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Review

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

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Abstract

Aim: Spinal cord injury (SCI) is a devastating neurologic disorder. It is estimated to affect approximately a 1,000 patients each year in the Republic of Turkey. The purpose of this review was to populate the recent evidence related to the acute management of patients with SCIs in the pre-hospital and emergency care settings.

Materials and Methods: We conducted a literature review of publications in the English language, indexed in Pubmed, ScienceDirect, and Scopus using the following search terms: "spinal cord injury" and "acute management," "spinal cord injury" and "immobilization," "spinal cord injury" and "transfer," "spinal cord injury" and "transport," "spinal cord injury" and "airway management," "spinal cord injury" and "hemodynamic management," "spinal cord injury" and "steroid." We also reviewed the recent international guidelines.

Results: This review reports the immobilization of patients with SCI and management strategies relevant to the transfer of an SCI patient, airway management in cervical SCI, hemodynamic management of SCI, and methylprednisolone use in SCI.

Conclusion: Patient's spinal aliment should be maintained using appropriate techniques for sufficient immobilization, safe extrication, and transport. The patient with an acute spinal injury should be rapidly and carefully transported from the site of injury to the nearest specialist SCI facility.

Keywords: Spinal cord injury, hemodynamic management, airway, immobilization

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

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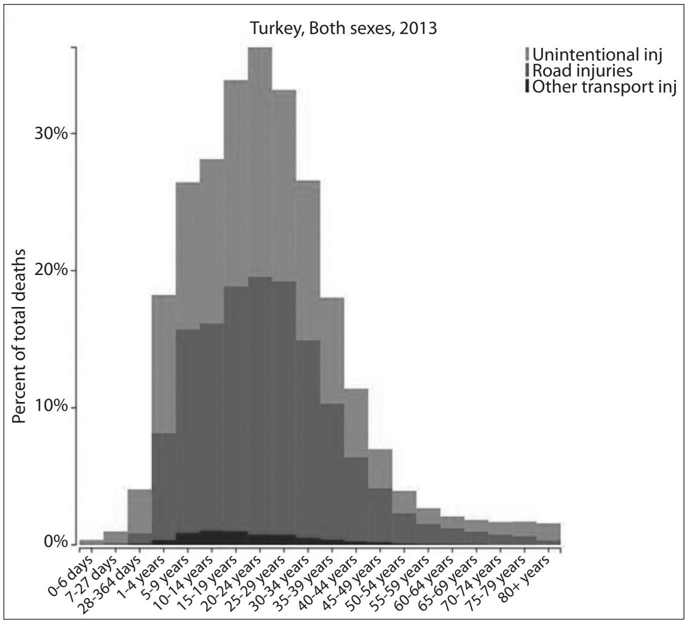

Figure 1. Age distribution of injuries in Turkey, Institute for Health Metrics and Evaluation (IHME). GBD Compare. Seattle, WA: IHME, University of Washington, 2015. Available from http://vizhub.healthdata.org/gbd-compare. (Accessed [21/05/2016])

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

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 paraplegics. 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 prevention. The secondary injury starts within minutes and involves a complex cascade of events including inflammation, edema, 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 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 myocardial 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 Surgeons 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 high-energy impact mechanism; and fourth, the assessment of special 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 hospitals 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 evidence on the effect of pre-hospital cervical immobilization on the consequences. The systematic review of eight studies including 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

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

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 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
VAL	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

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. Pre-hospital spine immobilization 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 immobilization, spinal posture should be evaluated to prevent secondary injuries. Schriger (16) defined neutral spinal posture as "the normal anatomic position of the head and torso that one assumes when standing and looking ahead". This posture corresponds to 12° of cervical spinal extension on a lateral radiograph. Podolsky et al. (17) found that hard collars had better outcomes compared to soft collars.

The American College of Surgeons suggest using a hard backboard, an inflexible cervical neckline, horizontal bolster gadgets, and tape or straps to secure the patient's head, neckline, and parallel bolster gadgets to the backboard. Pronged and wrong utilization of unbending backboard can cause 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 immobilization of injury patients with entering wounds is not prescribed.

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, 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-1980s, manual in-line adjustment (MILS) is prescribed to help aviation route administration in patients with suspected SCI (21). The purpose of MILS is to maintain any flexion; expansion or pivot of the cervical spine amid laryngoscopy is performed. In any case, use of MILS appeared to exacerbate the laryngoscopic view, 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 cannot be refined. In this manner, MILS might be changed or ceased if its utilization hinders tracheal intubation.

Direct laryngoscopy is more straightforward than fiber optic or video-assisted laryngoscopy (VAL) and is favored in critical pressing circumstances. It was established to be more sheltered, powerful, and expedite in ordinary aviation routes and in any event proportional in troublesome aviation routes. In immobilized patients, particularly for dire intubations, coordinate laryngoscopy with the utilization 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 the nasotracheal intubation is contraindicated in particular craniofacial injuries and may cause further trauma and bleeding in the upper airway (24). FSI provides little spinal motion; however, it is challenging for inexperienced providers, results in slower intubation compared to orotracheal intubation, is hindered by secretions and bleeding, and needs continuous patient cooperation (25).

The blind-intubating laryngeal mask airway has been used successfully in trauma settings and uninjured but immobilized patients with rigid cervical collars (26, 27). However, this approach showed to cause low intubation success rate in inexperienced staff (24). VALs and other imaging approaches allow a better laryngeal view than do traditional methods in immobilized SCI patients (28). Table 1 provides the advantages and disadvantages of commonly used airway management devices.

Muscle trismus or clenched jaw may cause failure in pre-hospital intubation (29, 30). However, 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, such as cricothyrotomy, should be attempted (32).

Each airway maneuver has its inherent weaknesses and advantages. There is no conclusive evidence that an optimal airway management strategy in patients with cervical instability affects the outcome. 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 optional 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 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 >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 regiments 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 at the 6- or 12-month follow-up periods. 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 geology 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 pneumonic brokenness; along these lines, respiratory bolster measures ought to be accessible amid transport.

Despite starting stable heart and pneumonic 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 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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