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ORIGINAL ARTICLE

Analysis of prehospital care and emergency room treatment of patients with acute traumatic spinal cord injury: a retrospective cohort study on the implementation of current guidelines

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Study design: Retrospective cohort study.
Objectives: The aims of the current study were (i) to analyze prehospital and emergency room treatment of patients with acute traumatic spinal cord injury (SCI) and (ii) to analyze whether recommendations given by the current guidelines are implemented.
Setting: German level I trauma center.
Methods: All patients suffering from traumatic SCI who were initially surgically treated in our hospital in the period from January 2008 to December 2013 were included in this study. Available data documented as a standard procedure in our trauma center included patient's demographic and medical information, as well as trauma mechanisms, cause of injury, neurological diagnosis and detailed clinical information about prehospital and early hospital management procedures. Retrospectively, statistical analysis was performed to describe spinal immobilization rates, transportation times and methylprednisolone administration.
Results: A total of 133 patients (mean age: 50.5 ± 21.2 years) met the inclusion criteria. Immobilization was performed on 69.9% of the patients with traumatic SCI. From 60 patients suffering from cervical traumatic SCI, 47 patients had a cervical collar. Full immobilization was only performed in 34 of these 60 patients. Mean time from accident site to emergency room was 61.3 ± 28.7 min. In 25 out of the 133 patients included in the current study, early surgery was not possible because of insufficient circulation and/or increased intracranial pressure. A total of 108 patients could be prepared for early surgery within 322.8 ± 254.1 min after the accident.
Conclusion: The current study shows that recommendations of the current literature and guidelines are mostly followed.
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INTRODUCTION

About 2% of all patients suffering from blunt trauma will also have a spinal cord injury.[1] In multiple-injured patients, the ratio of patients with traumatic spinal cord injury increases up to 7.5%.[2] The role of the commonly accepted practice of spinal immobilization in prehospital and early hospital care for reducing secondary neurological damage to the spinal cord and improved outcomes remains controversial.

As the spine can cope even with high energies,[3] there is general doubt that prehospital deterioration in patients with traumatic spinal cord injury is caused by manipulations on the spine within the normal range of motion by the rescue personnel[4] or the transport.[5,6] On the other hand, there are authors stating that major neurological deterioration can occur because of inadequate immobilization[7] and inappropriate handling.[8,9] Of course, many factors may contribute to increasing neurological deficits after traumatic spinal cord injury such as expanding hematoma, ongoing ischemia or hypoxia, electrolyte shifts, as well as formation of free radicals and inflammatory mediators.[10] These factors may be enhanced by inappropriate handling under certain circumstances.

Therefore, current guidelines for prehospital and emergency room treatment recommend immobilization of the spine in case of traumatic spinal cord injury.[11,12] Furthermore, a gentle patient transport should be performed without delay.[11] A transport by rescue helicopter[11] to a specialized center[11,12] is preferred. Administration of methylprednisolone is not recommended as a standard procedure.[12,13] Despite prospective randomized controlled trials not being available, current literature[14–17] and guidelines[13] recommend early decompression of patients with spinal cord injury for several reasons. Despite these recommendations by current guidelines, treatment of patients with traumatic spinal cord injury may vary from standard procedures for several reasons, especially in prehospital emergency care.

Therefore, the aim of the current study was (i) to analyze prehospital and emergency room treatment of patients with acute traumatic spinal cord injury retrospectively and (ii) to analyze whether recommendations given by the current guidelines are implemented.

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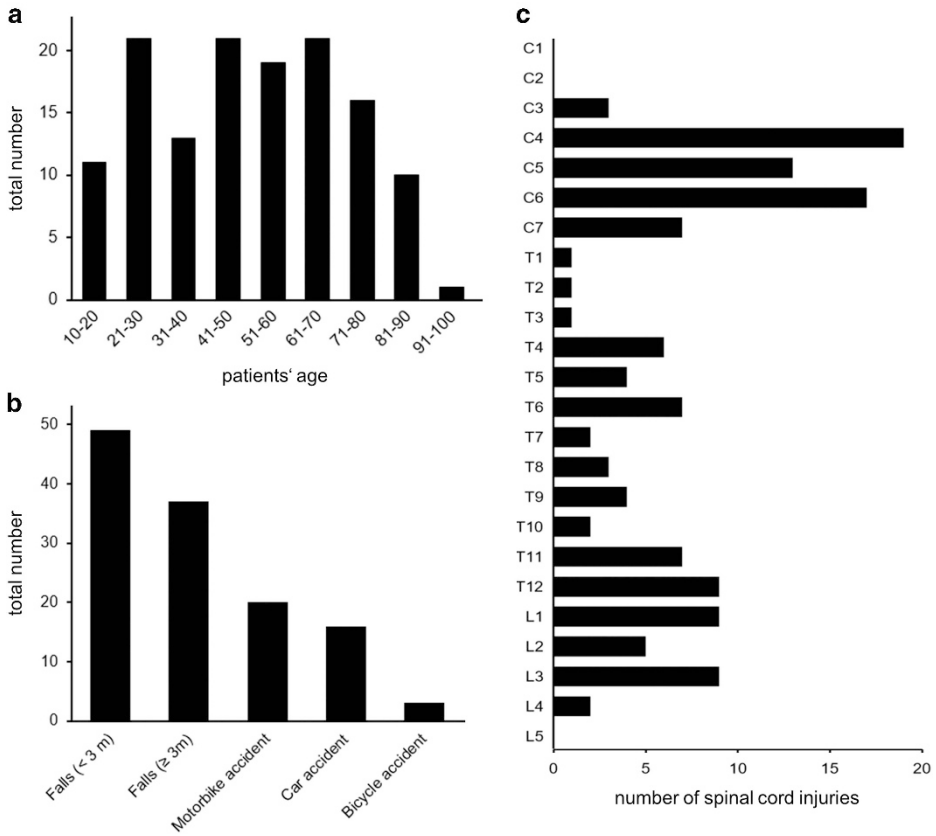

Figure 1 Distribution of patients' age (**a**) and causes of injury for traumatic spinal cord injury (**b**) leading to different neurological levels of spinal cord injury (**c**).

MATERIALS AND METHODS

The study hospital of this single-center study is a level I trauma center in a German metropolitan area with 2.3 million inhabitants. The hospital is highly specialized for trauma patients of all severity levels including patients with acute spinal cord injury. Thus, patients with isolated traumatic spinal cord injury, as well as multitrauma patients not only from the metropolitan area but also from regions more distant, will be taken to our hospital by emergency medical services via air rescue or ambulance car. Furthermore, the hospital is a specialized rehabilitation center for patients with spinal cord injury.

All patients suffering from a traumatic spinal cord injury and who were initially surgically treated in our level I trauma center in the time period from January 2008 to December 2013 were included in this retrospective cohort study. Nontraumatic spinal cord injuries were excluded from the current study. Furthermore, all patients with spinal cord injury initially treated in other hospitals and who were taken to our hospital for rehabilitation only were excluded from the current study.

Demographic data of the patient, data on prehospital and emergency room treatment, as well as available medical data including trauma mechanisms, cause of injury, neurological diagnosis, and detailed clinical information about prehospital and early hospital management procedures were documented as a standard procedure in our trauma center.

Retrospectively, patients' personal data (age, gender and comorbidities), prehospital data (cause of injury, use of immobilization tools, airway management, administration of steroids and type of transport) and early clinical data (level of spinal cord injury and pathology of spinal cord injury) were analyzed anonymously. Furthermore, time periods for prehospital and emergency room treatment were analyzed.

Statistical analysis was performed using SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA). In case of metric variables, the results are described using distributional parameters such as arithmetic means, standard deviations and ranges. Results concerning categorical variables are given as absolute and relative frequencies. The *t*-test for independent samples was used to verify whether or not the transport time by helicopter or ambulance car is significantly different. A *P*-value <0.05 was considered to be statistically significant.

The authors certify that all applicable institutional and governmental regulations concerning the ethical use of patients were followed during the course of this research. The current study was approved by the ethical committee in charge (Ethics committee of the State Medical Association Rhineland-Palatinate, Mainz, Germany).

RESULTS

In the time period from January 2008 to December 2013, a total of 133 patients (males: 104; females: 29) met the inclusion criteria. The mean age of the patients was 50.5 ± 21.2 years (range: 13.0–97.0 years). The detailed distribution of the patients' age is shown in Figure 1a. A total of 14 patients (10.5%) had previously existing spinal comorbidities such as ankylosing spondylitis ($n=7$), herniated disks ($n=5$) and spinal stenosis ($n=2$). Seven patients (5.3%) had previously existing pulmonary comorbidities.

The main cause of injury is shown in Figure 1b. Falls from any height accounted for the majority (64.6%) of spinal cord injuries, with motor bike and motor vehicle collisions resulting in 27.1%. Bony fractures were seen in 127 cases. In 39 of these patients, an additional dislocation could be seen. In six patients, traumatic spinal cord injury occurred without bony injury. The origin of the trauma was attempted suicide in 13 cases (9.8%) and working accidents in 24 cases (18%). Spinal cord injuries were classified complete in 55 patients (44.0%) and incomplete in 78 patients (56.0%). The most frequent levels of spinal cord injuries (60 cases) were located in the cervical spine,

Table 1 Prehospital measures in patients with traumatic spinal cord injury

	Cervical collar	*Spine board*	*Vacuum mattress*	*Airway secured*	*Methylprednisolone administration*	*Air rescue*
Yes (%)	81.0	16.5	53.4	16.9	32.8	58.6
No (%)	19.0	83.5	46.6	83.1	67.2	41.4

Table 2 Treatment and transport time of patients with traumatic spinal cord injury

Accident–ER	*Accident–ER air rescue*	*Accident–ER ambulance*	*ER–operation*	*Accident–operation*
63.1 ± 28.7 min (n = 113)	64.9 ± 22.2 min (n = 72)	60.0 ± 28.7 min (n = 41)	252.6 ± 232.6 min (n = 108)	322.8 ± 254.1 min (n = 108)

Abbreviation: ER, emergency room.

whereas the neurological level of injury ranged from C3 to L4 (Figure 1c).

In the prehospital phase, 69.9% of the patients with traumatic spinal cord injury were immobilized on a spine board or on a vacuum mattress (Table 1). Cervical spine was immobilized in 81.0% with a cervical collar (Table 1). From 60 patients suffering from cervical traumatic spinal cord injury, 47 patients (78.3%) had a cervical collar. Full immobilization was only performed in 34 patients (56.7%), and 12 patients (20%) were not immobilized in any way. Only one of the non-immobilized patients suffered from severe accompanying injuries and hemodynamic instability due to a hemorrhagic shock. Administration of methylprednisolone in the prehospital phase was performed in 32.8% of the cases (Table 1).

Most of the patients arrived in our level I trauma center by rescue helicopter (Table 1). Mean time from accident site to our emergency room was 61.3 ± 28.7 min (Table 2). There is no significant difference in transport time if patients are transported by air rescue or an ambulance car (Table 2).

As a best practice care standard, we aim to perform surgical stabilization and decompression as early as possible once a patient's vital signs are stabilized. In 25 out of the 133 patients included in the current study, early surgery within 12 h after arriving in our emergency room was not possible because of insufficient circulation and/or increased intracranial pressure. These patients suffered from life-threatening injuries such as severe traumatic brain injury, as well as multiple fractures (long bones and pelvis), hematothorax or blunt abdominal trauma causing hemorrhagic shock.

A total of 108 patients could be prepared for early surgery starting 252.6 ± 232.6 min after arriving in our emergency room (Table 2). Thus, mean duration from accident to surgery was 322.8 ± 254.1 min (Table 2).

DISCUSSION

In the current study, main cause of injury leading to a traumatic spinal cord injury was falls from a height <3 m, followed by falls from a height >3 m. Traffic accidents are less common to cause traumatic spinal cord injury. These results were confirmed by an US multicenter study with 315 patients.[18] Most spinal cord injuries occurred in the cervical spine, as it has been described before in an analysis of the German trauma register.[2]

Even though the effect of spinal immobilization on mortality and patients' outcome remains uncertain because of the lack of randomized controlled trials,[19] current guidelines strictly recommend spinal immobilization for patients with traumatic spinal cord injury.[11,12] In the current study, 19.0% of all patients did not have a cervical collar. Several reasons may exist, why cervical collars are not provided to a trauma patient. If trauma is associated with severe brain injury, cervical collars may contribute to increased intracranial pressure.[20,21] Furthermore, if patients have spinal comorbidities (as 10.5% of the patients in our study have) such as ankylosing spondylitis, applying a cervical collar can exacerbate spinal cord injury according to some reports.[22,23]

In the current study, most patients were immobilized on a vacuum mattress. According to the literature, the vacuum mattress provides a better immobilization than a spine board.[24–26] Spinal immobilization is best performed by fixation of the body, the extremities and the head.[27] This procedure of full immobilization should also be performed if only the cervical spine is injured, as a cervical collar alone is not able to provide full immobilization of the cervical spine.[28,29] In the current study, only 56.7% of the patients with cervical spinal cord injury had full immobilization. A total of 12 patients with cervical spinal cord injury were not immobilized. One reason to neglect spinal immobilization may be the indication for immediate transport without any further delay of a patient in an unstable condition (for example, fulminant hemorrhagic shock), as immobilization procedures are time consuming.[30] However, in the current study, most of the non-immobilized patients were not in circulatory unstable conditions, and spinal immobilization should have been considered.

Thus, recommendations given by current guidelines toward immobilization of a trauma patient with spinal cord injury are not completely followed. In single cases, exceptions may be justified by patients' overall outcome.

In the current study, 32.8% of all patients with traumatic spinal cord injury were administered methylprednisolone in the prehospital phase by the emergency physician. Giving steroids in case of traumatic spinal cord injury is not recommended by the guidelines of the American Association of Neurological Surgeons,[12] with concerns about adverse effects such as increased rates on pneumonia and sepsis.[31] Nevertheless, positive effects of early administration of methylprednisolone have also been reported.[32] The current German guideline for treatment of trauma patients[11] advises against administration of methylprednisolone as a standard procedure, but allows administration of methylprednisolone to be considered under certain circumstances. Thus, early administration of methylprednisolone according to the protocol of the third National Acute Spinal Cord Injury Study (NASCIS III), could be considered in the case of isolated traumatic spinal cord injury according to the guidelines of the German Association of Neurologists.[13] On the basis of these statements, German emergency physicians will individually decide about the administration of methylprednisolone in the case of traumatic spinal cord injury. As almost every third patient was given steroid in the current study, it is questionable whether every emergency physician is

familiar with the current guidelines and the adverse effects that have been reported following the administration of methylprednisolone.

The current study shows that the mean out-of-hospital time for patients with traumatic spinal cord injury is 63.1 ± 28.7 min. This finding is confirmed by another study evaluating the mean rescue time for trauma patients in Germany, in the range from 65.1 min (metropolis) to 72.8 min (provincial towns).[33] A mean rescue time of about 1 h seems to be acceptable, as this time period includes the time of reaching the patient by rescue personnel, as well as prehospital treatment time and at least the transport to the hospital. Most patients, included in the current study, were transported by air rescue to our hospital. This may provide a more gentle transport, but does not reduce out-of-hospital time. According to the literature, air rescue increases prehospital time significantly.[33] The cause may be a delayed order of the rescue helicopter by ground emergency medical services that often are sent first.

On the basis of short rescue times, we could provide early operation of the patients with traumatic spinal cord injury at a mean time of around 5 h (322.8 ± 254.1 min) after the accident. Therefore, first clinical assessment and treatment including emergency room treatment, neurological diagnostics as well as imaging by means of computed tomography and magnetic resonance imaging as well as preoperative preparation by the anesthesiologist was done in a mean time of around 4 h (252.6 ± 232.6 min). Therefore, a highly specialized interprofessional team must be on call at all times.

The findings of the current study are limited to some extent because of the retrospective study design. Because of the single-center analysis, a sampling bias cannot be excluded. Therefore, generalization of the findings to other trauma centers, to other health systems or to other countries should be performed carefully.

In conclusion, the current retrospective analysis shows that recommendations of the current literature and guidelines, such as out-of-hospital immobilization of the patients, providing early and gentle transport as well as early operation, are mostly followed. However, immobilization procedures and administration of methylprednisolone in some cases differ from the recommendations. This may be justified in single cases for the patient's best overall outcome, but indications seem to be rare.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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