VIA MEDICA

ORIGINAL ARTICLE

Disaster and Emergency Medicine Journal

DOI: 10.5603/demj.97463

ISSN 2451–4691, e-ISSN 2543–5957

ATTITUDES OF PREHOSPITAL EMERGENCY HEALTH CARE WORKERS TOWARDS SPINAL CORD IMMOBILIZATION IN PATIENTS WITH MULTIPLE TRAUMA

Lütfi Mert Güler , Ali Ekşi, Süreyya Gümüşsoy, Sevgi Öztürk Günay

Health Sciences Institute, Ege University, İzmir, Türkiye

ABSTRACT

INTRODUCTION: To evaluate the attitudes of prehospital emergency health care workers towards spinal cord immobilization in trauma patients.

MATERIAL AND METHODS: This is a descriptive study, and its participants were 407 pre-hospital emergency healthcare workers working in a province in the west of the country between April 2022 and October 2022. The data were collected online with a questionnaire consisting of twenty-four questions. Statistical significance was defined as a p value of 0.05 for all analyses.

RESULTS: 73% of the participants that they decided to perform routine spinal cord immobilization in all trauma patients regardless of the clinical findings. 85% of the participants said they generally preferred the backboard for spinal cord immobilization of trauma-injured people.

CONCLUSIONS: The study showed that prehospital emergency health care workers stated that they routinely perform spinal cord immobilization in every traumatized patient, despite knowing the indication for spinal cord immobilization of trauma patients.

KEYWORDS: backboard; paramedic; spinal cord; trauma; vacuum stretcher

Disaster Emerg Med J

INTRODUCTION

Approximately six million people die annually due to trauma [1]. Trauma ranks first among the causes of death in the young age group in Türkiye, where a significant portion of the population consists of young people and children [2]. According to the Turkish Statistical Institute data, trauma is responsible for 12.9% of all age group deaths [3]. In Türkiye, 30.9% of the patients who are given pre-hospital emergency health services (PEHCS) are trauma patients [4]. Although significant system traumas and different complications can be encountered in trauma patients, spinal cord injuries hold an important place in PEHCS. Traumas are first place in the aetiology of spinal cord injuries [5]. Spinal cord injuries are a predictable and preventable public health problem with significant financial impacts on the healthcare system [6]. Traumatic spinal cord injuries can cause significant morbidity and mortality, as well as many neurological problems, such as loss of motor and sensory functions [7]. Most deaths in traumatic spinal cord injuries occur within the first four hours. This situation renders PEHCS crucial in spinal cord injuries [8].

CORRESPONDING AUTHOR:
Lütfi Mert Güler, Health Sciences Institute, Ege University, Atatürk Health Services Vocational School, 35100 İzmir, Türkiye, e-mail: prm112@outlook.com
Received: 02.05.2023 Accepted: 11.11.2023 Early publication date: 22.12.2023

The main goal of PEHCS is to deliver quality emergency medical care to the sick and injured outside the hospital as soon as possible. PEHCS has been rapidly growing in recent years, especially in developing countries, and the number of patients receiving service is increasing each year. In parallel with this, PEHCS is one of the fastest-growing areas in the field of health sciences [9]. Effectively performing spinal cord immobilization and transferring the patients to appropriate hospitals according to their medical needs in PEHCS can not only ensure the survival of the patients but also reduce the possibility of permanent neurological problems. Early emergency intervention in patients with spinal cord injury will significantly reduce the progression of neurological damage. One of the most important steps in the emergency medical care of patients with spinal cord injury is spinal immobilization of the traumatized patient [10]. Vacuum stretchers are reported as an important alternative in some sources, together with the backboard in immobilizing the traumatized patient, and spider belts are generally used as auxiliary equipment for immobilization [11]. In addition to the fact that immobilization performed in PEHCS is life-saving, complications that may occur due to the application of immobilization equipment, and their adverse effects on mortality and morbidity have been frequently discussed in recent years [12].

This study sought answers to the questions of what the equipment preferences of PEHCS employers are in spinal immobilization of traumatized patients, what attitudes PEHCS staff has in making their decisions to immobilize or not to immobilize, and what side effects they observe in their patients after immobilization. Although many studies on the equipment used in spinal cord immobilization of traumatized patients exist in the literature, the lack of sufficient studies evaluating the attitudes of PEHCS in Türkiye renders this study important. Evaluating the attitudes and observations of PEHCS workers will contribute to the literature.

MATERIAL AND METHODS

The present study is descriptive, and its participants were 407 PEHCS professionals working in a province in the west of the country between April 2022 and October 2022. The data were collected online with a questionnaire consisting of twenty-four questions. The universe of the study consisted of PEHCS employees working in this province (N = 600). There was a minimum sample size to perform the planned analyses, with the goal of recruiting as many as possible. By using OpenEpi software (Dean AG, Sullivan KM, Soe MM. OpenEpi: Open Source Epidemiologic Statistics for Public Health, Version 3.01 www.OpenEpi.com, updated 2013/04/06), the sample size was determined as 234 participants [Population size (N): 600, Hypothesized % frequency of outcome factor in the population (p): 50% ± 5, Confidence limits as % of 100 (absolute ± %) (d): 5%, Design effect (for cluster surveys-DEFF): 1]. Of these 600 PEHCS employees, 407 participated in the study voluntarily.

Instruments

Pre-hospital emergency health services employees in Türkiye work according to a spinal immobilization guideline created according to the Canadian-C Spine Rules. For spinal immobilization, ambulances have a backboard and vacuum stretcher. PEHCS employees choose either of these two options at their discretion, as there are no formal criteria for which one to choose. To evaluate the attitudes of PEHCS staff towards trauma patients, the study data was collected with a questionnaire form. The first part of the questionnaire consisted of seven questions (age, gender, educational status, job title, experience in the profession, region of the station where you work, and type of the station you work) to determine the socio-demographic and descriptive characteristics of the employees. In the second part of the questionnaire, there were 17 questions including the equipment preferred by PEHCS employees in spinal cord immobilization, the attitudes of PEHCS employees to decide on spinal cord immobilization according to the Canada-C Spine Rule, and the complications observed in patients who had been treated with a trauma board. The questions in the survey are questions that have not been applied before and were prepared based on the opinions of 10 academicians who are experts in their fields.

Data collection

After explaining the aim and method of the 002597 study to each one, the questionnaire form online was applied, which was prepared via "google forms", for those who agreed to participate in the study. The number of PEHCS staff actively working in the city where the survey was conducted was 600 employees. Of these 600 employees, 407 agreed to participate in the survey and 197 did not choose to

participate in the survey. There were no incomplete or missing responses to the survey. The survey was not applied to the employees who were not actively working. Those who accepted to participate in the study were able to continue the study by clicking the "I agree to participate in the study" button before filling out the questionnaire. In this way, consent was obtained in the digital environment. The questionnaire was applied by taking precautions so as not to allow the same person to answer repeatedly. Since the survey form was filled out online, participants were allowed to fill it out at any time. No rewards or incentives were offered to those who completed the survey.

Statistical analysis

All the data were analyzed using IBM SPSS for Windows version 25.0 (Armonk, NY: IBM Corp.). Used were mean, standard deviation, normality tests and chi-square tests for statistical evaluation. The statistical significance level was defined as $p < 0.05$.

Ethical considerations

The study was conducted in line with the principles of the Declaration of Helsinki. This study was approved by Muğla Provincial Health Directorate (E-15682851-062.07.04-850, 28.04.2022) and X University, Medical Research Ethics Committee (E-99166796-050.06.04-595573-211, 10.03.2022).

Table 1. Distribution of participants' sociodemographic characteristics

Features		n	%
Age	25 years and under	86	21.1
	26–35 years	221	54.3
	36–45 years	88	21.7
	46–55 years	12	2.9
Gender	Male	191	46.9
	Female	216	53.1
Education	High school	21	5.2
	Associate degree	171	42.0
	Undergraduate	177	43.5
	Graduate	38	9.3
Title	Physician	17	4.2
	Paramedic	227	55.8
	Emergency medical technician	144	35.4
	Nurse/Medical officer	19	4.7
Experience in the Profession	1–5 years	106	26.0
	6–10 years	94	23.1
	11–15 years	134	32.9
	16–20 years	46	11.3
	21 years and above	27	6.6
Station Area	Urban	308	75.7
	Rural	99	24.3
Total		407	100.0

RESULTS

A total of 407 people participated in the study. It was determined that 54.3% of the PEHCS employees participating in the study were between the ages of 26–35, 53.1% were women, and 43.5% were undergraduates. When the titles of the participants were examined, it was determined that the highest rank was Paramedic (55.8%) and Emergency Medical Technician (35.4), and 32.9% had professional experience between 11–15 years (Tab. 1).

85% of the PEHCS workers who participated in the study stated that they preferred the backboard for spinal cord immobilization of the injured with trauma, and 15% preferred the vacuum stretcher. When the equipment preference of the participants was compared with the education level, titles, and experience in the profession, no statistically significant relationship was found ($p > 0.05$).

73% of the participants declared that they decided to perform routine spinal cord immobilization in all trauma patients regardless of the clinical findings. In addition, the participants listed the conditions that were effective in deciding to perform spinal cord immobilization in trauma patients as pain or tenderness in the spine (73%), history of high-energy trauma (71.7%), anatomical deformity in the spine (66.3%), neurological findings (60%), altered level of consciousness (52.6%), and inability to communicate with the patient (47.4%) (Tab. 2).

The PEHCS workers who participated in the study listed the complications they frequently encountered in patients after spinal cord immobilization as increased agitation (76.2%), increased pain (66.6%), respiratory distress (48.4%), and soft tissue tenderness (20.9%) (Tab. 3).

According to the answers given by the PEHCS workers who participated in the study, it was reported that almost all of the ambulances had a spider belt on the backboard. 84% of the PEHCS workers

said they used spider belts in every patient they transported with a backboard (Fig. 1).

DISCUSSION

Although there are various types of equipment used for spinal cord immobilization in spinal traumas in PEHCS, two types of equipment come to the fore. These are the backboard and the vacuum stretcher. In spinal cord immobilization, the head, neck, and trunk should be kept aligned and fixed [13]. Fischer et al. [14] concluded that this could be done via a backboard or vacuum stretcher. In the study of Mahshidfar et al. [15], in which they compared the backboard and vacuum stretcher, it was emphasized that the backboard was superior to the vacuum stretcher in terms of ease and speed of application, immobilization rate, and patient comfort in spinal cord immobilization of trauma patients. In the study of White et al. [16], it was reported that considering the normal shape of the human spine has curvature as opposed to a rigid backboard, there may be better alternatives to a rigid backboard to protect the spine. In their study, Jones Rhodes et al. [17] suggested that vacuum stretchers can be a safer and more comfortable alternative to the backboard for spinal cord immobilization. More than three-quarters of the PEHCS workers who participated in this study stated that they preferred the backboard for spinal cord immobilization of trauma patients. The present study shows no statistically significant relationship between stretcher preferences and educational status, title, and experience in the profession.

Although using a backboard in trauma patients has many benefits, some studies emphasize its various side effects. Barney et al. [18] reported that patients at risk of developing pressure ulcers might suffer from severe pain if placed on a backboard

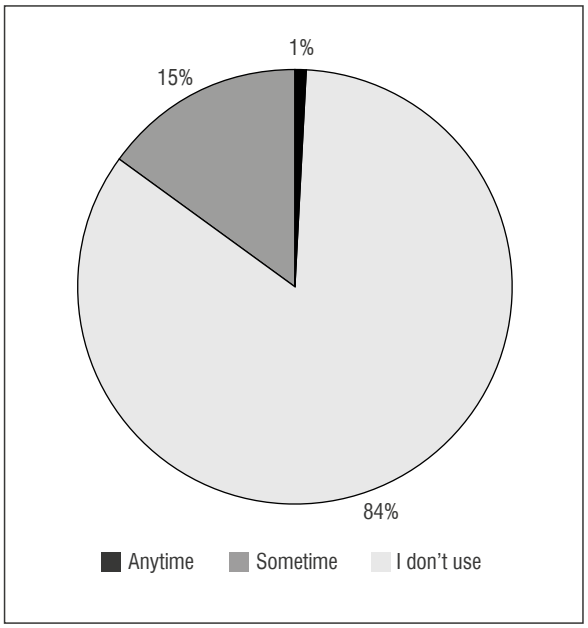

FIGURE 1. Spider belt usage status of the participants

Table 2. Backboard practice of the participants

Questions	Answers	n	%
Do you routinely apply a backboard in all trauma patients regardless of clinical findings?	Yes	297	73.0
	No	110	27.0
Do you practice a backboard in the presence of altered consciousness?	Yes	214	52.6
	No	193	47.4
Do you apply a backboard in case of pain or tenderness in the spine?	Yes	297	73.0
	No	110	27.0
Do you apply a backboard in case of neurological findings?	Yes	244	60.0
	No	163	40.0
Do you apply a backboard in case of an anatomical deformity in the spine?	Yes	270	66.3
	No	137	33.7
Do you apply a backboard to the ones with high-energy trauma?	Yes	292	71.7
	No	115	28.3
If communication with the patient is not possible, would you apply a backboard?	Yes	193	47.4
	No	214	52.6
Total		407	100.0

Table 3. Complications observed in patients who underwent spinal cord immobilization with a backboard

Questions	Answers	n	%
Has the agitation increased?	Yes	310	76.2
	No	97	23.8
Has the pain increased?	Yes	271	66.6
	No	136	33.4
Is there respiratory distress?	Yes	197	48.4
	No	210	51.6
Has tenderness started in soft tissue?	Yes	85	20.9
	No	322	79.1
Total		407	100.0

for a long time. In a study conducted on healthy volunteers who had no pain before, it was reported that back and neck pain started after only one hour of lying on the backboard, and the pain continued after 24 hours [19]. Berg et al. [20] reported that tissue hypoxia developed in the sacral tissues of healthy adults 30 minutes after they were fixed to the backboard. In another study, pressure sores were reported as a potential complication in long-term backboard applications [21]. In a study by Jones Rhodes et al. [17], immobilizing trauma patients on a backboard was associated with morbidity, including pressure sores, inadequate breathing, and increased intracranial pressure. PEHCS workers who participated in this study reported that they observed complications such as increased pain, respiratory distress, soft tissue tenderness, and agitation in patients with backboard application. The complications observed by PEHCS workers are generally consistent with the literature.

Recently, it has been seen that the vacuum stretcher is popular in some European countries. Vacuum stretchers are filled with small polystyrene beads, and the air inside the stretcher is pumped out, allowing the polystyrene beads to harden. Thus, the vacuum stretcher takes the shape of the patient's body and ensures that the patient remains motionless. In the study of Pernik et al. [22], vacuum stretchers and backboards were compared regarding pressure ulcer development. It has been shown that the vacuum stretcher can reduce the incidence and severity of pressure ulcer development compared to the backboard. At the same time, backboards were associated with more pain compared to vacuum stretchers by the patients [23]. In the study of Rahmatalla et al. [24], the most commonly used backboard and vacuum stretcher were compared in terms of effectiveness in limiting the involuntary movements of the patient while being transported in the ambulance, and it was reported that the vacuum stretcher was more effective in reducing involuntary movements. In the study by Wampler et al. [25], it was suggested that the vacuum stretcher is safer than the backboard in reducing the patient's movement in the ambulance in potential spinal injuries. In another study, vacuum stretchers and backboards were compared in terms of comfort, application speed, and degree of immobilization. The vacuum stretcher was more effective than the backboard in terms of comfort and application speed. As for the degree of immobilization, it was reported that the vacuum stretcher fixed the body better [26]. In their study, Quinn et al. [27] supported the preference for vacuum stretchers over backboards in terms of immobilization and comfort of the patient. The International Commission for Alpine Rescue (Icar Medcom) recommends that spinal cord immobilization with a vacuum stretcher will be more effective in potential spinal injuries [28]. Although there are studies in the literature suggesting that the vacuum stretcher may be a better alternative for possible spinal injuries, only one-sixth of the PEHCS workers in this study expressed that they preferred the vacuum stretcher for stabilizing trauma patients.

Spider belts are used as fixation equipment and trauma boards for spinal cord immobilization of trauma patients in PEHCS. There are some discussions in the literature about the use of spider belts. According to a 2020 study conducted in Germany, it was emphasized that when patients were immobilized on a backboard with a spider belt system, the remaining movement of the cervical spine could be

performed effectively when additional headblocks were used [29]. In addition, it is said that spider belts used in patients immobilized on the backboard may cause compression of the neck vessels and an increase in intracranial pressure, especially in patients with swallowing difficulties [30]. The study of Bauer and Kowalski [31] on healthy people reported that spider belts have a restrictive effect on lung functions. In another study, it was reported that spider belts worsen respiratory mechanics in patients with chest trauma and that the removal of spider belts improves lung parameters in such injuries [32]. It was observed that almost all of the ambulances of the participants of this study had spider belts, and PEHCS staff used them in most of the patients who were fixed with backboards.

It is clear that backboards can be beneficial as a spinal protection measure during the recovery of trauma patients from the injured position in PEHCS. However, there is still no proven data that exposing these patients to a backboard during transport prevents injury from worsening [30]. In some countries, it is known that there are applications where the backboard is used as a rescue tool and that the spine protection measures are continued independently of the backboard during the transport of the patient [16]. At the same time, studies show that using a backboard may cause complications in patients. Today, although spinal cord immobilization and backboard have become synonymous with each other, the use of a backboard during transport has been restricted in some emergency health services protocols worldwide. In most countries, the concept of "spine protection measures" has begun to be adopted instead of routine backboard application during the transport of trauma patients [21]. To determine which patients will need spinal cord immobilization, it is necessary to establish criteria for patients who are truly at high risk [33]. According to the publication of the National Association of Emergency Physicians and the American College of Surgeons Trauma Committee in 2014, the criteria for patients to be immobilized with a backboard and spider belt were determined [16]. In the literature, it is reported that there is increasing evidence that using selective criteria that provide spinal cord immobilization with a backboard, with the decision of PEHCS staff, is effective and safe [17]. More than two-thirds of the participants in this study stated that they routinely use backboards in all trauma patients. In addition, the participants supported using a backboard in criteria such as the presence of altered consciousness, spinal pain or tenderness, neurological complaints, anatomical deformity in the spine of trauma patients, and high-energy trauma mechanism. However, in the present study, it was observed that most participants performed spinal cord immobilization in trauma patients, even if the trauma patients did not meet these criteria.

Limitations

Participants may have deliberately given misleading answers to the questions. On the other hand, since the data is collected online, there may be some negations, such as security concerns about the electronic environment, respondents' uncertainty, problems accessing the data collection form, misunderstanding of the sensitivity of the research, and problems in accessing the web page. In addition, the results are valid only for the health personnel who completed the data collection form and cannot be generalized to other populations

CONCLUSIONS

Pre-hospital emergency health services staff is generally aware of the indications for providing spinal cord immobilization in trauma patients. However, even if the patient does not have a condition that requires spinal cord immobilization, the general practice in routine is to provide spinal cord immobilization in all trauma patients. Although vacuum stretchers are seen as an alternative to spinal cord immobilization, PEHCS workers currently use backboards and spider belts extensively. Complications observed by PEHCS workers in spinal cord immobilization are in line with the literature. However, there is a need for further studies to help determine the absolute indications and contraindications for spinal cord immobilization of the trauma patient in PEHCS.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement

The data that support the findings of this study are available on request from the corresponding author (L.M.G).

Ethics statement

We conducted our study in line with the principles of the Declaration of Helsinki. This study was

approved by Muğla Provincial Health Directorate (E-15682851-062.07.04-850, 28.04.2022) and X University, Medical Research Ethics Committee (E-99166796-050.06.04-595573-211, 10.03.2022).

Author contributions

Study design, L.M.G., A.E., S.G., S.O.G.; data collection, L.M.G., A.E.; data analysis, L.M.G., A.E.; study supervision, L.M.G., A.E., S.G., S.O.G.; manuscript writing, L.M.G., A.E., S.G., S.O.G.; critical revisions for important intellectual content, L.M.G., A.E., S.G., S.O.G.

Funding

The authors reported there is no funding associated with the work featured in this article.

Acknowledgments

None.

Conflict of interest

No potential conflict of interest was reported by the authors.

REFERENCES

1. Cameron AP, Kna JB, Teeter W. Trauma in adults. In: Tintinalli JE, et al. ed. Tintinalli's emergency medicine: a comprehensive study guide. McGraw Hill Education 2020: 1669–1762.
2. Yıldırım SA. General aroach to trauma cases. In: Ekşi A, Gümüşsoy S. ed. Trauma book in pre-hosital emergency health service. EMA Tıp Kitapevi, Istanbul 2020: 3–22.
3. Turkish Statistical Institute. Cause of Death Statistics. https://data.tuik.gov.tr/Kategori/GetKategori?p=saglik-ve-sosyal-koruma-101&dil=1 (19.01.2023).
4. Sarı A. Retrospective evaluation of sociodemographic characteristics and clinical outcomes of patients applying to pamukkale university faculty of medicine hospital emergency department by 112 ambulance. 2020. http://acikerisim.pau.edu.tr:8080/xmlui/handle/11499/35293 (19.01.2023).
5. Alizadeh A, Dyck SM, Karimi-Abdolrezaee S. Traumatic spinal cord injury: an overview of pathophysiology, models and acute injury mechanisms. Front Neurol. 2019; 10: 282, doi: 10.3389/fneur.2019.00282, indexed in Pubmed: 30967837.
6. Hagan M, Feler J, Sun F, et al. Spinal cord injury in adult and pediatric populations. Interdisciplinary Neurosurgery. 2022; 29: 101594, doi: 10.1016/j.inat.2022.101594.
7. Galeiras Vázquez R, Ferreiro Velasco ME, Mourelo Fariña M, et al. Update on traumatic acute spinal cord injury. Part 1. Med Intensiva. 2017; 41(4): 237–247, doi: 10.1016/j.medin.2016.11.002, indexed in Pubmed: 28161028.
8. Kondapalli S, Parikh P, Repas S, et al. Benchmarking performance in emergency medical services for improving trauma care: A data driven approach. Inform Med Unlocked. 2022; 29: 100882, doi: 10.1016/j.imu.2022.100882.
9. Paksoy VM. Comparison of international practice models in emergency health care: anglo-american and franco-german model. Journal Of Vocational School Of Health Service. 2016. https://dergipark.org.tr/en/pub/inonusaglik/issue/26767/410372 (16.01.2023).
10. Middleton PM, Davies SR, Anand S, et al. The pre-hospital epidemiology and management of spinal cord injuries in New South Wales: 2004–2008. Injury. 2012; 43(4): 480–485, doi: 10.1016/j.injury.2011.12.010, indexed in Pubmed: 22244002.
11. Geduld C, Muller H, Saunders CJ. Factors which affect the application and implementation of a spinal motion restriction protocol by prehospital providers in a low resource setting: A scoping review. Afr J Emerg Med. 2022; 12(4): 393–405, doi: 10.1016/j.afjem.2022.08.005, indexed in Pubmed: 36187075.
12. Kaba H. Stabilization of the patient with spinal trauma. In: Ekşi A, Gümüşsoy S. ed. Trauma book in pre-hospital emergency health service. EMA Tıp Kitapevi, Istanbul 2020: 349–366.
13. Purvis TA, Carlin B, Driscoll P. The definite risks and questionable benefits of liberal pre-hospital spinal immobilisation. Am J Emerg Med. 2017; 35(6): 860–866, doi: 10.1016/j.ajem.2017.01.045, indexed in Pubmed: 28169039.
14. Fischer PE, Perina DG, Delbridge TR, et al. Spinal motion restriction in the trauma patient — a joint position statement. Prehosp Emerg Care. 2018; 22(6): 659–661, doi: 10.1080/10903127.2018.1481476, indexed in Pubmed: 30091939.
15. Mahshidfar B, Mofidi M, Yari AR, et al. Long backboard versus vacuum mattress splint to immobilize whole spine in trauma victims in the field: a randomized clinical trial. Prehosp Disaster Med. 2013; 28(5): 462–465, doi: 10.1017/S1049023X13008637, indexed in Pubmed: 23746392.
16. White CC, Domeier RM, Millin MG, et al. EMS spinal precautions and the use of the long backboard - resource document to the position statement of the National Association of EMS Physicians and the American College of Surgeons Committee on Trauma. Prehosp Emerg Care. 2014; 18(2): 306–314, doi: 10.3109/10903127.2014.884197, indexed in Pubmed: 24559236.
17. Jones Rhodes W, Steinbruner D, Finck L, et al. Community implementation of a prehospital spinal immobilization guideline. Prehosp Emerg Care. 2016; 20(6): 792–797, doi: 10.1080/10903127.2016.1194932, indexed in Pubmed: 27410996.
18. Barney R, Cordell w, Miller E. Pain associated with i mmobilization on rigid spine boards. Ann Emergy Med. 1989; 18(9): 918.
19. Lerner EB, Billittier AJ, Moscati RM. The effects of neutral positioning with and without padding on spinal immobilization of healthy subjects. Prehosp Emerg Care. 1998; 2(2): 112–116, doi: 10.1080/10903129808958853, indexed in Pubmed: 9709329.
20. Berg G, Nyberg S, Harrison P, et al. Near-infrared spectroscopy measurement of sacral tissue oxygen saturation in healthy volunteers

immobilized on rigid spine boards. Prehosp Emerg Care. 2010; 14(4): 419–424, doi: 10.3109/10903127.2010.493988, indexed in Pubmed: 20662677.

21. Milland K, Al-Dhahir MA. EMS long spine board immobilization. StatPearls. https://www.ncbi.nlm.nih.gov/books/NBK567763/ (22.01.2023).
22. Pernik MN, Seidel HH, Blalock RE, et al. Comparison of tissue-interface pressure in healthy subjects lying on two trauma splinting devices: the vacuum mattress splint and long spine board. Injury. 2016; 47(8): 1801–1805, doi: 10.1016/j.injury.2016.05.018, indexed in Pubmed: 27324323.
23. Cross DA, Baskerville J. Comparison of perceived pain with different immobilization techniques. Prehosp Emerg Care. 2001; 5(3): 270–274, doi: 10.1080/10903120190939779, indexed in Pubmed: 11446541.
24. Rahmatalla S, DeShaw J, Stilley J, et al. Comparing the efficacy of methods for immobilizing the thoracic-lumbar spine. Air Med J. 2018; 37(3): 178–185, doi: 10.1016/j.amj.2018.02.002, indexed in Pubmed: 29735231.
25. Wampler DA, Pineda C, Polk J, et al. The long spine board does not reduce lateral motion during transport — a randomized healthy volunteer crossover trial. Am J Emerg Med. 2016; 34(4): 717–721, doi: 10.1016/j.ajem.2015.12.078, indexed in Pubmed: 26827233.
26. Johnson DR, Hauswald M, Stockhoff C. Comparison of a vacuum splint device to a rigid backboard for spinal immobilization. Am J Emerg Med. 1996; 14(4): 369–372, doi: 10.1016/S0735-6757(96)90051-0, indexed in Pubmed: 8768157.
27. Quinn RH, Williams J, Bennett BL, et al. Wilderness Medical Society. Wilderness Medical Society practice guidelines for spine immobilization in the austere environment: 2014 update. Wilderness Environ Med. 2014; 25(4 Suppl): S105–S117, doi: 10.1016/j.wem.2014.05.004, indexed in Pubmed: 25498256.
28. Ellerton J, Tomazin I, Brugger H, et al. Immobilization and splinting in mountain rescue. Official recommendations of the International Commission for Mountain Emergency Medicine, ICAR MEDCOM, Intended for Mountain Rescue First Responders, Physicians, and Rescue Organizations. High Altitude Medicine & Biology. 2009; 10(4): 337–342, doi: 10.1089/ham.2009.1038.
29. Uzun DD, Jung MK, Weerts J, et al. Remaining cervical spine movement under different immobilization techniques. Prehosp Disaster Med. 2020; 35(4): 382–387, doi: 10.1017/S1049023X2000059X, indexed in Pubmed: 32430091.
30. Vaillancourt C, Charette M, Taljaard M, et al. Pragmatic strategy empowering paramedics to assess low-risk trauma patients with the canadian c-spine rule and selectively transport them without immobilization: protocol for a stepped-wedge cluster randomized trial. JMIR Res Protoc. 2020; 9(6): e16966, doi: 10.2196/16966, indexed in Pubmed: 32348267.
31. Bauer D, Kowalski R. Effect of spinal immobilization devices on pulmonary function in the healthy, nonsmoking man. Ann Emerg Med. 1988; 17(9): 915–918, doi: 10.1016/s0196-0644(88)80671-1, indexed in Pubmed: 3415063.
32. Walsh M, Grant T, Mickey S. Lung function compromised by spinal immobilization. Ann Emerg Med. 1990; 19(5): 615–616, doi: 10.1016/s0196-0644(05)82211-5, indexed in Pubmed: 2331117.
33. Abram S, Bulstrode C. Routine spinal immobilization in trauma patients: what are the advantages and disadvantages? Surgeon. 2010; 8(4): 218–222, doi: 10.1016/j.surge.2010.01.002, indexed in Pubmed: 20569942.