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Impact of a LUCAS 3 on chest compression quality during simulated cardiopulmonary resuscitation performed by lifeguards: a randomized crossover study

Wpływ zastosowania systemu LUCAS 3 na jakość uciśnięć klatki piersiowej podczas symulowanej resuscytacji krążeniowo-oddechowej wykonywanej przez ratowników wodnych: badanie randomizowane krzyżowe

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Keywords

cardiopulmonary resuscitation, drowning, chest compression, quality, lifeguard

Słowa kluczowe

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

Conflict of interest
Konflikt interesów

None
Brak konfliktu interesów

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Summary

Introduction. High quality chest compressions, which are one of the basic elements of resuscitation procedures, directly affect the chances of returning of spontaneous circulation. The American Society of Cardiology recommends that compressions should be performed with a frequency of 100 to 120 compressions per minute with a depth of 5-6 cm and allowing for the full chest relaxation after each compression.

Aim. The aim of the study was to compare the quality parameters of chest compressions performed during manual chest compressions and resuscitation performed with the use of the LUCAS 3 chest compression system.

Material and methods. We conducted randomized crossover study on manikin (Resusci Anne). Thirty-eight lifeguards participated in an out-of-hospital simulation of cardiac mechanism caused by drowning during which lifeguards performed 2-min cycle of cardiopulmonary resuscitation.

Results. The median depth of chest compressions for manual chest compression was 46 mm (IQR: 42-50) and was statistically significantly lower than when using the mechanical compression system LUCAS 3 – 50 mm (IQR: 49-51). Compression rate with and without mechanical chest compression LUCAS 3 varied and was at 127 (IQR: 120-135) vs. 100 (IQR: 99-101) compressions per minute, respectively. When using the LUCAS 3 chest compression system, we achieved a 0% (IQR: 0-1) of incomplete chest relaxation vs. 48% (IQR: 34-65) when performing manual chest compressions.

Conclusions. The use of the LUCAS 3 chest compression system significantly increased the quality of chest compressions compared to the manual compression of the chest performed by lifeguards.

Streszczenie

Wstęp. Wysokiej jakości uciski klatki piersiowej stanowią jeden z kluczowych elementów resuscytacji krążeniowo-oddechowej, bezpośrednio wpływających na szanse powrotu spontanicznego krążenia. Wytyczne Amerykańskiego Towarzystwa Kardiologicznego zalecają, aby uciski klatki piersiowej były prowadzone z częstością 100-120 uciśnięć na minutę, przy głębokości uciśnięć od 5 do 6 cm oraz przy zachowaniu pełnej relaksacji klatki piersiowej po każdym jej uciśnięciu.

Cel pracy. Celem badania było porównanie jakości parametrów uciskania klatki piersiowej wykonywanych w sposób bezprzyrządowy przez ratowników wodnych oraz wykonywanych z wykorzystaniem mechanicznego systemu kompresji klatki piersiowej LUCAS 3.

Materiał i metody. Przeprowadziliśmy randomizowane krzyżowe badanie z wykorzystaniem symulatora człowieka (Resusci Anne). Trzydziestu ośmiu ratowników wodnych wykonywało dwuminutowe cykle resuscytacji krążeniowo-oddechowej podczas scenariusza pozaszpitalnego zatrzymania krążenia w wyniku podtopienia.

Wyniki. Mediana głębokości uciśnięć klatki piersiowej podczas bezprzyrządowego uciskania klatki piersiowej wynosiła 46 mm (IQR: 42-50) i była statystycznie istotnie niższa niż w przypadku zastosowania systemu LUCAS 3 – 50 mm (IQR: 49-51).

Częstotliwość ucisków klatki piersiowej z wykorzystaniem systemu LUCAS 3 oraz w sposób bezprzyrządowy wynosiła odpowiednio 127 (IQR: 120-135) vs. 100 (IQR: 99-101) uciśnięć na minutę. W przypadku zastosowania systemu LUCAS 3 stopień niepoprawnej relaksacji klatki piersiowej został osiągnięty na poziomie 0% (IQR: 0-1), zaś w przypadku bezprzyrządowego uciskania klatki piersiowej wynosił on 48% (IQR: 34-65).

Wnioski. Zastosowanie systemu kompresji klatki piersiowej LUCAS 3 istotnie statystycznie podniosło jakość ucisków klatki piersiowej w porównaniu z bezprzyrządowym uciskaniem klatki piersiowej wykonywanym przez ratowników wodnych.

INTRODUCTION

The ability to perform cardiopulmonary resuscitation is one of basic procedures which lifeguards should be able to perform. Drowning is a major cause of morbidity and mortality worldwide, predominately affecting low- and middle-income countries (LMICs). According to the World Health Organization (WHO), drowning accounted for an estimated 372,000 deaths in 2012 (1). Patients in age from 1 to 18 years (2) are especially susceptible with over 450 children drowning each day worldwide and thousands suffering debilitating injuries, including brain injury, as a result of drowning events. In high-income countries (HICs), drowning risk factors include male gender, less than 14 years of age (3, 4), risky behavior including alcohol use (3, 5), rural areas (6), low income (7), and lack of supervision (3).

However, regardless of the cause of cardiac arrest, lifeguards should perform high quality cardiopulmonary resuscitation. According to the current guidelines for cardiopulmonary resuscitation (CPR) published in 2015 by the European Resuscitation Council (8, 9), CPR should be based on high-quality chest compressions and rescue breaths. The guidelines recommend that for adults chest compressions are performed with a frequency of chest compressions (CCPM) of 100-120 compressions. The depth of compressions should be of least 5 cm, and allow for the full relaxation of the chest after each pressure. An additional aspect of cardiopulmonary resuscitation is performing rescue breaths, which should be of volume of 6-7 mL/kg.

However, according to the studies, many people do not achieve a proper depth when compressing chest and also perform the compressions at too high. The quality of chest compressions is influenced by many factors including the physical condition of lifeguards. The search for solutions that may improve the quality of chest compressions is one of the main directions of research in emergency medicine.

AIM

The aim of the study was to compare the quality parameters of chest compressions performed during manual chest compressions and resuscitation performed using the LUCAS 3 chest compression system.

MATERIAL AND METHODS

Design

This was a prospective randomized crossover simulation study where each participant performed chest compression with and without LUCAS 3 device. The study is a continuation of the research cycle undertaken by the authors to determine the most optimal method of chest compressions by lifeguards (10).

Setting

Study was conducted from May 2017 to December 2017. The study protocol was approved by the Institutional Review Board of the International Institute of Rescue Research and Education (Approval no. 32.12.2017.IRB).

Participants

The participation in the study was voluntary. 38 lifeguards with a professional experience over 2 years were included. The only exclusion criterion for this study was having a degree in a medical field (i.e. paramedic studies).

Training

Prior to the study, all participants took part in a study regarding elements of basic life support, which also included the operating of the mechanical chest compression device LUCAS 3 (fig. 1). LUCAS 3 is an electric-powered mechanical chest compression device. LUCAS 3 was designed to work in two modes: 30 chest compressions to 2 rescue breaths, or constant compressions at a consistent rate and depth (11, 12). After theoretical part and demonstration of the correct way of using the device, the participants had a 20-minute practical training regarding the usage of the device.

Study protocol

During the main study, the participants were performing a 2-minute cardiopulmonary resuscitation cycle with and without the usage of LUCAS 3. In order to simulate the patient in cardiac arrest requiring cardiopulmonary resuscitation we used Resusci Anne Simulator (Laerdal, Stavanger, Norway).

Fig. 1. LUCAS 3 mechanical chest compression device

The participants were divided into two groups. In order to assign the patients to the aforementioned groups we used the coin throw technique. The first group performed cardiopulmonary resuscitation without using a chest compression system. The second group performed resuscitation using the LUCAS 3 chest compression system. The participants then had a 30-minute break and then performed cardiopulmonary resuscitation using a different technique. A detailed randomization procedure is presented on figure 2. Compressions of the chest were performed continuously, in order to make it possible a supraglottic airway device was used as it allows for asynchronous resuscitation (13).

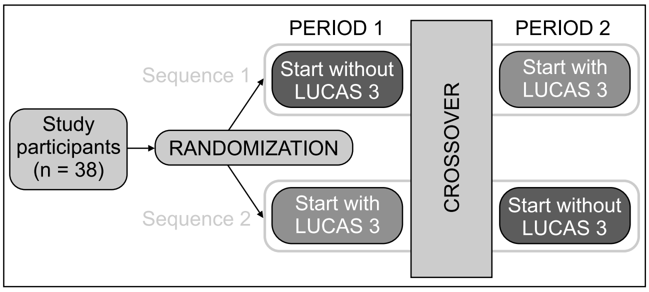

Fig. 2. CONSORT flow chart

Measurements

All parameters regarding the quality of chest compressions were measured with SimPad PLUS which was attached to the simulator and allows for both recording of resuscitation parameters and also allows for controlling the simulator. The parameters of chest compression effectiveness (compression depth, compression rate, incomplete chest relaxation rate, inappropriate hand position on the chest surface) were monitored with software compatible with the training manikin. Following the CPR effort, the participants were asked to rate the usefulness of chest compression device LUCAS 3 on a scale ranging from 1 (definitely useless) to 5 (definitely useful).

Statistical analysis

All of statistical analysis were performed with the Statistical Package Statistica ver. 12 (StatSoft, Tulusa, OK, USA). Each variable was evaluated for normality using Kolmogorov-Smirnov and Shapiro-Wilk normality tests. Analysis of variance (ANOVA) post hoc tests with the Bonferroni corrections for metric data were used for univariate analysis to compare the three study groups. The Kruskal-Wallis test was used to compare non-normally distributed data. Results were considered significant at $p < 0.05$.

RESULTS

The study group included 38 lifeguards (15 female; 41.7%) with a mean age of 25.5 ± 3.5 years, mean body weight of 63.2 ± 9.5 kg, and mean height of 172 ± 12.5 cm.

The chest compressions data from the mechanical chest compression device LUCAS 3 and manual chest compressions are presented in table 1. The median depth of chest compressions for manual chest compression was 46 mm (IQR: 42-50) and was statistically significantly lower than when using the mechanical compression system LUCAS 3 – 50 mm (IQR: 49-51) (p = .002; fig. 3).

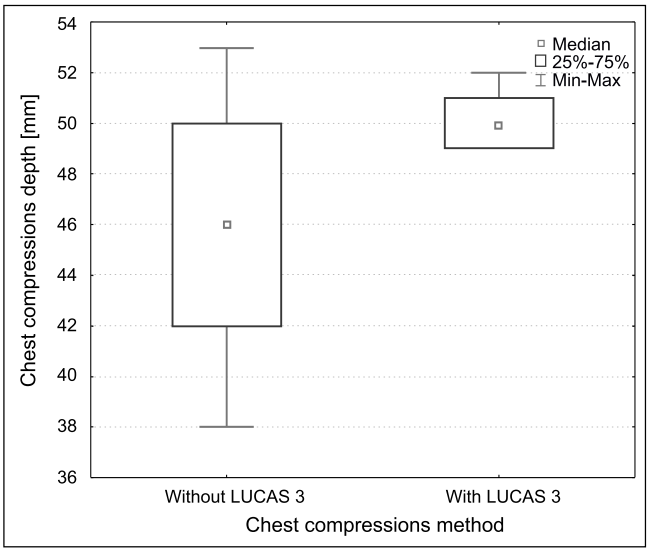

Fig. 3. The median depth of chest compressions

Compression rate with and without mechanical chest compression LUCAS 3 varied and was at 127 (IQR: 120-135) vs. 100 (IQR: 99-101) compressions per minute, respectively.

When using the LUCAS 3 chest compression system, we achieved a 0% (IQR: 0-1) of incomplete chest relaxation vs. 48% (IQR: 34-65) ($p < .001$) when performing manual chest compressions.

The participants evaluated the usefulness of the chest compression system during cardiopulmonary resuscitation at 1 point (IQR: 1-1.5).

DISCUSSION

Many factors influence the effectiveness of cardiopulmonary resuscitation with the quality of chest com-

Tab. 1. Comparison of the chest compression data between the LUCAS 3 device and manual compression technique

Parameter	Manual chest compressions	LUCAS 3 device	p-Value
Compression depth (mm)	46 (42-50)	50 (49-51)	0.002
Too deep compression (> 60 mm) (%)	0 (0-0)	0 (0-0)	NS
Too shallow compression (< 50 mm) (%)	75 (67-89)	3 (2-5)	< 0.001
Compression rate (/min)	127 (120-135)	100 (99-101)	< .001
Incomplete chest relaxation (%)	48 (34-65)	0 (0-1)	< .001

NS – not statistical significant

pressions being among the most important cited by the most important scientific societies (AHA and ERC). According to the aforementioned guidelines, minimization of breaks during the chest compressions as well as performing the chest compressions in accordance with the guidelines are the main factors determining the quality of resuscitation.

In this study, the depth of chest compressions performed without the LUCAS 3 device was statistically significantly lower when the LUCAS 3 chest compression system was utilized. Current CPR guidelines do not recommend to use the chest compressions devices by medical personnel routinely, however, when transporting the patient or to achieve the high quality chest compressions, they allow for the utilization of those devices. Lifeguards due to the nature of their work and due to the exposure to the effort caused by extracting the patient from the water are vulnerable to fatigue (14). Many studies indicate that physical exercise as well as fatigue caused by prolonged cardiopulmonary resuscitation may negatively affect the quality of chest compressions (15-17).

Therefore, it is desired that the chest compression systems are used by lifeguards. Numerous studies comparing the quality of chest compressions with and without mechanical chest compression systems indicate that utilizing the chest compression systems allows for providing higher quality chest compressions.

Another factor determining the quality of chest compressions is the frequency of compressions (18). In this study, the median frequency of chest compressions performed with the standard manual method was 127CPM. This value exceeds the values recommended by the guidelines of both the American Society of Cardiology and the European Resuscitation Council. The frequency of chest compressions in each age group recommended by the aforementioned guidelines should be 100-120 compressions per minute. However, there is no consensus regarding the optimal frequency of chest compressions. Kilgannon et al. (19) conducted a prospective observational study at a single academic medical center indicated that the best compression rate of 121-140 compressions/min, which had the highest odds ratio of return of spontaneous circulation. Moreover, Monsieurs showed an association between higher compression rates and lower compression depths. Avoiding excessive compression rates may lead to more compressions of sufficient depth (20). Whereas Zou et al. (21) indicate the most appropriate frequency of chest compressions to be at 120CPM.

According to Yannopoulos et al. (22), incomplete chest wall recoil during the decompression phase of CPR increases endotracheal pressure, impedes venous return and decreases mean arterial pressure, and coronary and cerebral perfusion pressures. Lee et al. (23) presents conflicting results regarding the quality of chest compression including chest compression depth and chest recoil by chest compression rate. In study by Lee Chest compression depth was proportional to chest compression rate, but there were significantly more incomplete chest recoils at the rate of over 120/min than at any other rates.

The study has some limitations. The main one is that the study was carried out in medical simulation environment, not during real-life resuscitation. However, as many studies indicate (24-27) it is the only way to conduct a randomized cross-over study. The second limitation is that the study assessed only a chest compression quality, however the lifeguards may use the supraglottic airway devices, which allow for uninterrupted chest compressions while the patient is ventilated. The last limitation is that only lifeguards were included in the study, however in the case of sudden cardiac arrest caused in the mechanism of drowning or in any other mechanism they are responsible for providing the cardiopulmonary resuscitation until the ambulance arrives. The study also has strengths. The undoubted advantage of the study is the use of the most advanced LUCAS 3 chest compression system and that the study was designed as a randomized cross-over study.

CONCLUSIONS

In the conducted simulation study, the usage of LUCAS 3 chest compression system significantly improved the quality of chest compressions, when compared with the manual compressions of the chest performed by lifeguards. Further studies are necessary to confirm those findings.

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