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IS AN EMERGENCY DEPARTMENT A SAFER PLACE FOR HYPOTHERMIC VICTIMS THAN AN AMBULANCE? A COMPARISON OF THE KNOWLEDGE OF MEDICAL PERSONNEL CONCERNING HYPOTHERMIA

CZY ODDZIAŁ RATUNKOWY JEST BEZPIECZNIEJSZYM MIEJSCEM DLA PACJENTA W HIPOTERMII NIŻ KARETKA? PORÓWNANIE WIEDZY PERSONELU MEDYCZNEGO NA TEMAT HIPOTERMII

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ABSTRACT

Introduction: Improper initial management of a victim in severe hypothermia is associated with a risk of cardiac arrest. At the same time, an uncontrolled drop in core body temperature in trauma victims is an independent risk factor for mortality. Medical personnel require a thorough understanding of the pathophysiology and treatment of hypothermia. Gaps in this understanding can lead to serious complications for patients.

The aim: To compare knowledge concerning hypothermia between medical personnel working in emergency departments (ED) and emergency medical services (EMS).

Materials and methods: A total of 5,362 participants were included in the study. In this study, EMS and ED personnel were encouraged to participate in an e-learning course on hypothermia. Subsequently, the scores of a pre-test, lesson tests and post-test completed by participants of this course were compared.

Results: Pre-test scores were significantly higher among personnel working in EMS compared with those working in EDs. Nurses employed in EDs had significantly more failures in completing the course than EMS nurses. The most difficult topics for all practitioners were post-traumatic hypothermia and hypothermia-related clotting disorders.

Conclusions: EMS personnel have a higher level of knowledge of hypothermia than ED personnel. Moreover, an e-learning course is an effective tool for improving medical personnel's knowledge of hypothermia.

KEY WORDS: e-learning; hypothermia; medical education; emergency department; emergency medical systems

STRESZCZENIE

Wstęp: Niewłaściwe postępowanie z pacjentami w głębokiej hipotermii wiąże się z ryzykiem zatrzymania krążenia. Wśród pacjentów, którzy doznali urazów, obniżenie temperatury głębokiej ciała stanowi niezależny czynnik ryzyka zgonu. Tak więc znajomość patofizjologii hipotermii oraz zasad postępowania wśród personelu medycznego ma kluczowe znaczenie dla uniknięcia powikłań.

Cel pracy: Porównanie wiedzy na temat hipotermii personelu oddziałów ratunkowych (ED) i pracowników zespołów ratownictwa medycznego (EMS).

Materiał i metody: Do badania włączono 5362 uczestników szkolenia. Personel medyczny pracujący zarówno w ED, jak i w EMS, został zaproszony do udziału w szkoleniu e-learningowym dotyczącym hipotermii. Porównano wyniki testu wstępnego, testów kończących poszczególne lekcje oraz testu końcowego, uzyskane przez obie grupy personelu.

Wyniki: Wyniki testu wstępnego były istotnie wyższe wśród personelu EMS niż wśród personelu ED. Pielęgniarki zatrudnione w ED miały istotnie więcej niepowodzeń w zaliczeniu kursu niż pielęgniarki EMS. Dla wszystkich uczestnicy najtrudniejsza do przyswojenia okazała się wiedza z zakresu hipotermii pourazowej i zależnych od wychłodzenia zaburzeń krzepnięcia.

Wnioski: Personel EMS dysponuje wyższym poziomem wiedzy o hipotermii niż personel ED. Szkolenie za pomocą e-learningu okazało się skutecznym narzędziem poszerzenia tej wiedzy.

SŁOWA KLUCZOWE: e-learning; hipotermia; kształcenie medyczne; oddział ratunkowy; zespół ratownictwa medycznego

INTRODUCTION

Reported deaths due to hypothermia number around 1,500 annually in the United States and around 125 annually in Poland [1, 2]. However, the real incidence of hypothermia remains unknown. Core body temperature is not routinely measured in patients who are admitted to hospitals. For this reason, hypothermia is less commonly recognized, while the actual number of cases could be significantly higher.

Cardiac arrest is the most dangerous complication of hypothermia. Ventricular Fibrillation (VF) may be precipitated by excessive movement while handling the patient, along with endotracheal intubation, aggressive ventilation, rapid core temperature declines (afterdrop), and unnecessary chest compressions [1, 3, 4]. Additionally, the heart becomes unresponsive to electrical defibrillation and drugs [5]. Although hypothermic cardiac arrest occurs most often below a core body temperature (Tc) of 28°C, it begins to be a risk below 32°C. It can occur in both the prehospital and hospital settings. Cardiac arrest associated with treatment or transport is called rescue collapse [1]. Debaty et al. showed that half of the patients in severe hypothermia who were found alive sustained rescue collapse. Therefore, the initial assessment is a high risk period for the hypothermic patient [6]. An appropriate level of understanding of these risks by first responders and other providers is a crucial component of patient survival.

Another important cold injury is post-traumatic hypothermia. It, along with acidosis and coagulopathy, comprises what is known as the triad of death in trauma patients. Hypothermia alone is also an independent risk factor of mortality in patients with traumatic injuries [7]. A very large study (n = 700,304) found the overall mortality in patients with post-traumatic hypothermia to be 25.5%, compared with only 3% in normothermic patients [8]. Thus, an awareness of this risk factor coupled with the appropriate use of thermal insulation and prophylaxis against hypothermia can play an important role in reducing mortality.

According to the Utstein Formula presented by The International Liaison Committee on Resuscitation, the effective education of medical personnel is an indispensable element in the Chain of Survival [9]. Our study presents the degree of effectiveness of hypothermia education and can provide useful insights into improving a healthcare system's capability to manage these vulnerable patients.

The aim of this study was to compare knowledge about the initial phase of care of hypothermic patients between emergency medicine departments personnel and ambulance personnel. An additional goal was to assess the effectiveness of an e-learning course for improving one's competency regarding hypothermia.

MATERIAL AND METHODS

DESIGN

A total of 5,677 medical practitioners participated in the online hypothermia course, including personnel from emergency departments and emergency medical services. The study was based on test results that assessed the initial knowledge of both ED and EMS groups, as well as their understanding of material covered in an online hypothermia course. Further, we evaluated any increase in knowledge as a result of this course. The course was implemented through an e-learning platform composed of an entry exam (pre-test), lesson topics on hypothermia followed by corresponding lesson tests, and a concluding final exam (post-test). The pre-test and post-test were composed of the same 15 questions. Participants were not informed of the correct answers after any test, with the achieved score only being shown. The course was accepted by the National Consultant of Emergency Medicine who approved it for Emergency Medical Staff curriculum. Personnel from EDs and EMS were invited to take part in the course. Information about the course was mailed in poster form and in a written recommendation to participate signed by the National Consultant of Emergency Medicine. While the course had tailored modules for EMS and ED personnel, the pre-test, post-test, and five lesson tests were identical. The pre-test was not timed although the post-test had a ten minute time limit for completion. A passing score was 75% on the post-test and for each lessons' practice test. Data were collected from December, 2015 to February, 2017.

PARTICIPANTS

Participants self-registered through an online platform, chose the appropriate learning module (ED or EMS), and specified their profession (physician, nurse, paramedic), age, and years of practice (seniority). The study only included individuals who registered as ED or EMS staff, submitted personal identifying information, completed a pre-test, all lesson tests, and a post-test. Individuals that did not provide demographic information, did not belong to one of the listed occupational groups, or who did not complete the entire course were excluded from the study. To limit the level of bias, each participant could be registered in only one module. The number of participants was not limited.

STATISTICAL ANALYSES

The results of the pre-test, the first attempts to pass each lesson test, and the final test were analyzed. Differences between the ED group and the EMS group in the occupational subgroups (physicians, nurses and paramedics) were compared. The proportion of correct pre- and post-test responses was reported using mean values with a standard deviation, minimum and maximum values, and due to a skewed distribution of the results, a median and interquartile range (IQR). The Mann-Whitney test was used to compare the median results between each occupational group in the ED with the corresponding occupational group in EMS. Non-parametric methods, instead of the parametric two-factor ANOVA analysis for repeated measurements, were applied because of the lack of normality of distributions of the examined features in individual groups. The non-parametric Mann-Whitney

Table I. Demographic characteristics of emergency departments and emergency medical services included in the study

		Physicians	Nurses	Paramedics
ED				
n		88	130	249
Sex n (%)	Women	35 (39.8)	120 (92.3)	126 (50.6)
	Men	53 (60.2)	10 (7.7)	123 (49.4)
Age (median [IQR])		33 [28, 42]	43 [32, 48]	28 [25, 32]
Lenght of service (median [IQR])		6 [2, 18]	21 [10, 28]	4 [2, 7]
EMS				
n		171	503	4221
Sex n (%)	Women	36 (21.1)	392 (77.9)	519 (12.3)
	Men	135 (78.9)	111 (22.1)	3702 (87.7)
Age (median [IQR])		44 [37, 50]	45 [41, 52]	34 [29, 44]
Lenght of service (median [IQR])		18 [10, 25]	25 [20, 31]	10 [5, 16]
p (ED-EMS)		<0.001	<0.001	<0.001

test was also used to compare age or seniority between groups of medical personnel. The analysis of the relationship between the two quantitative features was based on the Spearman rank correlation coefficient. Additionally, the Shapiro-Wilk test was used to check the compliance of the empirical distribution of the examined variable with the theoretical normal distribution. Categorized data were presented using frequency and percentages. The relationship between two qualitative features was based on the chi-square independence test.

The results were considered statistically significant if the calculated p-value did not exceed the significance level $\alpha = 0.05$. In addition, R software was used for statistical calculations, available at www.r-project.org.

ETHICS

The consent of the bioethical commission was not deemed necessary since the study does not rely on data from patients' medical records.

RESULTS

DEMOGRAPHIC CHARACTERISTICS

There were 315 individuals that did not complete their training and were excluded from the study. Of the 5,362 practitioners included in this study, 467 (8.7%) were employed by emergency departments and 4,895 (91.3%) by emergency medical services. The ED group consisted of 18.8% physicians (n=88), 27.8% nurses (n=130), and 53.3% paramedics (n=249). In the EMS group, 3.4% were physicians (n=171), 10.3% nurses (n=503), and 86.2% paramedics (n=4221). There were significant differences in age and seniority between the two groups which are summarized in Table I.

Correlation analysis did not reveal a statistically significant relationship between pre-test results and age ($R = 0.01$, $p = 0.907$), or between pre-test results and seniority ($R = 0.01$, $p = 0.802$) in the ED group. In the EMS group, however, there was a significant correlation between pre-test results and age ($R = 0.15$, $p < 0.001$) and between pre-test results and seniority ($R = 0.14$, $p < 0.001$). However, it should be emphasized that this is a very weak relationship and is probably due to the very large number of EMS participants.

INITIAL KNOWLEDGE AND LEARNING RESULTS

The median of the pre-test results of the ED physicians was significantly lower from the median pre-test results of EMS physicians ($p = 0.038$). This trend was also present for nurses ($p < 0.001$) and paramedics ($p = 0.002$). A summary of these results is shown in Figure 1.

Subsequently, the knowledge gained was assessed by comparing pre-test results with the first attempt at the final test (post-test) among the ED and EMS personnel. In all of the groups there was a statistically significant increase in the number of correct responses in the post-test, compared with the pre-test ($p < 0.001$). EMS nurses scored significantly better on their post-test than ED nurses ($p = 0.008$). The median of the post-test results among physicians employed in EDs and EMS was not significantly different ($p = 0.870$). Similarly, the median of the post-test results was not significantly different among paramedics from EDs and EMS ($p = 0.096$).

Among ED staff, 94 (20.1%) participants did not score the minimum points (12/15) needed to pass the course. The percentage of participants who did not pass was similar in the EMS group and amounted to 18.2% (n=890). There was no significant difference between the passing rates of physicians and paramedics working in an ED or EMS, while there was a statistically significant difference among nurses. Thus, 30.8% of nurses working in an ED and 15.1% of those working in EMS did not pass the post-test ($p<0.001$) - Figure 2.

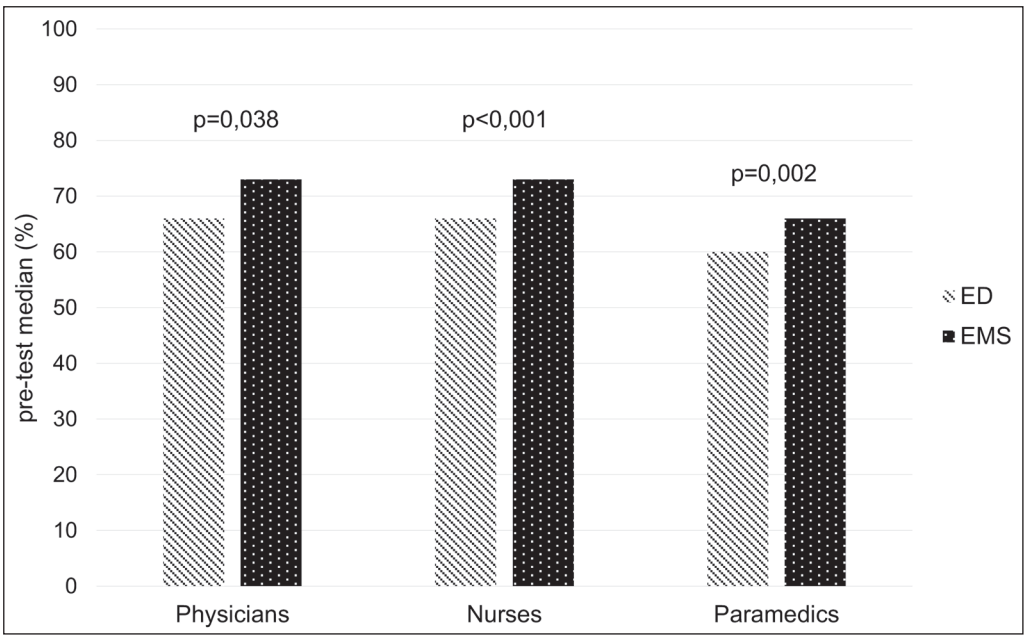

Fig. 1. Comparison of pre-test results of ED and EMS personnel in occupational groups.

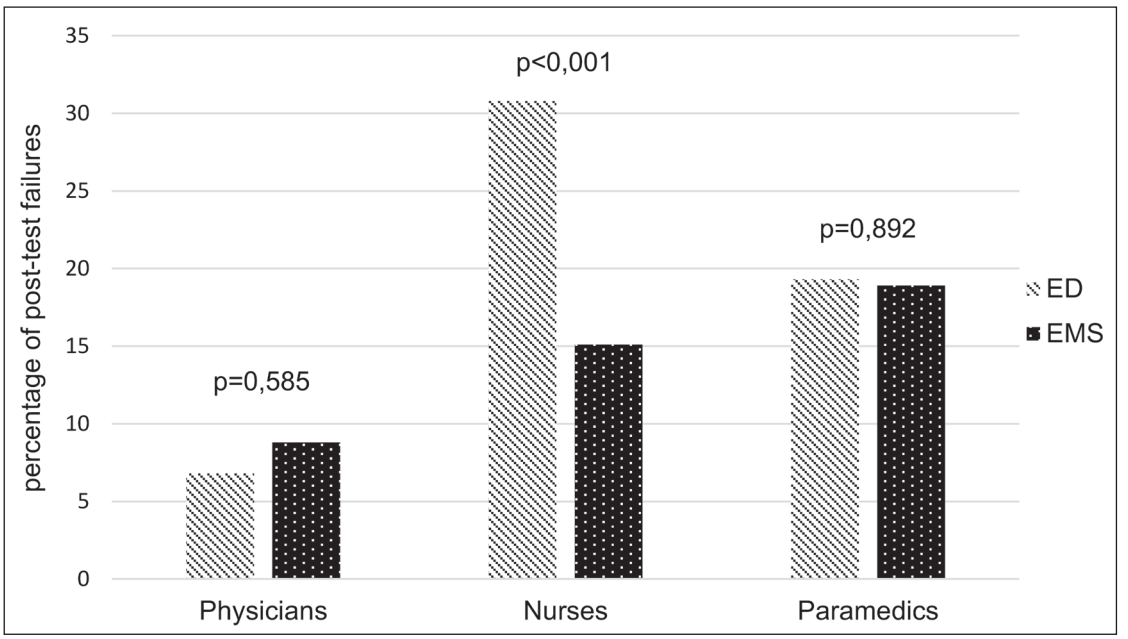

Fig. 2. The percentage of first attempt failed post-tests among occupational groups.

LESSON TESTS

The scores of five lesson tests were compared. The percentage of correct answers was lower in the ED group - Figure 3. Comparing the distribution of responses to the lesson tests among occupations (physicians, nurses and paramedics) showed a statistically significant difference for the *clotting disorders* lesson among all occupational groups; *avalanche*, *ECG*, and *temperature measurement* lessons among nurses; and *ECG* and *temperature measurement* lessons among paramedics (Tab. II).

As lesson modules on post-traumatic hypothermia differed for the ED and EMS groups, they cannot be directly compared. However, both groups scored poorly in these lesson tests.

DISCUSSION

Our study showed that the initial level of knowledge concerning hypothermia was significantly higher for all occupational groups working in EMS. The results of the pre-tests and most of the lesson tests in the EMS group were better across all EMS occupations compared with the ED group. These differences are statistically significant.

Regarding these data, one may pose the question whether a hospital is always a safe place for hypothermic patients. In their survey of hypothermia knowledge, Ireland *et al*. found trauma center staff to have significant gaps in understanding, similar to those uncovered by our study. Coagulation disorders were particularly misunderstood – only 27% of

Table II. Comparison of lesson test results from selected lessons (presented as medians [IQR])

		Physicians	Nurses	Paramedics
Avalanches	ED	100 [100, 100]	100 [75, 100]	100 [75, 100]
	EMS	100 [100, 100]	100 [100, 100]	100 [100, 100]
	p	0.219	**<0.001**	0.222
ECG	ED	75 [75, 100]	75 [50, 100]	75 [50, 100]
	EMS	75 [75, 100]	75 [75, 100]	75 [75, 100]
	p	0.332	**<0.001**	**0.004**
Thermal insulation	ED	100 [100, 100]	100 [75, 100]	100 [75, 100]
	EMS	100 [75, 100]	100 [75, 100]	100 [75, 100]
	p	0.175	0.058	0.083
Clotting disorders	ED	75 [50, 75]	75 [50, 75]	75 [50, 75]
	EMS	75 [50, 100]	75 [75, 100]	75 [50, 100]
	p	**0.042**	**<0.001**	**0.003**
Temperature measurement	ED	100 [75, 100]	75 [75, 100]	75 [75, 100]
	EMS	100 [75, 100]	100 [75, 100]	100 [75, 100]
	p	0.211	**<0.001**	**0.001**

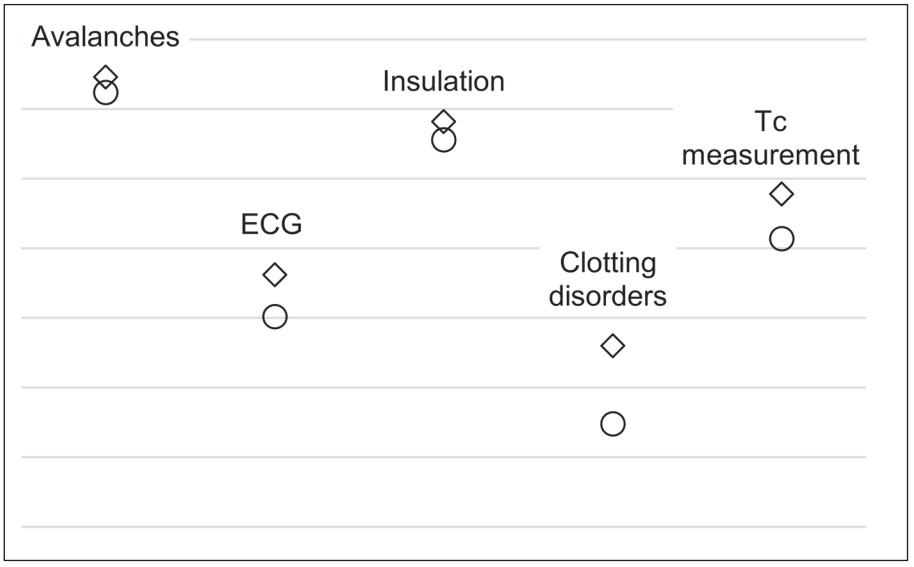

Fig. 3. Percentage of correct answers on lesson tests from individual lessons in the ED and EMS groups.

practitioners were able to identify coagulopathy as a pathology caused by hypothermia. Among those surveyed, other pathophysiological aspects of hypothermia were also poorly known: over 1/3 (36.4%) of respondents were unable to identify the temperature below which hypothermia is diagnosed, while 1/3 were unable to identify the most important mechanism of heat loss. Disturbingly, only 16% of respondents identified the esophagus as a possible location to measure core temperature. It must be mentioned that more than half of the physicians had had lengthy careers and held senior positions and that 1/3 of nurses had completed postgraduate training [10]. Similar results were obtained by Kosiński et al. in a survey on the treatment of patients with hypothermia in EDs. Relatively few patients had a correctly measured core temperature while no patients in cardiac arrest with deep hypothermia were transported to a facility equipped for extracorporeal life support [11]. In light of our results, EMS personnel appear to be better prepared to manage hypothermic patients. Two factors likely contribute to this trend. Firstly, the comparison of demographic data (Tab. I) shows that EMS personnel have significantly more work experience in their respective fields (physicians 18 *vs.* 6, nurses 25 *vs.* 21, paramedics 10 *vs.* 4 years). Secondly, as EMS personnel cannot easily receive help from more experienced colleagues at the scene, this may stimulate them to acquire more knowledge concerning initial patient management [12]. The data support this assumption, showing a correlation between years of service and the results of the pre-tests for the EMS group. However, this correlation is not seen in the ED personnel group.

Differences in the practitioners working in EDs compared with those in EMS are most pronounced among nurses. This is particularly clear in the analysis of first attempt failures on the post-test. Twice as many ED nurses failed the post-test on their first attempt compared to EMS nurses (30.8% vs 15.1%, p<0.001 respectively). The scores in the pre-test and individual lesson tests were also higher among the EMS nurses compared with ED nurses. The lower median age in ED staff also points to an overall less experienced population compared with EMS staff. Personnel working in EDs also often train in other specialties in order to work in other hospital departments, thereby further decreasing their time spent on training emergency medicine specifically. We can also assume that medical practitioners with longer careers in emergency medicine (EMS personnel) tend to be those that are the best suited to the profession and, as such, tend to be more effective in their roles. Two studies performed by Aiken *et al*. highlight the impact of nurses' educational levels on hospital mortality. Thus, the improvement of hospital staff knowledge may lead to an increase in the quality of care [13, 14].

Poor tests results may be a consequence of first-time exposure to a subject, while learning material for the first time is less effective than review [15, 16]. This phenomenon seems to be particularly present for the *clotting disorders* and *post-traumatic hypothermia* sections of our online course. The importance of post-traumatic hypothermia and hypothermic coagulopathy is underappreciated not only in Poland but also in other countries with cold climates. This can be seen in the paucity of hypothermia-specific equipment present in Scandinavian ambulances. A study of the equipment carried by the Norwegian emergency services showed that only 12% of ambulances have thermometers designed for core temperature measurement, and only 14% have equipment for the active warming of a patient [17].

Our study proved that an e-learning course is an effective teaching tool regarding hypothermia. The increase in theoretical knowledge ranges from 14.5 to 23.1 percentage points (pp) across all occupational groups in both the ED and EMS groups. This corresponds to the results of other studies evaluating e-learning as a medium for education among medical staff. Yao et al. obtained an increase in knowledge of 10.8 pp in the training of medical staff to diagnose gastric cancer. Nesterowicz observed a 16 pp increase in pharmacy course, while Nicastro and Morgulis described a 28 and 29 pp increase respectively in the fields of gastroenterology and hematology [18–21].

LIMITATIONS OF THE STUDY

The most significant limitation of the study is the disproportionate number of EMS participants compared with ED participants. The relatively small number of ED representatives limits the generalizability of our results. It is likely that individuals who decided to participate in the course are more interested in increasing their knowledge. Therefore, this may induce a selection bias. In addition, since the selection of the ED or EMS modules was used to identify each practitioner's primary workplace, it is difficult to determine the percentage of medical practitioners who work in both an ED and EMS.

CONCLUSIONS

EMS personnel participating in the training showed a higher level of knowledge concerning hypothermia than hospital ED staff. The biggest differences were seen among nurses. Additional training courses dedicated to ED nurses may be beneficial. All participants of the course displayed poor knowledge of post-traumatic hypothermia and its related coagulopathy. Since these disorders are associated with increased mortality, it seems to be reasonable to emphasize these topics in educational process. Indeed, an e-learning platform is an effective tool for improving emergency medical personnel's understanding of hypothermia.

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