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The impact of the use of a footrest on the quality of chest compressions. A prospective, randomized, cross-sectional study

Wpływ zastosowania podnóżka na jakość uciskania klatki piersiowej. Badanie prospektywne, randomizowane, krzyżowe

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Keywords

cardiopulmonary resuscitation, chest compressions, quality, footrest, doctor

Słowa kluczowe

resuscytacja krążeniowo-oddechowa, uciśnięcia klatki piersiowej, jakość, podnóżek, lekarz

Conflict of interest
Konflikt interesów

None
Brak konfliktu interesów

Summary

Introduction. Conducting high-quality chest compressions is a key element of cardiopulmonary resuscitation that translates directly into the return of spontaneous circulation.

Aim. The aim of the study was to evaluate the impact of the use of the footrest on the quality of chest compressions during simulated cardiopulmonary resuscitation of a patient on a hospital bed.

Material and methods. The study was designed as a prospective, randomized, cross-sectional, simulated study in which 55 doctors participated. The participants of the study were tasked with performing two-minute cardiopulmonary resuscitation based on continuous compressions of the chest. Participants of the study performed chest compressions in two scenarios; with and without using a footrest. The study protocol was accepted by the Institutional Review Board of the Polish Society of Disaster Medicine (Approval No. 21.0.2018.IRB).

Results. The frequency of chest compressions for standard CPR without using the footrest was 128 (IQR: 122-137) CPM and with using the footrest, 126 (IQR: 122-139) CPM. The median depth of chest compressions with and without the footrest varied and was 48 mm (IQR: 43-48) and 43 mm (IQR: 37-46), respectively. The correctness of chest relaxation in the case of with and without a footstool showed statistically significant differences ($P < 0.001$) and was 52% (IQR: 31-55) when using the footrest, and 30.5% (IQR: 26-35) when performing chest compressions without using the footrest. Correct positioning of the hands on the chest during chest compressions in the scenario without the footrest was 72% (IQR: 68-83), and 89% (IQR: 73-95, $P = 0.015$) when using the footrest.

Conclusions. The use of a footstool in a statistically significant way increases the quality of chest compressions in relation to the depth of compressions of the chest, the degree of correctness of chest relaxation and the correctness of hand positioning on the chest.

Streszczenie

Wstęp. Prowadzenie wysokiej jakości uciśnięć klatki piersiowej stanowi kluczowy element resuscytacji krążeniowo-oddechowej, przekładający się bezpośrednio na powrót spontanicznego krążenia.

Cel pracy. Celem pracy była ocena wpływu zastosowania podnóżka na jakość uciśnięć klatki piersiowej podczas symulowanej resuscytacji krążeniowo-oddechowej pacjenta na łóżku szpitalnym.

Materiał i metody. Badanie zostało zaprojektowane jako prospektywne, randomizowane, krzyżowe badanie symulacyjne, w którym udział wzięło 55 lekarzy. Uczestnicy badania mieli za zadanie wykonywanie 2-minutowej resuscytacji krążeniowo-oddechowej w oparciu o ciągłe uciśnięcia klatki piersiowej. Lekarze wykonywali uciśnięcia klatki piersiowej w dwóch scenariuszach: z podnóżkiem i bez stosowania podnóżka. Protokół badania został zaakceptowany przez Radę Programową Polskiego Towarzystwa Medycyny Katastrof (zgoda: 21.0.2018.IRB).

Wyniki. Częstotliwość uciśnięć klatki piersiowej w przypadku standardowej resuscytacji bez zastosowania podnóżka wynosiła 128 (IQR: 122-137) CPM, zaś w przypadku

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zastosowania podnóżka – 126 (IQR: 122-139) CPM. Mediana głębokości uciśnięć klatki piersiowej z podnóżkiem oraz bez podnóżka była zróżnicowana i wynosiła odpowiednio 48 mm (IQR: 43-48) vs. 43 mm (IQR: 37-46). Poprawność relaksacji klatki piersiowej w przypadku scenariusza z podnóżkiem i bez niego wykazywała istotnie statystyczne różnice ($P < 0,001$) i wynosiła odpowiednio 52% (IQR: 31-55) w przypadku zastosowania podnóżka oraz 30,5% (IQR: 26-35) podczas prowadzenia uciśnięć klatki piersiowej bez wykorzystania podnóżka. Poprawność ułożenia rąk na klace piersiowej podczas wykonywania uciśnięć klatki piersiowej w scenariuszu bez podnóżka wynosiła 72% (IQR: 68-83), zaś w scenariuszu z zastosowaniem podnóżka – 89% (IQR: 73-95; $P = 0,015$).

Wnioski. Zastosowanie podnóżka w statystycznie istotny sposób podnosi jakość uciśnięć klatki piersiowej w odniesieniu do głębokości uciśnięć klatki piersiowej, stopnia poprawności relaksacji klatki piersiowej oraz poprawności ułożenia rąk na klatce piersiowej.

INTRODUCTION

Sudden cardiac arrest constitutes as one of the major causes of mortality and morbidity worldwide. Atwood's research indicates that the prevalence of out-of-hospital cardiac arrest in Europe is 275,000 cases per year (1). The survival rate of cardiac arrest is small, as indicated in studies by Nakanishi et al. (2), and Lindner et al. (3) the average survival rate for discharging people from non-hospital cardiac arrest is from 3 to 25%. In the case of in-hospital cardiac arrest, Girotra et al. (4), as well as Andréasson et al. (5), indicate a survival rate of 20-40% with discharge from the hospital.

The history of cardiopulmonary resuscitation dates back to the middle of the 20th century, when mouth-to-mouth resuscitation was described by Dr. Peter Safar from the University of Pittsburgh in 1950's, and when chest compressions were described at Johns Hopkins. Those methods were combined into the description of Cardiopulmonary Resuscitation in 1960 (6, 7). Currently, thanks to medical development, we have much more knowledge and guidelines for the management of cardiac arrest which are issued by the European Resuscitation Council (ERC) as well as the American Heart Association (AHA) every five years (8-11). The current guidelines for CPR were published in 2015. They indicate the rules of conducting cardiopulmonary resuscitation for both adult patients, children and newborns. However, it should be noted that numerous clinical and simulation studies indicate insufficient quality of chest compressions performed both by medical personnel (12-14), as well as casual witnesses of the event (15).

AIM

The aim of the study was to evaluate the impact of the use of a footrest on the quality of chest compressions during simulated cardiopulmonary resuscitation of a patient on a hospital bed.

MATERIAL AND METHODS

The study was designed as a prospective, randomized, cross-sectional, observational study. After the approval of the examination protocol by the Institutional Review Board of the Polish Society of Disaster Medicine (Approval No. 21.0.2018.IRB), the study was conducted based on medical simulation in the period from January to March 2018. After informing the study participants about the research goals, 56 doctors were recruited who had previously received training in basic resuscitation. Criteria of inclusion in the study contained parameters as such: a professionally active physician; clinical experience in the field of cardiopulmonary resuscitation. Exclusion criteria included pain in the wrist, back pain, pregnancy, and refusal to participate in the study. Voluntary written informed consent was taken from each participant.

In order to simulate a patient requiring cardiopulmonary resuscitation, an adult simulator, Resusci Anne Simulator (Laerdal, Stavanger, Norway), was used. The patient was placed on the Prodigy 3 hospital bed (Famed, Zywiec, Poland) set in resuscitation mode. In order to exclude the impact of breathing on the quality of cardiopulmonary resuscitation, the simulator was previously intubated and connected to the ventilator to allow for asynchronous resuscitation. The participants of the study were tasked with performing a two-minute cardiopulmonary resuscitation cycle with and without a footrest. For this purpose, a 25-cm tall footrest was selected, which was placed next to the hospital bed during cardiopulmonary resuscitation. Both the order of the participants and the methods of chest compressions were randomized. For this purpose, the Research Randomizer program (randomizer.org) was used. The subjects were divided into two groups. The first

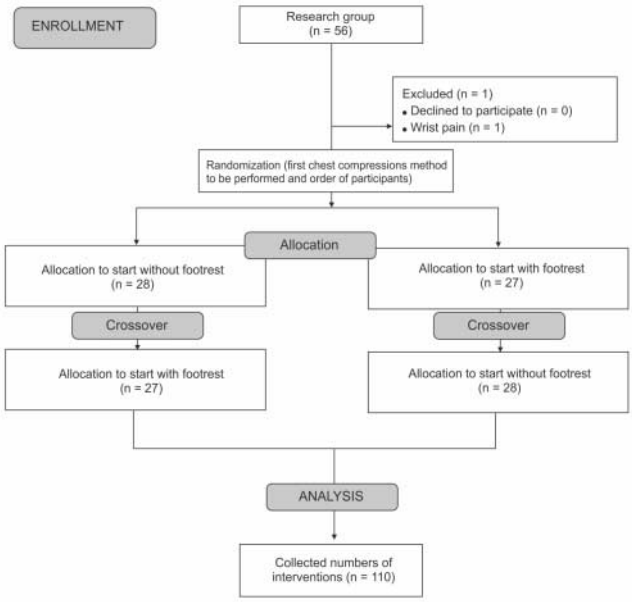

Fig. 1. Randomization flow chart

group began to perform continuous chest compressions without a footstool, and the second group with the use of a footstool. After the two-minute cycle, the participants had a 20-minute break and then performed compressions using a different method. A detailed randomization procedure for the study is shown on figure 1.

The study analyzed the quality parameters of chest compressions indicated by the software controlling the simulator. For this purpose, the following parameters were used: depth of chest compressions, frequency of chest compressions, degree of complete chest relaxation and proper positioning of hands during compressions. In addition, after completing the study, the participants filled out a questionnaire assessing the level of fatigue depending on the method of chest compressions. For this purpose, a 100-point scale was used ("1" – no fatigue, "100" – extreme fatigue).

All statistical analysis was performed using the statistical package, STATISTICA 13.0 EN (StatSoft, Tulusa, OK, USA). The results were presented as the median and the quarter interval (IQR), either as a number or percentage (%). The occurrence of normal distribution was confirmed by the Kolomogorov-Smirnov test. When the data was not characterized by normal distribution, non-parametric tests were used. Results were considered statistically significant at $p < 0.05$.

RESULTS

Participants

Initially, 55 people were included in the study. One person did not complete the study due to pain in the wrist. Ultimately, 55 doctors took part in the study. The median age of participants was 32.4 years (IQR: 28-40.5) and median work experience was 6.5 years (IQR: 5-11.5). All participants of the study had previously declared clinical experience in the field of cardiopulmonary resuscitation.

Chest compression parameters

A detailed summary of the data on the quality of chest compressions is shown on figure 2 a-d and in table 1.

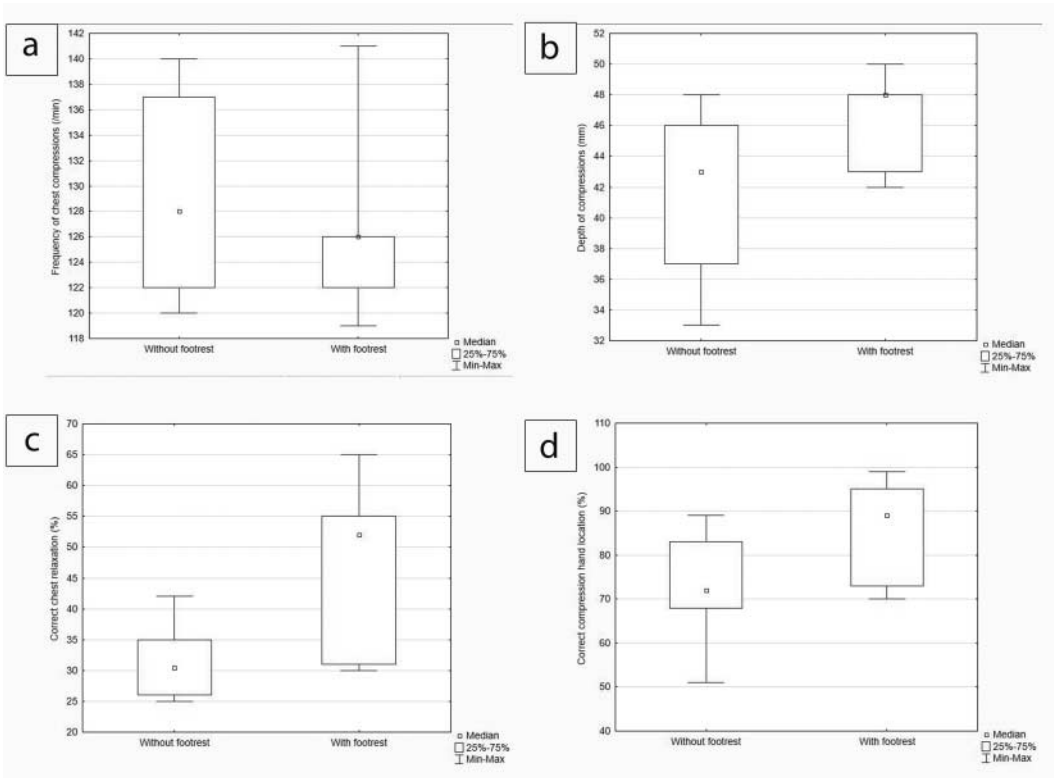

Fig. 2a-d. Parameters of chest compressions with and without footrest: (a) frequency of chest compressions; (b) depth of chest compressions; (c) degree of full chest relaxation; (d) proper positioning of hands on the chest

Tab. 1. Results of quality of chest compressions

Parameter	Compression of chest without a footrest (n = 55)	Compression of chest with a footrest (n = 55)	P value
Frequency of chest compressions (/min)	128 (IQR: 122-137)	126 (IQR: 122-139)	p = 0.712
Depth of compressions (mm)	43 (IQR: 37-46)	48 (IQR: 43-48)	p = 0.001
Correct chest relaxation (%)	30.5 (IQR: 26-35)	52 (IQR: 31-55)	p < 0.001
Correct compression location (%)	72 (IQR: 68-83)	89 (IQR: 73-95)	p = 0.015

The frequency of chest compressions for standard CPR without using the footrest was 128 (IQR: 122-137) CPM, and if the footrest was used, 126 (IQR: 122-139) CPM. The difference obtained in the frequency of chest compressions was not statistically significant ($p = 0.712$; fig. 2a).

The median depth of chest compressions with and without the footrest varied, resulting in 48 mm (IQR: 43-48) and 43 mm (IQR: 37-46), respectively. The use of the footrest statistically significantly increased the depth of chest compressions ($p = 0.001$; fig. 2b).

The correctness of chest relaxation when using and without using a footstool showed statistically significant differences ($p < 0.001$) resulting in 52% (IQR: 31-55) when using the footrest and 30.5% (IQR: 26-35) when performing chest compressions without using the footrest (fig. 2c).

Correct positioning of the hands on the chest during chest compressions in the scenario without the footrest was 72% (IQR: 68-83), while in the scenario using the footrest was 89% (IQR: 73-95, $p = 0.015$; fig. 2d).

When analyzing the subjective fatigue of participants in the study, the participants assessed their fatigue with 21 points (IQR: 19-33) when performing chest compressions without a footrest and 54 points (IQR: 35-59, $p < 0.001$) when performing chest compressions using a footrest.

DISCUSSION

In the conducted simulation study, we assessed the impact of the use of the footrest on the quality of resuscitation carried out by doctors. From our knowledge, it was the first study of this kind in the world. The obtained results allow us to conclude that the use of the footrest is associated with a higher quality of chest compressions on the patient lying on the hospital bed, as well as allowing a better position over the patient for the most efficient chest compressions.

Thanks to the development of medicine and technical progress, we are now able to determine which optimal parameters should characterize the performance of chest compressions. Current guidelines for resuscitation (8-11) indicate several important parameters such as the frequency of chest compressions, depth of chest compressions, degree of chest relaxation, correctness of the position of the hands on the chest and the last but equally important issue of minimizing breaks in the chest compressions.

In the conducted study, the frequency of chest compressions with and without the footrest was 126 (IQR: 122-139) and 128 (IQR: 122-137) CPM, respectively. This value is higher than recommended by the current guidelines for cardiopulmonary resuscitation. Among researchers, there is currently no explicitly defined frequency of chest compressions. In turn, Zou et al. (16) indicate an upper limit of chest compressions of 120 CPM. Research shows that faster chest compressions improve organ perfusion, but do not affect patients' survival. In addition, people performing chest compressions with a frequency above 120 CPM are much more quickly fatigued, which translates into a progressive deterioration in the quality of subsequent chest compressions. It is worth emphasizing the results obtained by Lee et al. (17), who in his study, showed that the average frequency of chest compressions was 110.2 ± 10.2/min with compressions at a depth of 49.0 ± 8.2 mm, and significantly deeper chest compression depths were noted at rates over 120/min than those at any other rates. On the contrary, Bae et al. (18), who has been analyzing different frequencies of chest compressions (100 vs. 120 vs. 140 CPM), showed that the chest was pressed to the deepest depth when using chest compressions at 100 CPM.

Another parameter of chest compressions indicated by guidelines for resuscitation (8-11) is the depth of chest compressions. In the study, the median depth of chest compressions using the footrest was 48 and 43 mm when not using the footrest. Guidelines for adults recommend that the depth of compression is between 5 and 6 cm. Out-of-hospital cardiac arrest patients demonstrated that increased cardiopulmonary resuscitation compression depth is strongly associated with better survival. Stiell et al. (19) also found a strong association between survival outcomes and increased compression depth but no clear evidence to support or refute the 2010 recommendations of > 50 mm. In turn, Vadeboncoeur et al. (20) indicated that deeper chest compressions were associated with improved survival and functional outcome following OHCA, moreover their results suggest that adhering to the 2010 AHA Guideline-recommended depth of at least 51 mm could improve outcomes for victims of OHCA.

The study was based on a continuous chest compressions scenario. In the case of proper protection of airways and ventilation, the method allows to minimize breaks in compressing the chest, thus increasing the chances of spontaneous circulation return. Zhan et al. (21) found that bystander-administered chest compression-only CPR, supported by telephone instruction, increases the proportion of people who survive to hospital discharge compared with conventional interrupted chest compression CPR plus rescue breathing. Similar observations are also shown by other authors (22, 23).

The simulation research we have carried out has limitations. The first of these was performing the test in the conditions of medical simulation, however, only such conditions allow conducting cross-randomized trials during cardiopulmonary resuscitation without any potential deterioration of the effectiveness of resuscitation (24-26). Another limitation is the research group itself, limited only to doctors, but it is them who relatively often face the necessity of undertaking resuscitation before the resuscitation team arrives. The study also has undoubted advantages, which include randomized character, cross-sectional study and standardized research procedures through the use of an adult simulator.

CONCLUSIONS

In the conducted simulation test, doctors using a footrest during cardiopulmonary resuscitation obtained a statistically significant improvement in the quality of chest compressions in relation to parameters such as depth of chest compressions, the degree of correctness of chest relaxation and proper positioning of the hands on the chest. The use of a footrest was also associated with less fatigue on a person performing chest compressions.

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