MMSL
Military Medical Science Letters
Since 1925

Mil. Med. Sci. Lett. (Voj. Zdrav. Listy) 2025, 94(4), 146-152
ISSN 2571-113X (Online)
DOI: 10.31482/mmsl.2024.017

ORIGINAL ARTICLE

THE IMPACT OF SIMULATION METHOD AND ENVIRONMENT ON STRESS LEVELS AND PERFORMANCE IN MILITARY PARAMEDICS: A PILOT STUDY

Jan Páleník [1,2], Michal Soták [1], Karel Roubík [2], Mikuláš Kosák [3], Martin Pochop [1], Adéla Bubeníková [4], Tomáš Tyll [1]✉

[1] Department of Anesthesiology and Intensive Care 1st Faculty of Medicine Charles University and Military University Hospital Prague, U Vojenské nemocnice 1200, Praha 6, 169 02, Czech Republic
[2] Department of Biomedical Technology, Faculty of Biomedical Engineering, Czech Technical University in Prague, náměstí Sítná 3105, Kladno, 272 01, Czech Republic
[3] Department of Medicine 1st Faculty of Medicine Charles University and Military University Hospital Prague, U Vojenské nemocnice 1200, Praha 6, 169 02, Czech Republic
[4] Department of Neurosurgery and Neurooncology, 1st Faculty of Medicine, Charles University and Military University Hospital, Prague, U Vojenské nemocnice 1200, Praha 6, 169 02, Czech Republic

Received 25th June 2024.
Accepted 3rd November 2024.
Published 1st December 2025.

Summary

Background: Medical simulation is widely recognized as an essential component of healthcare professional training, including in military training programs around the world. Combat medicine presents unique challenges that can affect the quality of care provided. We aimed to analyze the benefits of medical simulation in the training of combat paramedics.
Methods: Two groups of military medics underwent a simulation scenario. One group had previously completed a simulation training with a full-body mannequin, while the second group completed the same training under simulated battle conditions with using imitations of real injuries. The speed and precision of individual treatment procedures, as well as the physiological parameters of the participants, were analyzed during the simulation.
Results: A total of 14 participants were included with comparable demographic backgrounds. Both groups had comparable results regarding vital functions and behavior during the evacuation of the wounded as well as the performance tests. The second group performed better in all measured parameters. The rise in salivary cortisol was modest in both groups and no correlation between the Beck anxiety inventory and cortisol rise was found.
Conclusion: This pilot study suggests that conducting training in a realistic environment may be important. Participants who underwent realistic training successfully performed all necessary medical interventions.

Key words: combat medicine; combat medic; simulation medicine; trauma; tactical trauma casualty care; combat stress; cortisol

✉ 1st Faculty of Medicine Charles University and Military University Hospital Prague, Department of Anesthesiology and Intensive Care, U Vojenské nemocnice 1200, 169 02 Praha 6, Czech Republic
tomas.tyll@uvn.cz
☎ +420 973 20 2999

Background

Simulation in emergency medicine

Emergency care requires a combination of practical knowledge and manual skills to perform a rapid sequence of diagnostic and treatment steps. It is important to ensure effective communication and teamwork in order to link all of these elements together (1, 2). Most mistakes associated with the practice of healthcare are attributable to human error (3). Some of them are preventable, and are rarely due to lack of theoretical knowledge. Simulation medicine provides a safe and realistic environment for healthcare personnel and patients to practice theoretical knowledge and technical skills.

Specifics of training prehospital care in combat environment

Internships in civilian trauma centers present a valuable opportunity for military medical personnel to gain experience in treating trauma cases. However, it is important to note that these internships may have some limitations. The injuries observed in combat may differ significantly from those seen in peacetime (4), and the context in which the patient is treated can also be vastly different. The experience gained from past conflicts, such as the Persian Gulf War, with consistently high numbers of casualties led to the development of the Tactical Combat Casualty Care (TCCC) program (5). In addition, there were reports that almost 90% of combat-related deaths occurred before soldiers could reach a Military Treatment Facility (MTF) (5). After the integration of medical simulation in the training of military health personnel the death rate from combat-related wounds dropped to 10%, however there remained a significant portion (up to 25%) of deaths that were potentially survivable (6-9). All this has led to the establishment of a network of military simulation centers in the United States with standardized care for injured soldiers (10).

Simulation in the Czech military medicine

The education and training of military personnel of the Czech Armed Forces (CAF), involved in the provision of pre-hospital care in combat conditions, is currently based on the completion of certified courses from the National Association of Emergency Medical Technicians (NAEMT), specifically TCCC for Combat LifeSavers (CLS) and paramedics. The objective of these courses is to provide theoretical preparation and practical training through the methodical implementation of individual therapeutic interventions. It is unfortunate that the current system of education for Czech military personnel does not offer sufficient opportunities for integrating these acquired technical skills and applying them in a team setting.

This led to the creation of a new training concept for Czech CSL and military paramedics in the form of the Extended Combat Medical Skills (ECMS) course. This innovative course uses simulation of real combat scenarios with realistic simulation of injuries and combat environments. The model scenarios are designed to reflect a series of potential treatments, including initial care at the scene, later transport, and subsequent treatment in an emergency room setting. In a variety of emergency situations, it is essential that participants respond promptly and appropriately to changes in the patient's vital signs. It would be beneficial to simulate combat environments and combat wound preparation as much as possible in order to induce stress levels as close to real combat conditions as possible, thus enabling them to better prepare for combat situations.

Methods

We conducted a prospective, randomized pilot study with the aim of exploring the potential benefits of medical simulation in the training of pre-hospital care under combat conditions and to gain insight into the levels of stress experienced in such scenarios.

Participients

The study participants were members of the Czech Army (for detailed demographic data, refer to Table 1), who had the benefit of participating in the standardized NAEMT and TCCC-CLS courses. The participants were randomly

divided into two groups. One group had the opportunity to complete a classic simulation course with an advanced simulation mannequin in a classroom setting. The second group received an identical training programme with the same model, but under conditions that simulated combat enviroment and included the simulation of real injuries.

Table 1. Summary of demographic data of included study participants.

	Group 1	Group 2	p-value
N. of participants	7	7	
Age, mean – SD	25.71 – 3.30	27.43 – 4.12	0.407
Height, mean – SD	180.14 – 5.70	178.14 – 4.56	0.482
Weight, mean – SD	78.43 – 7.41	82.00 – 8.04	0.404
Months in AVCR, mean – SD	42.86 – 19.42	41.14 – 13.61	0.851

Measurement

Simulation scenario

The simulation scenario was conducted under conditions that simulated combat (noise, reduced visibility, special restrictions, real equipment, and imitation injuries and blood). A full-body medical simulation mannequin (SimMan 3G, Laerdal, Stavanger, Norway), equipped with standard armor and equipment of the Czech Army, was used to represent a wounded soldier.

The equipment was used to hide a massive extremity hemorrhage and a gunshot wound to the chest area. The mannequin was pre-programmed to simulate development of tension pneumothorax in the eighth minute of the simulation with a gradual deterioration of circulatory function and development of pulseless electrical activity (PEA). Combat conditions were simulated with confined space for provision of care, smoke and gunshot and helicopter noise. The simulation lasted 10 minutes after which it was terminated. The model simulation was preceded by a stress test consisting of dragging a wounded model weighing 80 kg along a pre-determined 100-meter route. The time and quality of performed treatment procedures was recorded.

Physiological functions and cortisol levels

Basic physiological functions were measured for all participants. Blood pressure before and after the simulation, and heart rate was measured continuously using a GARMIN® Fenix3HR sports watch. Salivary cortisol was obtained in the recovery period 15 – 23 (mean 18) minutes after the simulation has ended. Commercially available kits for saliva collection (Salivette, Sarstedt, Germany) were used. Salivary cortisol was analyzed after centrifugation of the specimen using ELISA.

Performance test

This test was aimed at investigating the effects of combat stress on the speed and manual dexterity of the participants. Before the simulated evacuation of an injured soldier as well as after completion of the simulation the participants were asked to fill an M4 magazine with 30 rounds of 5.56 mm ammunition.

BAI – Beck anxiety inventory

After completion of the simulation the participants were asked to complete the Beck anxiety inventory, (BAI) (11, 12), in order to evaluate the subjective levels of stress experienced during the simulation.

Statistical analysis

The normality of the data was evaluated according to the Shapiro-Wilks test. Differences of categorical variables were evaluated using the chi-square test. Comparisons of two continuous variables were calculated using t-tests for independent samples. In order to objectively evaluate practical performance, each performed task was assessed on a 10-point scale according to the quality, and time spent on each task. A detailed summary this scoring system can be found in supplementary material. All calculations were performed in the open-source R environment (v4.1.2, R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, https://www.R-project.org/).

Results

Participans

A total of 14 male participants (26.57 ± 3.69 years) were included in the study. There was no significant difference in the age between both groups (p=0.407), weight (p=0.404), height (p=0.482), number of years served (p=0.815), time spent on overseas missions (p=1), total time spent in the army (p=0.851), or level of experience with medical simulations (p=0.1266).

Measurements

Both groups were found to be comparable in their vital function measurements, performance during the simulated evacuation of an injured soldier (p = 0.1564), and ammunition-loading performance test (p = 0.07409; refer to Table 2 for a graphical summary). The data obtained during the simulation reflect the quality and speed of performance. The second group performed better in all required tasks of the simulation, including the "extra points" tasks (see Supplementary Table 4 for details of the "extra points" questionnaire).

Table 2. Differences between groups in the performance of required tasks assessed by points reflecting both quality and time spent on the task.

	Overall points	Massive hemorrhage	Airway opening	Naso-pharyngeal Airway	Chest seal	Extra points
Group 1	37.14	8	9.14	8	8.71	2.43
Group 2	41.14	9.57	10	9.57	8.86	3.14
p-value	0.291	0.282	0.601	0.282	0.811	0.328

Cortisol + BAI

The mean salivary cortisol level prior to the simulation was 6.78 nmol/L (range 3.43 – 20.50 nmol/L). The mean salivary cortisol level measured in the recovery period was 8.91 nmol/L (range 3.45 – 22.40 nmol/L). The mean increase in salivary cortisol level in our cohort was 1.52 nmol/L (range 0 – 4.2 nmol/L). The increase of salivary cortisol after the simulation was only modest and there was no correlation between BAI scores and cortisol levels. Two participants who scored over 15 pts (20 and 22 pts) on the BAI questionnaire had no (0.0 nmol/L) and a mild increase (1.8 nmol/L) respectively.

Discussion

Simple presence in a combat zone places all service members at risk of exposure to a range of significant stressors. It is important to understand that combat and operational experiences affect all soldiers and reflect all activities soldiers participate in (13). Combat-related acute stress reaction (ASR) is characterized by a temporary and variable set of psychological and physiological symptoms during a high-stress event. This reaction is particularly important when viewed though its impact on functional ability during high-stress scenarios. While the individual

may recover quickly, for occupations that require individuals to regularly operate under stress, even momentary failures of function increase risk to the individual, teammates, and the mission (14).

The role of cortisol in stress reaction and BAI

Cortisol is released in response to stress together with other hormones e.g. epinephrine, norepinephrine, growth hormone and prolactin. Insulin-induced hypoglycaemia is a recognized model of well-defined physiological stress and has been used for many years as a method of assessment of reserves. It is known that cortisol levels begin to rise approximately 10 - 20 minutes after hypoglycaemia is induced (15). Cortisol is usually measured from serum, however, measurement of cortisol from saliva has been confirmed to be a reliable method in various clinical scenarios (16, 17). It has been confirmed by several reports that salivary cortisol can replace serum cortisol assessment in dynamic tests as well (18). Another advantage of measuring salivary cortisol over serum cortisol is that it reflects the free fraction (biological active) of cortisol in blood and hence factors that can affect cortisol binding globulin (including using oral contraceptive pills) are excluded (19). We also decided to use salivary cortisol measurement in our study because the collection technique is more practical, convenient, rapid and noninvasive in comparison to blood sampling. It is also believed that blood drawing itself is a source of stress and can induce increases of serum cortisol. These results therefore do not confirm our expectation that the simulation scenario can induce stress reaction that is expected to occur in a real-life situation. There was significant variation in baseline cortisol levels within the cohort with three participants having salivary cortisol over 15 nmol/L. It is possible that some participants had elevated cortisol prior to the simulation due to anticipatory stress. Limitations of the study – timing of salivary cortisol measurement. From studies with insulin induced hypoglycaemia it is known that cortisol starts to rise almost immediately after stress is induced, however peak serum cortisol was observed 20-30 minutes after hypoglycaemia is induced (15). In our study salivary collection was performed approximately 18 minutes after the simulation had ended, with the assumption that participants became stressed almost immediately after the simulation began. However, as opposed to artificially induced hypoglycaemia, it is difficult to define a precise moment of stress induction in a simulation scenario, and it might have been beneficial to obtain more samples during the recovery period in order to establish a longer trend.

Subjectively assessed stress levels according to the BAI were not very high and in only 5 participants could be considered significant. This can be explained by the homogenity of the groups, consisting of experienced combat paramedics who already served for a significant time in the Czech military (mean time served was 42 months), and had already been deployed on several combat missions. We may expect different results if the experiment were expanded to include other units of the Czech Army.

Model simulation outcomes

A homogeneous group of participants was successfully obtained, with comparable demographic data. The focus was on evaluating specific medical interventions for some of the most common causes of preventable deaths on the battlefield (20). In our evaluation, we considered not only the speed of the procedures, but also their correct sequence and execution quality. It is worth noting that speed alone does not bring benefits if the procedures are not performed correctly. The quality of execution was evaluated using a standardized skill assessment checklist (www.deployedmedicine.com, Joint Trauma System – JTS, USA), with an emphasis on quality rather than speed. While the sample size was limited and no statistically significant differences were found between groups, certain trends were noted that reinforce the initial hypothesis regarding the significance of conducting training in a realistic environment. The participants received training in a realistic environment for all of the listed interventions. Furthermore, they were evaluated positively in soft skills, including communication and personal safety, which are crucial factors in the context of care provided (21). Based on the results of this pilot study, it is being considered to prepare a larger study with a wider sample base to monitor participant stress levels more effectively, including the use of telemedicine tools.

Conclusions

This pilot study suggests that conducting training in a realistic environment may be important. Participants who underwent realistic training successfully performed all necessary medical interventions. It is worth noting that despite

wearing a military uniform, soldiers are still human beings, not robots. Therefore, it is critical that they be trained in the management and conscious control of their emotions. Our experience to date has demonstrated the potential for further development in the field of emergency care.

Abbreviations

CAF: Czech Armed Forces, CLS: Combat Life Savers, CRM: Crisis resource management, ECMS: Extended Combat Medical Skills, JTS: Joint Trauma System, NAEMT: National Association of Emergency Medical Technicians, NATO: North Atlantic Treaty Organization, TCCC: Tactical Combat Casualty Care

Supplementary Material

The online Supplementary Material provides detailed visual documentation of the simulation scenario and the performance assessment used in this study. Supplementary Figures 1–8 illustrate key elements of the simulated tactical evacuation and treatment: towing an 80 kg dummy representing a wounded patient over a distance of 100 m (Figure 1), moving a wounded patient (SimMan 3G) to a safe treatment area (Figure 2), application of a tourniquet after identifying massive bleeding from the lower limb (Figure 3), an oral cavity check (Figure 4), NPA airway support (Figure 5), posterior body examination (Figure 6), and assessment of breathing rate and chest wall excursion (Figure 7). Supplementary Figure 8 provides a bird's-eye view of the simulation area layout. Supplementary Table 3 summarises the classification assessment used in this study to better reflect the relative significance of individual tasks, and Supplementary Table 4 presents the "extra points" questionnaire used to capture additional, non-mandatory performance indicators.

Declarations

Acknowledgements

The authors would like to thank the military paramedics of the Czech Army for their participation in the study.

Funding Sources

The article was supported by Military University Hospital Grant MO1012.

Clinical Trial Registration

The study was registered with ClinicalTrials.gov (NCT05612828, November 10, 2022).

Institutional Review Board

The study was approved by Ethics Committee of Military University Hospital Prague, REC reference: 108/17-93/2022, 19Sep2022. Informed consent was obtained from each participants. All methods were performed in accordance with the relevant guidelines and regulations.

Competeting Interests

Authors declare that they have no competing interests.

Individual Author Contribution Statement

Drs. Páleník and Soták contributed equally to this work and are co-first authors. J.P. and M.S. contributed to data interpretation, wrote and drafted the manuscript, T.T. was consultant of the study, contributed to data interpretation and is corresponding author, A.B. contributed to data analysis and statistics and contributed to data interpretation, K.R., M.P., M.K. revised and edited the manuscript critically for important intellectual consent. All authors read and approved the final manuscript.

Data Availability statement

Supplemental content is available for this article in the section Supplementary material. The complete data set that support the findings of this study are available on request from corresponding author.

Disclaimer

The views expressed in this material are those of the authors, and do not reflect the official policy or position of the Czech Government, the Department of Defense, or the Department of the Czech Army.

References

1. Maddry JK, Varney SM, Sessions D, et al. A comparison of simulation-based education versus lecture-based instruction for toxicology training in emergency medicine residents. J Med Toxicol. 2014;10(4):364-368.
2. McCoy CE, Menchine M, Anderson C, et al. Prospective randomized crossover study of simulation vs. didactics for teaching medical students the assessment and management of critically ill patients. J Emerg Med. 2011;40(4):448-455.
3. Gaba DM. Crisis resource management and teamwork training in anaesthesia. Br J Anaesth. 2010;105(1):3-6.
4. Leitch RA, Moses GR, Magee H. Simulation and the future of military medicine. Mil Med. 2002;167(4):350-354.
5. Kotwal RS, Montgomery HR, Kotwal BM, et al. Eliminating preventable death on the battlefield. Arch Surg. 2011;146(12):1350-1358.
6. Eastridge BJ, Mabry RL, Seguin P, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. J Trauma Acute Care Surg. 2012;73(6 Suppl 5):S431-437.
7. Kelly JF, Ritenour AE, McLaughlin DF, et al. Injury severity and causes of death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003-2004 versus 2006. J Trauma. 2008;64(2 Suppl):S21-6; discussion S6-7.
8. Butler FK. TCCC Updates: Two Decades of Saving Lives on the Battlefield: Tactical Combat Casualty Care Turns 20. J Spec Oper Med. 2017;17(2):166-172.
9. D'Souza EW, MacGregor AJ, Dougherty AL, et al. Combat injury profiles among U.S. military personnel who survived serious wounds in Iraq and Afghanistan: A latent class analysis. PLoS One. 2022;17(4):e0266588.
10. McCarthy M. US military revamps combat medic training and care. Lancet. 2003;361(9356):494-495.
11. Beck AT, Epstein N, Brown G, et al. An inventory for measuring clinical anxiety: psychometric properties. J Consult Clin Psychol. 1988;56(6):893-897.
12. Wang CP, Hung FM, Ling MS, et al. Factors associated with critical care nurses' acute stress disorder after patient death. Aust Crit Care. 2022;35(4):402-407.
13. Brusher EA. Combat and Operational Stress Control. Int J Emerg Ment Health. 2007;9(2):111-122.
14. Adler AB, Gutierrez IA. Acute Stress Reaction in Combat: Emerging Evidence and Peer-Based Interventions. Curr Psychiatry Rep. 2022;24(4):277-284.
15. Dökmetaş HS, Colak R, Keleştimur F, et al. A comparison between the 1-microg adrenocorticotropin (ACTH) test, the short ACTH (250 microg) test, and the insulin tolerance test in the assessment of hypothalamo-pituitary-adrenal axis immediately after pituitary surgery. J Clin Endocrinol Metab. 2000;85(10):3713-3719.
16. Bedini S, Braun F, Weibel L, et al. Stress and salivary cortisol in emergency medical dispatchers: A randomized shifts control trial. PLoS One. 2017;12(5):e0177094.
17. Grace C, Heinrichs M, Koval P, et al. Concordance in salivary cortisol and subjective anxiety to the trier social stress test in social anxiety disorder. Biol Psychol. 2022;175:108444.
18. Kim YJ, Kim JH, Hong AR, et al. Stimulated Salivary Cortisol as a Noninvasive Diagnostic Tool for Adrenal Insufficiency. Endocrinol Metab (Seoul). 2020;35(3):628-635.
19. Qureshi AC, Bahri A, Breen LA, et al. The influence of the route of oestrogen administration on serum levels of cortisol-binding globulin and total cortisol. Clin Endocrinol (Oxf). 2007;66(5):632-635.
20. Belmont PJ, Schoenfeld AJ, Goodman G. Epidemiology of combat wounds in Operation Iraqi Freedom and Operation Enduring Freedom: orthopaedic burden of disease. J Surg Orthop Adv. 2010;19(1):2-7.
21. Milling L, Kjær J, Binderup LG, et al. Non-medical factors in prehospital resuscitation decision-making: a mixed-methods systematic review. Scand J Trauma Resusc Emerg Med. 2022;30(1):24.