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Review
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Acute Management of Spinal Cord Injury in Out-of-hospital and Emergency Department Settings

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Abstract

Spinal cord injury (SCI) is a devastating neurological disorder that is estimated to affect approximately 1000 patients each year in the Republic of Turkey. With this review, we aim to update the recent evidence related to the acute management of patients with SCI in out-of-hospital and emergency department settings.

We performed a literature review of publications in the English language and indexed in PubMed, ScienceDirect and Scopus using the following search terms: "spinal cord injury" and "acute management", "spinal cord injury" and "immobilisation", "spinal cord injury" and "transfer", "spinal cord injury" and "transport", "spinal cord injury" and "airway management", "spinal cord injury" and "haemodynamic management", "spinal cord injury" and "steroid". We also reviewed the recent international guidelines.

This review reports the immobilisation of patients with SCI and management strategies relevant to their transfer, airway management in cervical SCI, haemodynamic management and methylprednisolone use.

The patient's spinal alignment should be maintained with appropriate techniques for sufficient immobilisation to ease safe extrication and transport. Patients with acute SCI should be promptly and carefully transported from the place of injury to the nearest specialist SCI facility.

Keywords: Spinal cord injury, haemodynamic management, airway, immobilisation

Introduction

Injuries contributed to the 6% of total deaths in Turkey (Table 1). Mostly young people affected by the injury related deaths (Figure 1). According to the data from the Turkish Statistical Institute, over one million traffic accidents occurred during the year 2014. 168,512 of the accidents resulted in fatality or injury. Seventy-five point one percent occurred in the populated areas, during the month of August at day hours. As a result of these accidents, 3,524 people died and 285,059 injured (Table 2). Among the people died in the accidents, 42.7% of them were drivers, 40.3% were travelers and 17% were people on foot. Concerning the sexual orientation breakdown of individuals died 76.8% of them were men and 23.2% were women; while for the general population harmed 70.2% of them were men and 29.8% were women (1).

There is no recent Turkish epidemiological study published in spinal cord injury (SCI) topic. According to a nation-wide retrospective study published by Karacan et al. (1) in 2000, 5,081 traumatic SCI cases were reported in 1992 (2). The estimated annual incidence of traumatic SCI was found 12.7 per million people. Male to female proportion was 2.5:1 and the normal age at harm was 35.5±15.1 (35.4±14.8 for guys and 35.9±16.0 for females). The most widely 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%). One hundred and eighty-seven patients (32.18%) were tetraplegic and 394 patients (67.8%) were paraplegic. The most well-known level of damage was C5 among tetraplegics and T12 among paraplegics. The most common related injury was head trauma took after by extremity fractures.

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Table 1. Percent distribution of injuries in Turkey		
	2010% of deaths n=24,857 total deaths	2013% of deaths n=24,703 total deaths
Road injuries	2.2	2.19
Self-harm	1.13	0.94
Falls	0.63	0.74
Mechanical forces	0.68	0.56
Violence	0.72	0.52
Drowning	0.25	0.25
Other unintentional	0.27	0.22
Foreign body	0.2	0.19
Poisoning	0.12	0.11
Fire, heat	0.11	0.1
Other transport	0.1	0.1
Animal contact	0.036	0.03
Institute for Health Metrics and Evaluation (IHME). GBD Compare. Seattle, WA: IHME, University of Washington, 2015		

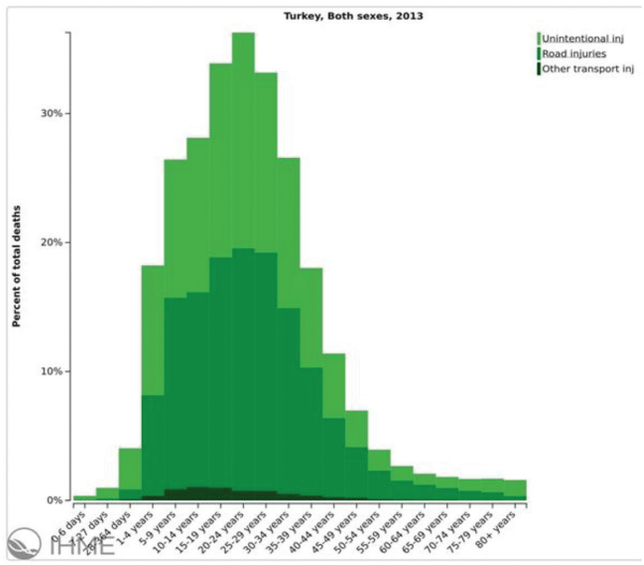

Figure 1. Age distribution of injuries in Turkey, Institute for Health Metrics and Evaluation (IHME). GBD Compare. Seattle, WA: IHME, University of Washington, 2015. Available from http://vizhub.healthdata.org/gbd-compare. [Accessed (21/05/2016)]

Acute phase of SCI management is critical for the minimization of the secondary injury, which directly affects the outcome quality and survival of the patient. Initial trauma results in an irreversible neuronal damage (Primary injury) and is only modifiable by prevention. Secondary injury starts within minutes and involves complex cascade of events including inflammation, oedema, ischemia, and excitotoxicity leading to further ischemia and progressive neurological deterioration in the following days. Carefully coordinated management strategies aim to limit/reverse this progression. Treatment and damage control starts

Table 2. Road Traffic Accident Statistics				
Year	Total accidents (n)	Accidents resulting death or injury (n)	Persons killed (n)	Persons injured (n)
2010	1,106,201	116,804	4,045	211,496
2011	1,228,928	131,845	3,835	238,074
2012	1,296,634	153,552	3,750	268,079
2013	1,207,354	161,306	3,685	274,829
2014	1,199,010	168,512	3,524	285,059
T.C. Basbakanlik Turkiye Istatistik Kurumu, Neactibey Caddesi No 114 06100 – Ankara. www.tuik.gov.tr				

at the seen and critical during the first 24 hours. Early clinical assessments, accurate spinal immobilisation, prompt transfer of injured patient to a SCI unit, and respiratory and haemodynamic support are recommended for the acute management of spinal cord injured patients (3).

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

1. Transfer of 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 have an unstable spine. Emergency first responders therefore should exercise high index of suspicion for SCI in the major trauma settings. In a study performed to evaluate pre-hospital management of spinal cord injuries in New South Wales between 2004 and 2008, found that the median time from the scene to a SCI unit was 12 hours, with 60% of patients needed multiple transfers. The odds of reaching a SCI unit in 24 hours were 1.71 times greater for patients injured in a major city (95% CI: 1.00-2.90) than in the other areas. SCI patients with multiple traumas had more delays to reach a SCI unit (59%) than the isolated SCI patients (40%). Patients who reached a SCI unit after 24 hours were at 2.5 times greater risk to develop a secondary complication (95% CI: 1.51-4.17) (8).

The trauma patient triage scheme of the American College of Surgeons Committee on Trauma has 4-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 high- energy impact mechanism, and, fourth, the assessment of special patient characteristics, like age, pregnancy, anticoagulation treatment, burns, and end-stage renal disease (9).

In 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 stabilisation of spinal column. On the other hand, air

transport of patients and on time transfers of the patients from the disaster zone to tertiary care hospitals had provided low mortality rates (10).

However, Oteir et al. (11) found that there is a lack of high-level evidence on the effect of pre-hospital cervical immobilisation on consequences in their systematic review of the literature to determine the efficacy of cervical immobilisation in patients with suspected cervical SCI. In their systematic review, which the eight studies included, cervical 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 consequences. In another study, investigators found that there are some 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 about 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 also 19 studies opposing spinal immobilization. They said that; decisions to use spinal immobilisation 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 prehospital trauma patients with a four-step clinical assessment protocol and to 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 found 87.0% (14). In a recent study conducted a retrospective analysis of penetrating trauma patients in the National Trauma Data Bank of United States, 45,284 penetrating trauma patients were concentrated; 4.3% of whom experienced spine immobilisation.

In a recent study, a retrospective analysis of penetrating trauma patients was performed in the National Trauma Data Bank of United States, 45,284 penetrating trauma patients were concentrated; 4.3% of whom experienced spine immobilization. General mortality was 8.1%. Unadjusted mortality was twice as high in spine-immobilized patients (14.7% vs 7.2%, $p<0.001$). The chances proportion of death for spine-immobilised patients was 2.06 (95% CI: 1.35-3.13) contrasted and non-immobilised patients. Prehospital spine immobilisation is related with higher mortality in penetrating trauma (15).

Various devices and methods were used for immobilization of the cervical spine in SCI patients. Before the immobilisation, spinal posture should be evaluated to prevent secondary injuries. The neutral spinal posture was defined as "the normal anatomic position of the head and torso that one assumes when standing and looking ahead" by Schriger (16). This posture corresponds to 12 degrees of cervical spinal extension on a lateral radiograph. Podolsky et al. (17) found that hard collars had better outcomes than soft collar.

The American College of Surgeons suggests the utilization of a hard backboard, an inflexible cervical neckline, horizontal bolster gadgets, and tape or straps to secure the patient's head, the neckline, and the parallel bolster gadgets to the backboard. Pronged and wrong utilisation of unbending backboard can bring about patient dismalness and ought to be stayed away from. Backboard ought to be expelled when a complete assessment is refined as well as conclusive administration is started. Spinal immobilisation of injury patients with entering wounds is not prescribed.

It is estimated that up to 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 it's possible, patients should be transported to specialised acute spinal cord injury treatment centre.

2. 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, cervical spine injury should be presumed in all trauma patients requiring intubation prior to complete physical and radiographic evaluation. If the level of injury is at or above C5, tracheal intubation and ventilation are often required (20).

Since the mid-eighties, manual in-line adjustment (MILS) is prescribed to help aviation route administration in patients with suspected SCI (21). The point of MILS is to keep any flexion; expansion or pivot of the cervical spine amid laryngoscopy is performed. In any case, use of MILS appeared to exacerbate the laryngoscopic see, draw out the intubation time or make disappointment secure the aviation route (22). One must adjust the advantages of MILS against the hazard for hypoxic harm if intubation and sufficient ventilation can't be refined. In this way, MILS might be changed or ceased if its utilisation hinders tracheal intubation.

Direct laryngoscopy is more straightforward than fiberoptic or video assisted laryngoscopy and, in this way, favoured in pressing circumstances. It was established to be more sheltered, powerful, and quicker in ordinary aviation routes and in any event proportional in troublesome aviation routes. In immobilised patients, particularly for dire intubations, coordinate laryngoscopy with the utilisation of a gum flexible bougie is a phenomenal decision to rapidly and dependably secure the aviation route while limiting the compel to the cervical spine (23).

Alternative methods may include flexible scope intubation (FSI) and nasotracheal intubation; both have restricted application in the acute trauma management. Because of the nasotracheal intubation is contraindicated with particular craniofacial injuries, and may causes further trauma and bleeding in the upper airway (24). FSI provide little spinal motion, however, it is hard to perform for inexperienced providers, results in slower intubation compared to orotracheal intubation, and also is hindered by secretions and bleeding, needs continuous patient cooperation (25).

The blind-intubating laryngeal mask airway has been used successfully in trauma settings and uninjured but immobilised patients with rigid cervical collars (26,27). But this approach showed to cause low intubation success rate in inexperience staff (24). Video assisted laryngoscopes and other imaging approaches allow a better laryngeal view than traditional methods in immobilised SCI patients (28) Table 3 provides the pros and cons of commonly used airway management devices.

Muscle trismus or clenched jaw may cause failure in pre-hospital intubation (29,30). But these situations can be eliminated with the appropriate use of fast acting neuromuscular blocking agents (31). Regarding the choice of muscle relaxant, succinylcholine remains the gold standard for rapid sequence intubation in the early stages of SCI management. If these techniques fail to intubate the trachea of SCI patients, surgical methods like cricothyrotomy should be tried (32).

Each airway manoeuvre has its inherent weaknesses and advantages. There is no conclusive evidence that an optimal airway management strategy in patients with cervical instability affects outcome. The most suitable choice will often depend on the practitioner's experience with a particular technique and the specifics of the clinical situation (33).

In the post-traumatic period, progressive neck swelling due to oedema and pre-vertebral haematoma expansion may further compromise the airway, even in the absence of positive examination findings in the early phase of the injury. Intubation should minimise cervical movement to prevent further neurological deterioration in a potential or actual SCI. Manual inline stabilization, gum elastic bougie and attention to detail required. Cricoid pressure (CP) ought to be connected amid acceptance and kept up 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 on the off chance that they hinder sufficient intubation or ventilation (34).

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

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

Adopted from; Austin N, Krishnamoorthy V, Dagal A. Airway management in cervical spine injury. International journal of critical illness and injury science. 2014;4:50-6
SCI: Spinal card injury

3. Haemodynamic Management of Spinal Cord Injury

7-10% of the SCI patients develop neurogenic circulatory shock and demonstrate hypotension with or without bradycardia (35,36). Besides to this condition, hypotension may be caused by trauma itself and may be difficult to differentiate in acute trauma (37). Kong et al. (38) found that 18.4% of the cervical SCI patients had 80 mmHg or below mean arterial pressure levels. Other possible major cardiovascular complications in the acute stage following SCI were heart rate abnormalities and venous thromboembolism. These 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 happening from C-1 through T-12 with an end goal to keep up spinal line blood stream and avert optional harm. They performed surgical strategies for decompression and adjustment, and combination in chose cases. Sixty-four of the 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 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 work.

Levi et al. (42) studied the acute phase of SCI. Management protocol included invasive haemodynamic monitoring and cardiovascular support with dopamine and/or dobutamine, titrated to maintain a haemodynamic profile with adequate cardiac output and a mean arterial pressure of >90 mmHg.

Stevens et al. (43) reported that the neurogenic circulatory shock should be treated with fluid resuscitation until intravascular volume is restored and, afterwards, use of vasopressors (eg. dopamine, norepinephrine, and phenylephrine) should be considered. Zäch et al. (44) given an account of a planned medical administration worldview in the treatment of 117 back to back intense SCI patients in the Swiss Paraplegic Centre of Basel, Switzerland in 1976. The creators reasoned that early exchange and "prompt medicinal particular treatment of the spinal damage" with consideration regarding upkeep 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 higher than 85 mm Hg for a period extending up to one week following acute SCI (45).

4. 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 SCI patients (47). On the other hand, two other studies reported that high-dose methylprednisolone can be associated increased complication rates (48,49).

The role of the steroids in treatment of SCI patients is debatable. The possible mechanisms for proposed benefits include 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 based upon three prospective randomised multi-centre trials named National Acute Spinal Cord Injury Studies (NASCIS) I, II and III (46,51-53).

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

In NASCIS II, 487 patients treated first 12 hours of SCI, in the first group with methylprednisolone with dose of 30 mg bolus, then 5.4 mg/kg/hour x 23 hours, in the second group with naloxone with dose of 5.4 mg/kg bolus, then 4.0 mg/kg/hourx 23 hours. The third group was placebo group. 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 groups (46,52,53).

NASCIS III was performed with 499 patients treated within first 8 hours of SCI, in the first group with methylprednisolone with dose of 30 mg bolus, then 5.4 mg/kg/hour×23 hours, in the second group with methylprednisolone with dose of 30 mg bolus, then 5.4 mg/kg/hour×47 hours, in the third group with tirilazad mesylate with dose of 2.5 mg/kg every 6 hours for 48 hours. It was found that there was no significant difference in neurologic recovery between the three groups at 6 or 12 months follow-up period. If the treatment was started 3 to 8 hours after SCI, 48-hour methylprednisolone group had significantly better improvement than 24-hour methylprednisolone group at 6 months and 12 months follow-up period but had more severe sepsis and severe pneumonia (53-55).

In a case report of a 37-year-old woman with whiplash injury after a motor vehicle collision, who had treated 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, the patient became unresponsive; electrocardiography showed ventricular fibrillation, necessitating prompt cardiac defibrillation and renal failure after the infusion. The evaluation of the patient showed that, the patient had diffused large B-cell lymphoma and methylprednisolone induced acute tumour

lysis syndrome causing ventricular fibrillation and renal failure. The authors said that, the physicians be aware of this clinical entity, and the importance of monitoring patients very close when prescribing corticosteroids, even in those with only mild anaemia (56).

In a cohort study, all patients with cervical cord injury were treated with methylprednisolone sodium succinate within 8 hours of their injuries (MPSS group) versus no treatment group (non-MPSS) and both groups followed up for two 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 said that, methylprednisolone ought to be utilised under constrained conditions due to the high occurrence of pulmonary complications (57).

Summary

Spinal immobilisation 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. Immobilisation of the entire spinal section is crucial in these patients until a spinal string harm (or various injuries) is disallowed or until fitting treatment is begun. Regardless, not all damage patients must be treated with spinal immobilisation in the midst of prehospital restoration and transport. Various patients do not have spinal injuries and along these lines don't require such mediation.

There is an absence of authoritative proof to suggest a uniform gadget for spinal immobilisation 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 immobilise the whole body is powerful at accomplishing protected, successful spinal immobilisation for transport. Spinal immobilisation gadgets ought to be utilised 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 office with SCI unit. The method of transportation picked ought to be founded on the clinical conditions, separation, and geology to be voyage and ought to be the quickest means accessible. Cervical SCI patients have a high occurrence of aviation route trade off and pneumonic brokenness; along these lines, respiratory bolster measures ought to be accessible amid transport.

In spite of beginning stable heart and pneumonic capacity it is normal to watch 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 ICU or other checked setting seems to favourably affect neurological result after intense cervical SCI. Keeping up MAP between 85-90 mm Hg for the initial seven days taking after intense SCI to enhance spinal string perfusion is the present proposal of the American Association of Neurological Surgeons and Congress of Neurological Surgeons (58).

Conclusion

Both noteworthy methodological mistakes and conflicting neurological results in the reviews distributed to date with respect to the gainful impacts of methylprednisolone can as effectively be devoted to 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, hyperglycaemia requiring insulin organization, GI discharge and demise. Methylprednisolone ought not be routinely utilized as a part of the treatment of patients with intense SCI (59).

Ethics

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: A.D., Design: A.D., Data Collection or Processing: B.K., Analysis or Interpretation: B.K., Literature Search: B.K., Writing: B.K., A.D., S.K., A.O.K.

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