sphincter tonus is assessed. In patients with altered mental status, muscle strength assessment score obtained by giving painful stimulant can be misleading. In patients who do not have consciousness problem, anterior spinothalamic tractus is assessed with superficial palpation, while lateral spinothalamic tractus is assessed with injection. Posterior colon functions are assessed with proprioception or vibration. Deep tendon reflex, abdominal skin reflex, cremasteric reflex, bulbocavernosus reflex and anal reflex examination are made in the assessment of reflexes. The patient's clinical state is determined by using ASIA impairment scale with these data. In addition to being used to document the first examination, this scoring system also has prognostic value. However, it is not a practical scoring system to be used in the emergency service [32].

Treatment in Spinal Cord Injuries

The aim of the treatment is to prevent damage, to alleviate cord compression and to provide spinal stability. All vertebral fractures and ligament injuries, regardless of the presence of neurological loss, should immediately be assessed by brain surgery.

Medical treatment in spinal cord injuries

Glucocorticoids

Methylprednisolone [MP] is the only medical treatment choice used to treat neurological consequences in acute, blunt spinal cord injuries. However, the evidence is limited and its use controversial [33]. American Neurological Surgeons Association reported in 2013 that methylprednisolone should not be used routinely in the treatment [34]. In addition, American Food and Drug Administration (FDA) did not approve of corticosteroid use for SCI. Due to controversies continuing in its use, it is recommended to continue its use with the opinion of surgical department. If the patient is neurogically impaired and less than 8 hours have passed since the time of injury, high dose steroid infusion has been shown to significantly alter the possibility of neurological improvement, where no contraindications to steroid usage exists. In these situations the patient should be commenced on an infusion of steroid as follows: 30 mg per kg MP dissolved in saline or dextrose and given over 15 minutes. Wait 45 minutes and commence again with 5.4 mg MP per kg per hour to be continued. If 3 hours or less since injury this infusion should be given for 23 hours. If more than 3 hours and less than 8 hours have elapsed, continue infusion for 48 hours [35].

In patients who receive high dose and long term protocol MP treatment, high rates of sepsis, pneumonia, wound site infection and delayed recovery, pulmonary embolism, deep vein thrombosis, gastrointestinal hemorrhage and death rates have been reported [36]. In addition, patients with brain injury should avoid steroid use since it aggravates the results in patients with brain damage [37].

Surgical Treatment in Spinal Cord Injuries

The goals of surgical intervention are: stabilization of vertebral colon, reduction of dislocations and decompression of nerve elements. There is no guide based on evidence about the timing of surgical treatment, the timing of the intervention is not clearly defined and it is controversial [30,38]. Early surgical intervention provides early mobilization, decrease in the period of stay in intensive care and hospital and decrease in the rates of complication [39-42]. Most of the clinicians opt for surgical intervention as early as possible in patients with incomplete spinal cord injury if there is no condition causing contraindication such as hemorrhagic shock and/or bleeding disorder. In patients with complete spinal cord injury, timing is controversial in this patient group since the possibility of changing the prognosis of early surgery is very low [43].

Emergency Decompressive Surgical Indications

Deterioration of neurological symptoms,

Conditions in which subarachnoid distance is shown to be completely closed with Queckenstedt test (a test which assesses the presence of an event preventing BOS circulation in spinal subarachnoid space) or radiological imaging,

Radiological imaging of bone pieces, hematoma or soft tissue components causing spinal cord pressure inside the spinal canal, The need to decompress a cervical nerve root with critical significance, Presence of spinal penetran or complex fractures, Acute anterior spinal cord syndrome,

Fractures and dislocations that cause spinal cord pressure and that cannot be fixed due to facet locking [44].

Mortality in Spinal Cord Injuries

Post-traumatic SCI early period mortality rates differ between 4 and 20% [45,46]. The patient's age, the level of spinal cord injury and neurological staging predict survival. Severe systemic injuries, traumatic brain damage, comorbid diseases, abnormal coagulation and malnutrition increase mortality [44,45].

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