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CPREzy chest compression feedback device use by lifeguards: A randomized crossover trial

Zastosowanie urządzenia CPREzy przez ratowników wodnych: Badanie randomizowane krzyżowe

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Abstract

Background. The quality of chest compressions directly influences the effectiveness of cardiopulmonary resuscitation. Lifeguards, due to the high possibility of having to help victims with cardiac arrest in the mechanism of drowning, are taught cardiopulmonary resuscitation based on basic resuscitation procedures. One of the most important factors directly affecting the effectiveness of cardiopulmonary resuscitation is the quality of chest compressions, which consist of chest compressions of appropriate frequency and depth, as well as the degree of complete chest relaxation after each compression. The aim of the study was to assess the impact of cardiopulmonary resuscitation with the use of cardiopulmonary resuscitation CPREzy feedback device on the quality of chest compressions performed by lifeguards during simulated resuscitation of a submerged patient. ***Material and methods.*** This was a randomized cross-over stud, which included 41 lifeguards. The participants were performing two scenarios of 2-minute cardiopulmonary resuscitation cycle with and without CPREzy feedback device. Prior to the resuscitation, the participants swam 25m in the pool, and then return to a starting position while towing a phantom which was simulating the submerged patient. The simulation of cardiopulmonary resuscitation was performed on the edge of the pool on a manikin equipped with sensors which measured the quality of chest compressions. ***Results.*** All subjects completed 2min of cardiopulmonary resuscitation with both methods. Median depth of compressions was higher without CPREzy – 50 mm [IQR; 44-52], compared with CPREzy – 45 mm [IQR; 40-47] (p = 0.009). No flow fraction was also better in manual chest compression without CPREzy technique. Full chest release was better with CPREzy -87% compared with manual compressions – 68% (p = 0.021). ***Conclusion.*** In the conducted simulation study, lifeguards were able to perform chest compressions at the appropriate depth and at the appropriate frequency without the need to use CPR feedback devices. The use of CPREzy was correlated with better relaxation of the chest. *Anestezjologia i Ratownictwo 2018; 12: 24-30.*

Keywords: cardiopulmonary resuscitation, chest compression, quality, lifeguard, drowing

Streszczenie

Wstęp. Jakość uciskania klatki piersiowej bezpośrednio wpływa na skuteczność resuscytacji krążeniowo-oddechowej. Ratownicy wodni, ze względu na wysokie prawdopodobieństwo udzielania pomocy poszkodowanym w stanie nagłego zatrzymania krążenia na skutek tonięcia, szkoleni są w zakresie resuscytacji krążeniowo-oddechowej zgodnie z obowiązującymi wytycznymi. Jednym z najistotniejszych czynników bezpośrednio wpływających na skuteczność resuscytacji krążeniowo-oddechowej jest jakość uciskania klatki piersiowej, na którą składa się odpowiednia częstość i głębokość uciśnięć, jak również stopień całkowitej relaksacji klatki piersiowej po każdym jej uciśnięciu. Celem badania była ocena wpływu stosowania urządzenia CPREzy podczas resuscytacji krążeniowo-oddechowej prowadzonej przez ratowników wodnych podczas symulowanej resuscytacji u pacjenta po tonięciu w wodzie na jakość uciskania klatki piersiowej. ***Materiał i metody.*** Badanie przeprowadzono jako badanie krzyżowe randomizowane na grupie 41 ratowników wodnych. Uczestnicy badania przeprowadzali 2-minutową resuscytację zgodnie z dwoma scenariuszami, w których stosowali – lub też nie – urządzenie CPREzy. Przed prowadzeniem resuscytacji uczestnicy badania musieli przepłynąć 25 metrów w basenie i następnie wrócić do pozycji startowej, holując fantom imitujący poszkodowanego tonącego w wodzie. Resuscytacja prowadzona była przy brzegu basenu na fantomie wyposażonym w czujniki mierzące jakość uciskania klatki piersiowej. ***Wyniki.*** Wszyscy uczestnicy badania przeprowadzili 2-minutową resuscytację obiema metodami. Średnia głębokość uciskania klatki piersiowej była wyższa bez stosowania urządzenia CPREzy – 50 mm [IQR; 44-52], w porównaniu ze stosowaniem CPREzy – 45 mm [IQR; 40-47](p = 0,009). Odsetek braku przepływu był również wyższy przy stosowaniu ręcznego uciskania klatki piersiowej bez stosowania techniki CPREzy. Odsetek pełnej relaksacji klatki piersiowej był wyższy przy stosowaniu CPREzy – 87% w porównaniu z ręcznym uciskaniem – 68% (p = 0,021). ***Wnioski.*** W przeprowadzonym badaniu symulacyjnym ratownicy wodni byli w stanie prowadzić resuscytację krążeniowo-oddechową uzyskując odpowiednią głębokość i częstość uciśnięć klatki piersiowej bez potrzeby stosowania urządzenia do wspomagania prowadzenia resuscytacji. Stosowanie urządzenia CPREzy związane było z uzyskiwaniem lepszego odsetka relaksacji klatki piersiowej. *Anestezjologia i Ratownictwo 2018; 12: 24-30.*

Słowa kluczowe: resuscytacja krążeniowo-oddechowa, uciski klatki piersiowej, jakość, ratownik wodny, tonięcie

Introduction

The epidemiological data show that sudden cardiac arrest is a serious health issue. Global incidence of adult out-of-hospital-cardiac arrest is estimated at 95.9 per 100,000 persons-years [1]. Survival rates vary from approximately 5% to 50% in both out-of-hospital and in-hospital settings [2]. Moreover, more than half of survivors of cardiac arrest have brain damage of varying degrees [3,4].

The American Society of Cardiology guidelines indicate that providing high quality chest compressions is the main factor affecting the effectiveness of cardiopulmonary resuscitation [5]. The guidelines recommend that chest compressions are performed in adults with a 100-120 compressions per minute frequency with a depth of 5-6 cm. Simultaneously the complete chest relaxation after each compression must be reached. The aforementioned factors, combined with the minimization of pauses in chest compressions, significantly increase the chances of return of spontaneous circulation.

Studies indicate that a large number of people perform too shallow chest compressions, or the frequency of compressions is too high. This applies to both healthcare professionals and people working outside of medicine field [6,7]. Wik et al. [8], observed a mean chest compression depth of 34 mm in out-of-hospital resuscitation, and only 28% of chest compressions within 38-51 mm. Aufderheide et al. [9], showed that chest compressions performed by medical personnel in conditions of simulated cardiopulmonary resuscitation are of low quality. The results obtained by Wik et al. [8], as well as Aufderheide et al. [9] also confirmed by other studies [7,10,11].

In order to improve the quality of chest compressions both compression systems e.g. LUCAS2 [12], or CORPULS [13] or cardiopulmonary resuscitation feedback devices (i.e. CPREzy [14], TrueCPR [15], CPRMeter [16,17]) may be used. The latter providing the real life data regarding the depth and frequency of chest compressions allows the compressing person to modify the parameters of compressions and optimize them.

The aim of the study was to assess the impact of cardiopulmonary resuscitation with the use of cardiopulmonary resuscitation CPREzy feedback device on the quality of chest compressions performed by lifeguards during simulated resuscitation of a submerged patient.

Material and methods

- **Study design and participants**

This study was designed as a prospective randomized crossover observational trial, and the study protocol was approved by the Institutional Review Board of the Polish Society of Disaster Medicine (Approval no.: 84.2017.IRB). The study was conducted from the November to the December 2017. Volunteers aged 18 years or more were recruited from the lifeguards. Health care professional or medical students were excluded from this study. A total of 41 participants were enrolled.

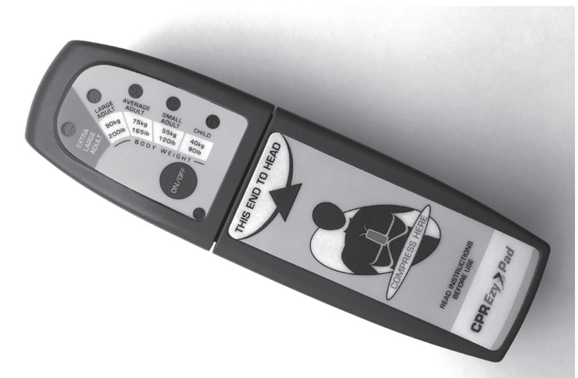

Figure 1. CPREzy feedback device

- **Device**

The CPREzy device is a re-usable device designed to assist in cardiopulmonary resuscitation [18]. The case of the device is made of plastic and has a dimension of 55x180x50 mm with a weight of 260g. The device is powered by a 9V battery. The device has a built-in metronome (100/min). The device shows the level of pressure generated by each compression of a chest. Device illuminates with each chest compression, providing continual chest compression quality feedback and guiding the amount of pressure applied by the rescuer throughout the resuscitation. Activation pressures for the lights are (±5kg) 'child' – 23kg, 'small adult' – 32 kg, 'average adult' – 41kg, 'large adult' – 50kg, and 'caution' – 54 kg (figure 1). At the same time, when the proper chest relaxation is obtained the lights are turned off.

- **Device training**

Prior the study, all participants received a 30-minute CPR feedback device training session. It consisted of a 10-minute computer-based training provided by the device manufacturer and a 20-minute instructor-led skills practice session applying and using the CPREazy device on a manikin. The theoretical training instructed participants how to apply and use the CPREzy device to manage a patient in cardiac arrest. After that all participants were allowed to practice using the CPREzy device at their own pace and ask the instructor questions about how to use the device properly.

- **Simulation**

During the study, the participants had to perform a 2-minute cardiopulmonary resuscitation cycle in two scenarios: chest compressions without feedback device (Scenario A), and with chest compressions supported by the CPREzy device (Scenario B).

Prior to performing chest compressions, the rescuer was tasked with swimming 25 meters of the pool and on the way back they had to tow the manikin, which simulated simulating the submerged patient (figure 2). The next step was to perform a 2-minute cycle of cardiopulmonary resuscitation at the edge of the pool. Both the order of the participants and the research methods were randomized with the comprehensive internet-based randomization software (randomize.net). A detailed randomization procedure is presented on figure 3.

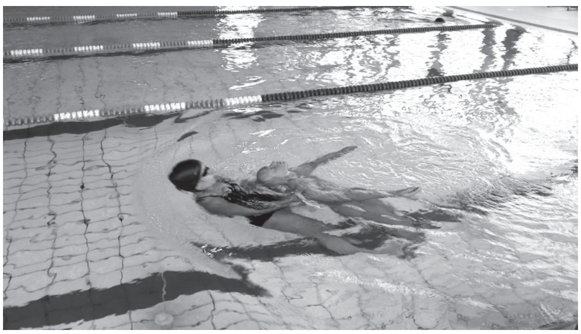

Figure 2. Lifeguard while towing a person

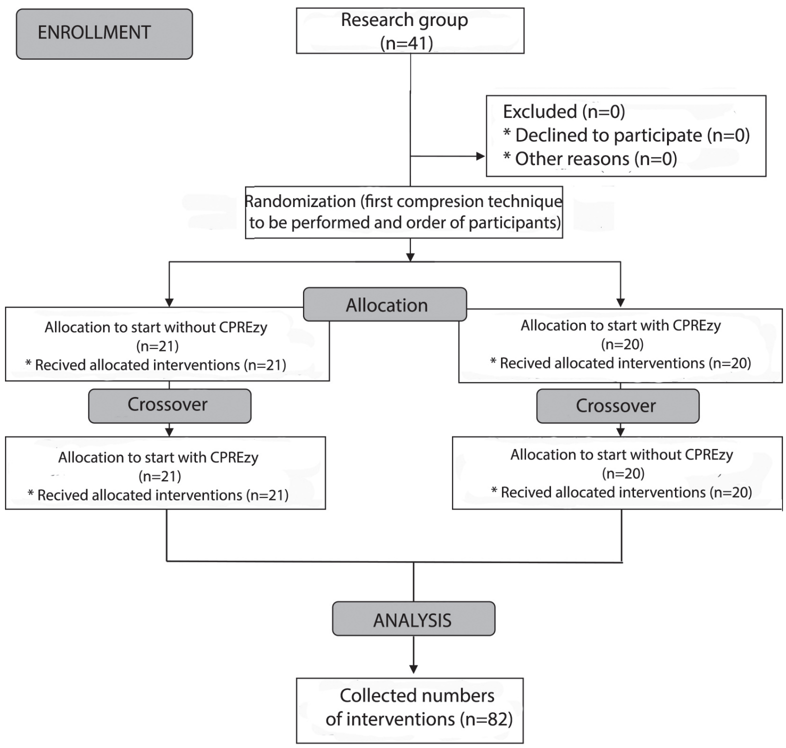

Figure 3. Study flow chart

- **Measurements of chest compressions**

Parameters which were evaluated during the test were measured with the use of the software included in the SimPad phantom (Laerdal, Stavanger, Norway).

The quality assessment parameters of chest compression consisted of the frequency of chest compressions per minute (CCPM), depth of compressions (mm), percentage of properly performed compressions (%) calculated as the proportion of chest compressions with appropriate depth among the total chest compressions during every 20-s CPR period. The appropriate depth was defined as 5–6 cm, and appropriate chest compression rate was defined as 100-120 compressions per minute, according to the American Heart Association cardiopulmonary resuscitation guidelines [5]. After the study was completed, participants were also asked about their preferences regarding the use of the CPREzy device during real-life resuscitation.

- **Statistical analysis**

Data were analyzed using the Statistica software version 12 (StatSoft, Tulusa, OK, USA). Values of P<0.05 were considered significant. Continuous and original data are presented as the median and interquartile range (IQR), and the categorical data ate presented as raw numbers and frequencies. Non-parametric tests were used because the data distribution was not normal based on Shapiro-Wilk and Kolmogorov-Smirnov tests. Participants did not receive feedback regarding their performance during the study period.

Results

41 lifeguards were included in the study (14 females; 34.1%) with a median age of 28.5 years [IQR; 25-31.5] and the median work experience on the swimming pool was 7.5 years [IQR; 3-8].

The frequency of chest compressions with the use of CPREzy device was 101[IQR; 98-103] *vs.* 107 [IQR; 102-111) for a non-assisted compressions (p = 0.43).

A detailed summary of the chest compressions parameters with and without CPREzy device is presented in table I.

The frequency of chest compressions in the analyzed scenarios was 107 [IQR; 102-111] CCPM during the non-assisted cardiopulmonary resuscitation *vs.*

Table I. Chest compression parameters

	Resuscitation without CPREzy	Resuscitation with CPREzy	p-value
Chest compression rate (min)	107 [102-111]	102 [99-102]	0.086
CC depth (mm)	50 [44-52]	45 [40-47]	0.003
No flow fraction (s)	21 [18-25]	28 [23-30]	0.009
Full release (%)	68%	87%	0.021
Effective compression rate (%)	85%	81%	0.364

102 [IQR; 99-102] CCPM with CPREzy device assist.

The depth of chest compressions with and without CPREzy use was different and it was 50 [IQR; 44-52] mm *vs.* 45 [IQR; 40-47] mm (without *vs.* with CPREzy, respectively). The difference in the depth of compressions in the case of CPREse and non-asisted resuscitation was statistically significant (P = 0.003; figure 4). 'No flow fraction' in the case of non-asisted resuscitation was 21 [IQR; 18-25] sec and was statistically significantly shorter than in the scenario with the CPREzy assist - 28 [IQR; 23-30] sec (P = 0.009).

Effective compression during resuscitation rate without CPREzy was 85% *vs.* 81% when resuscitation was performed with the CPREzy assist.

43.9% (18/41) of participants declared that they would use the CPREzy device in a real cardiac arrest situation.

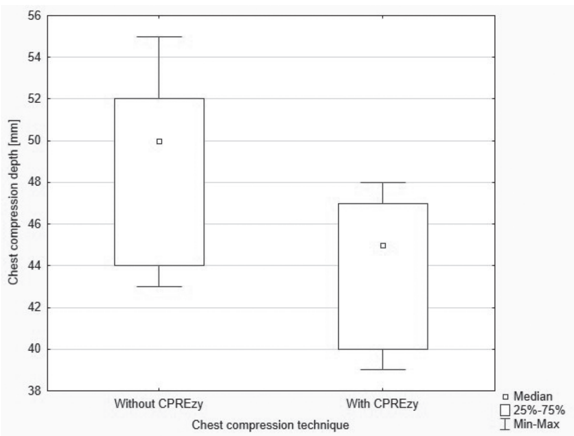

Figure 4. Median of chest compressions depth

Discussion

In this study we performed cardiopulmonary resuscitation with and without CPREzy device, which is a type of cardiopulmonary resuscitation feedback monitor. The study was conducted by experienced lifeguards who performed cardiopulmonary resuscitation based on the 2015 American Heart Association resuscitation algorithm [5]. The study analyzed chest compressions parameters only.

Both the depth and the frequency of chest compressions affect the survival of patients with cardiac arrest [19,20]. Numerous studies show that the use of both mechanical chest compressions or CPR feedback devices allows for the optimization of the frequency of chest compressions [21]. In the conducted study, the frequency of chest compressions during non-asisted resuscitation was 107 [[IQR; 102-111] chest compressions per minute and when using CPREzy it was 102 [IQR; 99-102] CCPM. Many CPR feedback devices have a built-in metronome that facilitates chest compressions in accordance with the recommendations of the AHA guidelines [22], or ERC [19]. Many studies suggest that medical personnel tend to compress the chest too quickly during cardiopulmonary resuscitation [23,24].

American Society of Cardiology guidelines recommend that during cardiopulmonary resuscitation the chest of an adult should be pressed to a depth of 5 to 6 cm. In the conducted study, lifeguards conducting manual compression of the chest achieved a 5 cm depth of compressions. When using the CPREzy system, the depth was 4.5 cm. The studies by Kurowski et al. [6] indicate that the depth of chest compressions can be different when utilizing various chest compression supporting deceives. In Kurowski's studies, the highest quality chest compressions were obtained with the use of TrueCPR device.

In a study comparing the effectiveness of chest compressions between the non-assisted method and the assist of the CPRMeter device, higher quality of chest compressions was obtained when using CPR meter [17]. Sutton et al. [25] indicated that the use of feedback device improves adult cardiopulmonary resuscitation quality and the rate of return of spontaneous circulation, which is also confirmed by Abella [26].

In the conducted study, the participants performed higher quality of chest compressions during manual chest compressions, however, the use of CPREzy was associated with better chest relaxation, which can be explained due to the feedback mechanism of CPREzy. When the full relaxation is reached, the lights on the device turn off. Other studies also indicate that the use of CPR feedback devices improve the full chest relaxation rate [6,27]. Due to the compressions at the appropriate depth and the full relaxation of the chest after each pressure, it is possible to create an appropriate pressure difference, allowing to maintain the blood flow both through the vital organs and coronary vessels.

Numerous studies indicate that the lifeguard's fatigue may affect the quality of cardiopulmonary resuscitation. The study was designed in such a way that before performing each cycle of cardiopulmonary resuscitation, lifeguards swam a total of 50 m, therefore fatigue component was included into the study. According to the study lifeguards despite previous physical exertion, were able to provide compressions with both the appropriate depth and frequency.

Study had several limitations. First, although we used an advanced cardiopulmonary resuscitation manikin, we did not exam real clinical resuscitation of patients, as the feeling of the chest compression and motivations vary to some extent when providing CPR to humans and simulators Another limitation is limiting the research group to the water rescuers, however when there is a cardiac arrest in the pool, they are the ones who have to pull the person out of the water and begin cardiopulmonary resuscitation before the emergency medical team arrives. In addition, the study did not assess the impact of sex, age and body weight on the quality of chest pains, because the studies of Ødegaard et al show that compression depth does not depend on rescuer gender, height, or weight [28]. In addition, the lifeguards participating in the study, due to the type of work they do, were athletic people.

Conclusion

In the conducted simulation study, lifeguards were able to provide the chest compressions with the appropriate depth and frequency without the need to use CPR feedback devices. The use of CPREzy was associated with better relaxation of the chest.

Conflict of interest
None

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