Acute Management of Spinal Cord Injury at the Out-of-Hospital and Emergency Department Settings

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Introduction

Injuries contribute 6% of total deaths in Turkey (Table 1). Mainly, injury-related deaths are known to occur mostly in young people (Figure 1). According to data from the Turkish Statistical Institute, over one million traffic accidents occurred during the year 2014. Overall, 168,512 of the accidents resulted in fatality or injury; 75.1% occurred in the populated areas in the month of August during day hours. As a result of these accidents, 3,524 people died and 285,059 were injured (Table 2). Among those who died in the accidents, 42.7% of them were drivers, 40.3% were travelers, and 17% were on foot. With regard to gender of individuals died, 76.8% were men and 23.2% were women; for the general population harmed, 70.2% were men and 29.8% were women (1). There is no recent Turkish epidemiological study published with regard to spinal cord injury (SCI). According to a nationwide retrospective study published by Karacan et al. in 2000, 5,081 traumatic SCI cases were reported in 1992. The estimated annual incidence of traumatic SCI was 12.7 per million people. The male to female proportion was 2.5:1, and the normal age at harm was 35.5±15.1 years (35.4±14.8 years for males and 35.9±16.0 years for females). The most widely...
neuronal damage (primary injury) and is only modifiable by preven-
tion. The secondary injury starts within minutes and involves a com-
plex cascade of events including inflammation, edema, ischemia,
and excitotoxicity leading to further ischemia and progressive neu-
rological deterioration in the following days. Carefully coordinated
management strategies aim to limit/reverse this progression. Treat-
ment and damage control starts at the scene of injury and is critical
during the first 24 hours. Early clinical assessments, accurate spinal
immobilization, prompt transfer of injured patient to a SCI unit, and
respiratory and hemodynamic support are recommended for the
acute management of SCI patients (3).

It is important to recognize that 20%–60% of SCIs will also have a
concurrent traumatic brain injury. Thoracic spine injuries may be
accompanied with a major vascular injury pneumothorax and myo-
cardial and/or pulmonary contusion. Lumbar spine fractures may be
associated with bowel and solid organ injury (4-7).

Transfer of a spinal cord-injured patient
SCI occurs in up to 2%–5% of all major trauma cases and at least
14% of these cases have the potential to develop into an unstable
spine. Emergency first responders therefore should exercise high
index of suspicion for SCI in the major trauma settings. A study
performed to evaluate pre-hospital management of SCIs in New
South Wales between 2004 and 2008 found that the median time
of transport from the scene to an SCI unit was 12 hours, with 60%
of patients needing multiple transfers. The odds of reaching an SCI
unit in 24 hours were 1.71 times higher for patients injured in a
major city (95% confidence interval [CI]: 1.00–2.90) compared the
other areas. SCI patients with multiple traumas had more delays to
reach an SCI unit (59%) compared to isolated SCI patients (40%).
Patients who reached an SCI unit after 24 hours were at 2.5 times
higher risk to develop a secondary complication (95% CI: 1.51–
4.17) (8).

The trauma patient triage scheme of the American College of Sur-
geons Committee on Trauma has a four-step evaluation process: first,
the assessment of vital signs and Glasgow Coma Scale score; second,
the evaluation for critical injury patterns; third, the assessment of spe-
cial patient characteristics, such as age, pregnancy, anticoagulation
treatment, burns, and end-stage renal disease (9).

A review of the cases with SCI after the 2005 Pakistan earthquake
reported that the lack of SCI evacuation protocols caused permanent
neurological deficits in some patients because of missed stabilization
of spinal column. In contrast, air transport of patients and on-time
transfers of the patients from the disaster zone to tertiary care hospi-
tals have resulted in low mortality rates (10).

However, a systematic review of the literature by Oteir et al. (11) to
determine the efficacy of cervical immobilization in patients with
suspected cervical SCI found that there is a lack of high-level evi-
dence on the effect of pre-hospital cervical immobilization on the
consequences. The systematic review of eight studies including cer-
vical collar application in penetrating trauma was associated with
increased mortality in two of the studies. In blunt trauma, one study
indicated that stabilization might worsen the neurological conse-
quences. In another study, investigators found that there are some

Table 1. Percent distribution of injuries in Turkey

<table>
<thead>
<tr>
<th></th>
<th>2010, % of deaths n=24,857 total deaths</th>
<th>2013, % of deaths n=24,703 total deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road injuries</td>
<td>2.2</td>
<td>2.19</td>
</tr>
<tr>
<td>Self-harm</td>
<td>1.13</td>
<td>0.94</td>
</tr>
<tr>
<td>Falls</td>
<td>0.63</td>
<td>0.74</td>
</tr>
<tr>
<td>Mechanical forces</td>
<td>0.68</td>
<td>0.56</td>
</tr>
<tr>
<td>Violence</td>
<td>0.72</td>
<td>0.52</td>
</tr>
<tr>
<td>Drowning</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Other unintentional</td>
<td>0.27</td>
<td>0.22</td>
</tr>
<tr>
<td>Foreign body</td>
<td>0.2</td>
<td>0.19</td>
</tr>
<tr>
<td>Poisoning</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>Fire, heat</td>
<td>0.11</td>
<td>0.1</td>
</tr>
<tr>
<td>Other transport</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Animal contact</td>
<td>0.036</td>
<td>0.03</td>
</tr>
</tbody>
</table>

recognized reason for harm was engine vehicle mischances (48.8%),
trailed by falls (36.5%), cut injuries (3.3%), shot wounds (1.9%),
and wounds from jumping (1.2%). In total, 187 patients (32.18%) were
tetraplegic and 394 (67.8%) were paraplegic. The most well-known
level of damage was C5 among tetraplegics and T12 among paraple-
gics. The most common related injury was head trauma taken after
by extremity fractures (2).

The acute phase of SCI management is critical for the minimization
of a secondary injury, which directly affects the outcome quality of
life and survival of the patient. Initial trauma results in an irreversible
neuronal damage (primary injury) and is only modifiable by preven-

Figure 1. Age distribution of injuries in Turkey, Institute for Health
Metrics and Evaluation (IHME). GBD Compare. Seattle, WA: IHME, Uni-
org/gbd-compare. (Accessed [21/05/2016])

Table 1. Percent distribution of injuries in Turkey
adverse effects of pre-hospital immobilization, including increased aspiration risk, airway problems, delay in transfer, and patient discomfort (12).

In a recent systematic review of 47 studies regarding spinal immobilization in pre-hospital and emergency care settings from 1966 to 2015, authors found that there were 15 studies supportive of spinal immobilization, 13 studies neutral for spinal immobilization, and 19 studies opposing spinal immobilization. They reported that decisions to use spinal immobilization should be based upon careful assessment of the risk–benefit ratio (13).

Burton et al. (14) found that emergency medicine service providers were able to triage pre-hospital trauma patients with a four-step clinical assessment protocol and could accurately identify the patients likely to benefit from immobilization. Data from a statewide hospital registry included all patients treated for spine fracture during the 12-month period with 207,545 encounters, including 31,885 transports to an emergency department for acute trauma-related illness. The protocol sensitivity for immobilization of any acute spine fracture was 87.0%. In a recent retrospective analysis conducted in penetrating trauma patients in the National Trauma Data Bank of the United States, 45,284 penetrating trauma patients were concentrated; 4.3% of whom experienced spine immobilization. The general mortality was 8.1%. Unadjusted mortality was twice as high in spine-immobilized patients (14.7% versus 7.2%, p < 0.001). The chance proportion of death for spine-immobilized patients was 2.06 (95% CI: 1.35–3.13) contrasted and non-immobilized patients.

Table 2. Road traffic accident statistics

<table>
<thead>
<tr>
<th>Year</th>
<th>Total accidents (n)</th>
<th>Accidents resulting death or injury (n)</th>
<th>Persons killed (n)</th>
<th>Persons injured (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1,106,201</td>
<td>116,804</td>
<td>4,045</td>
<td>211,496</td>
</tr>
<tr>
<td>2011</td>
<td>1,228,928</td>
<td>131,845</td>
<td>3,835</td>
<td>238,074</td>
</tr>
<tr>
<td>2012</td>
<td>1,296,634</td>
<td>153,552</td>
<td>3,750</td>
<td>268,079</td>
</tr>
<tr>
<td>2013</td>
<td>1,207,354</td>
<td>161,306</td>
<td>3,685</td>
<td>274,829</td>
</tr>
<tr>
<td>2014</td>
<td>1,199,010</td>
<td>168,512</td>
<td>3,524</td>
<td>285,059</td>
</tr>
</tbody>
</table>

Table 3. Airway management options for the patient with potential cervical spine injury

<table>
<thead>
<tr>
<th>Airway management device</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awake fiberoptic intubation</td>
<td>Excellent for cooperative patients&lt;br&gt;Allows documentation of neurologic exam before and after intubation</td>
<td>Relatively expensive&lt;br&gt;Longer time to perform&lt;br&gt;Not appropriate for uncooperative patients, excess blood or secretions in the airway, and inexperienced provider</td>
</tr>
<tr>
<td>VAL</td>
<td>Often excellent laryngeal visualization&lt;br&gt;Less for laryngoscopic view required&lt;br&gt;Less mouth opening required</td>
<td>Not always available&lt;br&gt;Blood or secretions may obscure camera view&lt;br&gt;Relatively new technology with lack of evidence in studies in this area</td>
</tr>
<tr>
<td>Direct laryngoscopy</td>
<td>Most studied technique&lt;br&gt;Usually available, even in remote locations&lt;br&gt;Allows rapid ability to secure airway</td>
<td>High percentage of Grade III and Grade IV views&lt;br&gt;May require adjunctive equipment</td>
</tr>
<tr>
<td>Laryngeal mask airway</td>
<td>Essential tool in the difficult airway algorithm</td>
<td>May not be appropriate for routine intubation in SCI</td>
</tr>
</tbody>
</table>

It is estimated that up to a quarter of SCI occur following the initial trauma during the acute phase. Expeditious and careful transport of patients with acute SCI is recommended from the site of injury by the most appropriate mode of transportation available to the nearest capable definitive care medical facility. Whenever possible, patients should be transported to a specialized acute SCI treatment center.

**Airway management in cervical spine injury**

Inappropriate and/or insufficient airway management is a leading cause of preventable death following injury (18, 19). In trauma, endotracheal intubation frequently needs to be accomplished before the presence or location of an injury can be confirmed. As a result, cervi-
Acute Management of Spinal Cord Injury

Katipoğlu et al.

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The most suitable choice will often depend on the practitioner’s experience with a particular technique and the specificity of the clinical situation (33).

In the post-traumatic period, progressive neck swelling due to edema and pre-vertebral hematoma expansion may further compromise the airway, even in the absence of positive examination findings in the early phase of the injury. Intubation should minimize cervical movement to prevent further neurological deterioration in a potential or actual SCI. Manual inline stabilization, gum elastic bougie, and attention to detail are required. Cricoid pressure (CP) ought to be connected amid acceptance and maintained through intubation until tube arrangement is confirmed; it might be connected through the front opening in cervical neckline before the neckline is briefly expelled. Both MILS and CP ought to be adjusted or expelled if they hinder sufficient intubation or ventilation (34).

**Hemodynamic management of spinal cord injury**

Overall, 7%–10% of the SCI patients develop neurogenic circulatory shock and demonstrate hypotension with or without bradycardia (35, 36). Besides, hypotension may be caused by trauma itself and may be difficult to differentiate in acute trauma (37). Kong et al. found that 18.4% of the cervical SCI patients had <80 mmHg mean arterial pressure (MAP) levels (38). Other possible major cardiovascular complications in the acute stage following SCI were heart rate abnormalities and venous thromboembolism (39). Heart rate abnormalities may lead to sinus bradycardia, repolarization changes, atrioventricular block, supraventricular tachycardia, ventricular tachycardia, and primary cardiac arrest (39, 40).

Vale et al. (41) applied resuscitation standards of volume development and circulatory strain upkeep to 77 patients who had intense neurological deficiencies taking after SCI occurring from C-1 through T-12 with an end goal to keep up spinal line blood stream and avert possible harm. They performed surgical strategies for decompression and adjustment and combination in chosen cases. Sixty-four patients have been taken after no less than 12 months post-harm by methods for point-by-point neurological appraisals and useful assessments. After the 12-month follow-up period, 92% of patients exhibited a clinical change subsequent to managing inadequate cervical spinal line wounds contrasted with their underlying neurological status. Ninety-two percent recaptured the capacity to walk and 88% recovered bladder activity (41).

Levi et al. (42) studied the acute phase of SCI. The management protocol included invasive hemodynamic monitoring and cardiovascular support with dopamine and/or dobutamine titrated to maintain a hemodynamic profile with adequate cardiac output and a MAP of >90 mmHg.

Stevens et al. (43) reported that the neurogenic circulatory shock should be treated with fluid resuscitation until the intravascular volume is restored, and subsequently, the use of vasopressors (e.g., dopamine, norepinephrine, and phenylephrine) should be considered. Zäch et al. (44) gave an account of a planned medical administration worldview in the treatment of 117 back-to-back intense SCI patients in the Swiss Paraplegic Center of Basel, Switzerland, in 1976. The creators reasoned that early exchange and “prompt medicinal particular treatment of the spinal damage” with consideration regarding up-
keep of adequate circulatory strain seemed to enhance neurological recuperation. Another systematic review of intensive cardiopulmonary management following acute SCI stated that there is weak evidence supporting the maintenance of MAP >85 mmHg for a period extending up to 1 week following acute SCI (45).

**Steroids in spinal cord injury**

Bracken et al. (46) first reported the effectiveness of methylprednisolone treatment in SCI patients. After this study, the use of intravenous high-dose methylprednisolone became a standard approach in acute management of SCI patients (47). However, two other studies reported that high-dose methylprednisolone could be associated increased complication rates (48, 49).

The role of the steroids in the treatment of SCI patients is debatable. The possible mechanisms for proposed benefits includes the inhibition of lipid peroxidation and inflammatory cytokines, modulation of the inflammatory/immune cells, improved vascular perfusion, and prevention of calcium influx and accumulation (50).

The current use of methylprednisolone therapy is based upon three prospective randomized multicenter trials, namely, National Acute Spinal Cord Injury Studies (NASCIS) I, II, and III (51-53).

In NASCIS I, 330 patients were treated in the first 48 hours of SCI with 100 mg bolus methylprednisolone dose followed by 25 mg every 6 hours for 10 days in one group and with 1,000 mg bolus methylprednisolone followed by 250 mg every 6 hours for 10 days in the other group. No significant difference was noted in neurologic recovery between the two groups with different dose regimens at the 6-month follow-up period (51).

In NASCIS II, 487 patients were treated in the first 12 hours of SCI with 30 mg bolus methylprednisolone dose followed by then 5.4 mg/kg/hour×23 hours in the first group and with 5.4 mg/kg bolus naloxone dose followed by 4.0 mg/kg/hour×23 hours in the second group. The third group was administered placebo. In patients treated with methylprednisolone within 8 hours of SCI, significant motor and sensory improvement was observed at 6 months and 12 months after both complete and incomplete injury (52, 53).

NASCIS III was performed with 499 patients treated within the first 8 hours of SCI with 30 mg bolus methylprednisolone dose followed by 5.4 mg/kg/hour×23 hours in the first group, with 30 mg bolus methylprednisolone dose followed by 5.4 mg/kg/hour×47 hours in the second group, and with 2.5 mg/kg tirilazad mesylate dose every 6 hours for 48 hours in the third group. No significant difference was noted in neurologic recovery between the three groups placebo. When the treatment was started 3 to 8 hours after SCI, the 48-hour methylprednisolone group had significantly better improvement compared to the 24-hour methylprednisolone group at the 6- and 12-month follow-up periods but had more severe sepsis and severe pneumonia (53-55).

In a case report, a 37-year-old woman with whiplash injury after a motor vehicle collision became unresponsive after treatment with intravenous high-dose methylprednisolone with a bolus dose of 30 mg/kg over 15 min followed by maintenance infusion of 5.4 mg/kg per hour for 23 hours; electrocardiography showed ventricular fibrillation, necessitating prompt cardiac defibrillation and renal failure after the infusion. The evaluation of the patient showed that she had diffuse large B-cell lymphoma and methylprednisolone-induced acute tumor lysis syndrome causing ventricular fibrillation and renal failure. The authors stated that the physicians should be aware of this clinical entity and the importance of monitoring patients very close when prescribing corticosteroids, even in those with only mild anemia (56).

In a cohort study, all patients with cervical cord injury were treated with methylprednisolone sodium succinate (MPSS) within 8 hours of their injuries versus no treatment group (non-MPSS), and both the groups were followed up for 2 years. Early spinal decompression and stabilization was performed as early as possible after injury in both groups. The authors found that there was no evidence to support that high-dose methylprednisolone administration facilitates neurologic improvement in patients with SCI. They stated that methylprednisolone ought to be utilized under constrained conditions due to the high occurrence of pulmonary complications (57).

**Summary**

Spinal immobilization can diminish improvement of the cervical spine and can decrease the probability of helper neurological injuries in patients with problematic cervical spinal breaks after harm. Immobilization of the entire spinal section is crucial in these patients until a spinal string harm (or various injuries) is disallowed or until fitting treatment has been imitated. Regardless, not all damage patients must be treated with spinal immobilization in the midst of pre-hospital restoration and transport. Various patients do not have spinal injuries and along these lines do not require such mediation.

There is an absence of authoritative proof to suggest a uniform gadget for spinal immobilization and system. It gives the idea that a mix of an inflexible cervical neckline with steady pieces on an unbending backboard with straps and tape to immobilize the whole body is powerful at accomplishing protected and successful spinal immobilization for transport. Spinal immobilization gadgets ought to be utilized to accomplish the objectives of spinal strength for safe removal and transport. Spinal immobilization of injury patients with entering wounds is not prescribed.

Tolerant with an intense cervical spinal damage ought to be quickly and precisely transported from the site of harm to the closest center with an SCI unit. The method of transportation chosen ought to be founded on the clinical conditions, separation, and geography to be voyage and ought to be the most expeditious means accessible. Cervical SCI patients have a high occurrence of aviation route trade off and pneumatic brokenness; along these lines, respiratory bolster measures ought to be accessible amid transport.

Despite starting stable heart and pneumatic capacity, it is normal to observe hypotension, hypoxemia, aspiratory brokenness, and cardiovascular insecurity in patients with intense cervical SCI. Patients with the most extreme neurological wounds seem to have the most serious danger of these life-undermining occasions. Administration in an intensive care unit or other checked setting seems to favorably affect neurological result an intense cervical SCI. Maintaining the MAP between 85–90 mmHg for the initial 7 days after an intense SCI to en-
enhance spinal string perfusion is the present proposal of the American Association of Neurological Surgeons and Congress of Neurological Surgeons (CNS) (58).

Both, noteworthy methodological mistakes and conflicting neurological results in the reviews conducted to date with respect to the gainful impacts of methylprednisolone can as effectively be devoted to an irregular shot as to any genuine restorative impact. Abnormal state of proof exists with respect to the hurtful symptoms of methylprednisolone organization in the setting of intense SCI including wound contamination, pneumonia, hyperglycemia requiring insulin organization, and gastrointestinal discharge and demise. Methylprednisolone ought not to be routinely utilized as a part of treatment of patients with intense SCI (59).

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