

CHEST COMPRESSION METHODS IN SIMULATED COVID-19 PATIENT RESUSCITATION: A RANDOMIZED CROSS-OVER SIMULATION TRIAL

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Background: High-quality chest compression is one of the key elements of resuscitation to return of spontaneous circulation. In the COVID-19 era, medical personnel should wear personal protective equipment (PPE) against aerosol generating procedures (AGP) during resuscitation. However, the use of this personal protection equipment may reduce the effectiveness of medical procedures performed.

Objective: We aimed to compare chest compression quality parameters between standard manual chest compression and chest compression with TrueCPR feedback device performed by medical students wearing full personal protective equipment against aerosol generating procedure.

Methods: The study was designed as a randomized, cross-over, single-blinded simulation study. Thirty-two medical students wearing PPE-AGP performed 2-min continuous chest compression on an adult simulator with and without TrueCPR feedback device.

Results: Median chest compression depth with and without TrueCPR feedback device varied and amounted to 46 (IQR; 42-53) vs. 41 (IQR; 36-45) mm (MCC vs. TrueCPR, respectively). The manual chest compression rate was 117 (IQR; 112-125) compressions per minute (CPM) and was higher than with TrueCPR feedback device - 107 (IQR; 102-115; $p = 0.017$). Full chest relaxation in the manual's chest compression technique (without TrueCPR) was 33 (IQR; 26-42)% and was lower than with chest compression with TrueCPR feedback device - 58 (IQR; 40-75)% ($p=0.002$).

Conclusions: We conclude that a TrueCPR feedback device improves chest compression quality during simulated COVID-19 resuscitation performed by medical students wearing PPE-AGP.

Keywords: chest compression; cardiopulmonary resuscitation; quality; feedback device; TrueCPR; personal protective equipment; COVID-19; SARS-CoV-2; medical simulation.

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Background

High-quality chest compressions are essential elements of out-of-hospital cardiac arrest (OHCA) and in-hospital cardiac arrest (IHCA). The guidelines for cardiopulmonary resuscitation by the European Resuscitation Council (ERC) and the American Heart Association (AHA) place great emphasis on high-quality chest compressions, thus showing the reference conditions against which there is the greatest chance of a return of spontaneous circulation (ROSC) [1,2].

The world now faces the new pandemic infectious disease COVID-19 induced by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-

CoV-2) [3] and asseverated to be transmitted from human-to-human by multiple means by droplets, aerosols, and fomites [4,5]. By October 5, 2020, nearly 35.54 million cases of SARS-CoV-2 infection were recorded, including nearly 1.04 million deaths and over 24.57 million recoveries.

The US Centers for Disease Control and Prevention (CDC) defines "aerosol-generating procedures" (AGPs) as procedures with the potential to generate infectious respiratory particles at higher concentrations than breathing, coughing, sneezing, or talking, or procedures that create uncontrolled respiratory secretions. In turns the World Health Organization (WHO) has recommended that when

dealing with patients whom are performing any AGP on a suspected COVID-19 positive patient must wear an N95 or FFP2 mask. There is also a recommendation that a medical mask, gown, gloves, and eye protection is sufficient [6]. In Polish conditions, the personnel of emergency medical teams, conducting resuscitation in patients with suspected / confirmed COVID-19, conducts cardiopulmonary resuscitation in full personal protective equipment (PPE) against aerosol generating procedures (AGP) suits, which is consistent with the suggestions Brown and Chan, where authors conclude that there are evidence for infection transmission during chest compressions and a precautionary approach with appropriate PPE is necessary to protect HCW from contracting a potentially fatal infection. [7].

Using PPE-AGP suits may affect the effectiveness of medical procedures by reducing their effectiveness and extending their duration. This applies to both the quality of chest compression [8,9], intravascular access [10,11] and instrumental airway management [12,13]. Regardless of the procedure should be sought alternative methods of influencing the actions taken to increase the effectiveness of medical devices by people dressed in the PPE-AGP.

Aim of the study

We aimed to compare chest compression quality parameters between standard manual chest compression and chest compression with TrueCPR feedback device performed by medical students wearing full personal protective equipment against aerosol generating procedure.

Methods

The study was designed as single-blinded, multicenter, prospective, randomized, crossover simulation trial. The Institutional Review Board of the Polish Society of Disaster Medicine approved the study protocol (Approval no. 23.01.20.IRB). Study was conducted in Warsaw, Poznan and Wroclaw in the period from January to February 2020. The study is a continuation of the research undertaken by the authors, aimed at evaluating various methods of cardiopulmonary resuscitation during the use of PPE-AGP [8,14].

Participants

Thirty-two medical students who completed advanced cardiovascular life support training took part in the study. Exclusion criteria were: 1) no consent to participation in study; 2) symptoms of an infectious disease; 3) asthma; 4) injuries that may affect the quality of performed chest compression (including injuries to the wrist, back). Voluntary written informed consent was obtained from each participant.

Simulation scenario

To simulate a patient with COVID-19 requiring CPR, an advanced SimMan 3G simulator (Laerdal, Stavanger, Norway) was used and placed on a flat surface in a well-lit room.

All study participants underwent training on how to put on and remove a full PPE-AGP suit. For this

purpose, Tychem F Level-C (DuPont, Wilmington, USA) suit, airway protection N95 respirator (3M Poland, Kajetany, Poland), face shield (3M Poland, Kajetany, Poland) including double nitrile gloves (MedaSEPT®, Poznan, Poland).

During the target study, participants performed a 2-minute cycle of continuous chest compression with and without TrueCPR feedback device (Figure 1).



Figure 1. – TrueCPR feedback device

Both the order of the participants and the methods of chest compression were random. For this purpose, the Research Randomizer program (randomizer.org) was used. We divided all participants using this program into two groups. The first group began chest compression with TrueCPR feedback device, while the second group started without TrueCPR device. After completing the 2-minute CPR cycle, participants had 20 minutes of rest and then performed chest compressions using a different method. We present a detailed randomization procedure on Figure 2.

Outcome measures

The chest compression quality parameters were recorded in real-time using the simulator control software - Laerdal Learning Application (LLEAP software, v.7.1.0; LaerdalInc, Stavanger, Norway). The study analyzed parameters such as the depth of chest compressions, the frequency of chest compressions, and the correctness of chest relaxation. We took the values recommended by the American Heart Association resuscitation guidelines as reference values [15]. After the study, we asked participants to define their preferences what method of chest compression they would use during real rescue operations.

Statistical analysis

Sample size calculations were performed based on a two-sided paired t-test assuming 80% power and a significance level of 0.05. Assumptions for expected results were based upon the work of Malysz et al. [14]. Those calculations indicated that a sample size of 32 participants would be required to power the trial adequately to detect a difference of 5 millimeters between the two modalities.

For the purposes of statistical analysis, the results of the study were blinded. The data were fed into

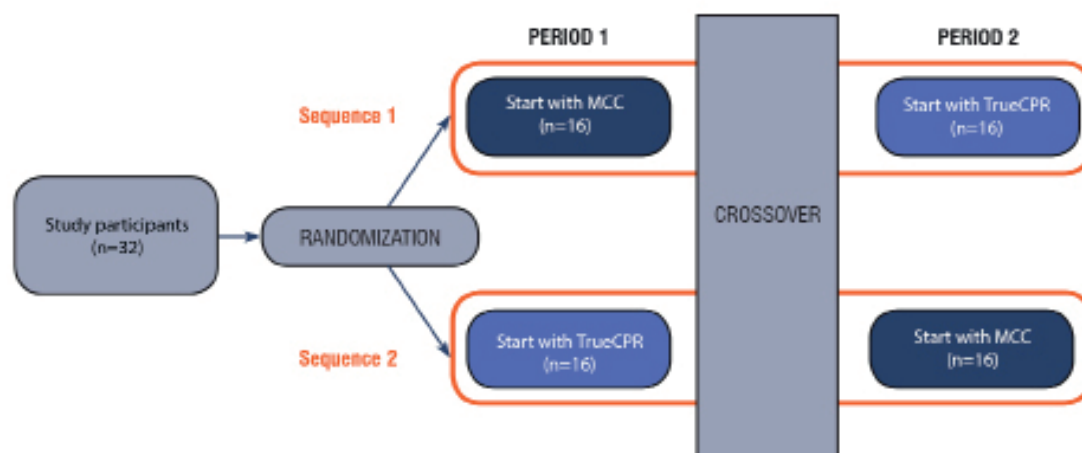


Figure 2. – Randomization flow chart

the computer having Statistica 13.3EN (TibcoInc, Tulsa, OK, USA). All statistical tests were two-sided. The occurrence of normal distribution was confirmed by the Kolmogorov-Smirnov test. We described variables using percentages for qualitative variables and using median with interquartile range for quantitative variables. The Friedman test was used for the intra-group analysis, and the Wilcoxon signed-rank test for the pairwise comparison. A P-value of <0.05 was considered statistically significant. Graphs were prepared with GraphPad Prism 6.0 (GraphPad Software, San Diego, CA) software.

Results

The study includes thirty-two medical students who had previously successfully completed the Advanced Cardiovascular Life Support course conducted by accredited American Heart Association instructors.

Median chest compression depth with and without TrueCPR feedback device varied and amounted to 46 (IQR; 42-53) vs. 41 (IQR; 36-45) mm (MCC vs. TrueCPR, respectively).

The manual chest compression rate was 117 (IQR; 112-125) compressions per minute (CPM) and was higher than with TrueCPR feedback device - 107 (IQR; 102-115; $p = 0.017$).

Full chest relaxation in the manual's chest compression technique (without TrueCPR) was 33 (IQR; 26-42)% and was lower than with chest compression with TrueCPR feedback device - 58 (IQR; 40-75)% ($p=0.002$).

90.6% of all participants showed TrueCPR as a method of chest compression that they would use in real cardiopulmonary resuscitation of a patient with COVID-19. 3 persons (9.4%) showed manual chest compression as the preferred method ($p < 0.001$).

Discussion

The objectives of our study were to evaluate the performance of chest compression with and without TrueCPR feedback device by medical students in PPE-AGP conditions. Our study shows that the chest compression with TrueCPR offer higher CC quality than manual chest compression (without TrueCPR).

High-quality chest compression is based on several important parameters, which include, among others, the depth of chest compression, the frequency of compressions or relaxation of the chest following compressions. According to the guidelines for CPR recommended by the American Heart Association, the depth of chest compression in an adult should be 5 to 6 cm, the compression rate should be higher than 100 CPM and no more than 120 CPM, and each chest compression should be full her relaxation [15].

Chest compression depth is strongly related to chest compression rate, and both are independently associated with survival [16]. Results got by Vadeboncoeur et al. suggest that adhering to the 2010 AHA Guideline-recommended depth of at least 51mm could improve outcomes for victims of OHCA [17]. Steill et al. found that maximum survival was in the depth interval of 40.3 to 55.3 mm (peak, 45.6 mm), suggesting that the 2010 American Heart Association cardiopulmonary resuscitation guideline target may be too high [18]. The depth of chest compressions in our study was lower than the depth recommended by the AHA guidelines and the European Resuscitation Council (ERC) guidelines. It is worth emphasizing, that the use of TrueCPR feedback device resulted in an increase in the depth of compressions compared to the group where CPR was conducted without CPR feedback device. Also, other studies where CPR was conducted without the use of PPE-AGP suits show that CPR feedback devices improve both the depth and frequency of chest compressions [19-22].

In our study, the rate of chest compressions during the study was within the limits recommended by the AHA. Although there is no consensus among researchers regarding the optimal rate of chest compression, Idris et al. indicated that compression rates between 100 and 120 per minute were associated with greatest survival to hospital discharge [23]. Duval et al. suggest that the combination of 107 compressions per minute and a depth of 47mm is associated with significantly improved outcomes for out-of-hospital cardiac arrest [24]. Study performed by Kilgannon et al. showed that chest compression rates above the recommended 100-

120 compressions/min may improve the chances of ROSC among IHCA patients [25].

Another important element influencing the quality of CPR is the correctness of chest relaxation after each compression. Full chest decompression affects higher cerebral blood flow [26, 27]. The conducted study showed a statistically significant improvement in the level of chest decompression with TrueCPR feedback device.

CPR feedback devices are becoming more and more appreciated in cardiopulmonary resuscitation. By showing the parameters of chest compression in real time, they improve the quality of compression. As indicated by the study by Katipoglu et al. observing real-time chest compression quality parameters during Basic Life Support training may improve the quality of chest compression one month after the training including correct hand positioning, compressions depth and rate compliance [28]. The study by Buléon et al. shows the use of CPR feedback devices, especially in the aspect of prolonged resuscitation [29].

The conducted study has limitations. Firstly, it was carried out in medical simulation conditions,

not in clinical conditions, however, because of the COVID-19 pandemic, performing tests under medical simulation conditions allows for safe performance of medical procedures and their full standardization [30,31]. The second limitation is the use of only TrueCPR feedback device in the study, however, it is the most advanced device of this type. The third limitation is the inclusion of only medical students in the study, however, such a choice was deliberate and was dictated that this group did not deal with CPR feedback devices, so an improvement in the quality of chest compression could be observed among people who have undergone only a short instructional training in CPR feedback devices.

Conclusions

We conclude that TrueCPR feedback device improves chest compression quality during simulated COVID-19 resuscitation performed by medical students wearing PPE-AGP.

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СПОСОБЫ КОМПРЕССИИ ГРУДНОЙ КЛЕТКИ ПРИ МОДЕЛИРОВАНИИ РЕАНИМАЦИИ ПАЦИЕНТОВ С COVID-19: РАНДОМИЗИРОВАННОЕ ПЕРЕКРЕСТНОЕ ИМИТАЦИОННОЕ ИССЛЕДОВАНИЕ

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Введение: Качественное сжатие грудной клетки - один из ключевых элементов реанимации для восстановления спонтанного кровообращения. В эпоху COVID-19 медицинский персонал должен носить средства индивидуальной защиты (СИЗ) от процедур, генерирующих аэрозоль (ПГА) во время реанимации. Однако использование этого средства индивидуальной защиты может снизить эффективность выполняемых медицинских процедур.

Цель: сравнить параметры качества компрессии грудной клетки между стандартной ручной компрессией грудной клетки и компрессией грудной клетки с устройством обратной связи TrueCPR, выполняемой студентами-медиками, носящими СИЗ от ПГА.

Методы: проведено рандомизированное перекрестное имитационное исследование с одинарным слепым методом. Тридцать два студента-медика в СИЗ против ПГА выполнили 2-минутное непрерывное сжатие грудной клетки на симуляторе для взрослых с устройством обратной связи TrueCPR и без него.

Результаты: Средняя глубина сжатия грудной клетки с устройством обратной связи TrueCPR и без него варьировала и составила 46 (IQR; 42-53) против 41 (IQR; 36-45) мм (ручное нажатие на грудную клетку против TrueCPR, соответственно). Частота сжатия грудной клетки вручную составляла 117 (IQR; 112-125) компрессий в минуту и была выше, чем с устройством обратной связи TrueCPR – 107 (IQR; 102-115; $p = 0,017$). Полное расслабление грудной клетки в методике сжатия грудной клетки, описанной в руководстве (без TrueCPR), составило 33 (IQR; 26-42)% и было ниже, чем при сжатии грудной клетки с устройством обратной связи TrueCPR - 58 (IQR; 40-75)% ($p = 0,002$).

Выводы: мы пришли к выводу, что устройство обратной связи TrueCPR улучшает качество компрессий грудной клетки во время имитации реанимации при COVID-19, выполняемой студентами-медиками, носящими СИЗ при ПГА.

Ключевые слова: компрессия грудной клетки; сердечно-легочная реанимация; качество; устройство обратной связи; TrueCPR; средства индивидуальной защиты; COVID-19; SARS-CoV-2; медицинская симуляция.

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Пособие к практическим занятиям по педиатрии включает блок теоретической информации и приложение. Разработано в соответствии с учебной программой для студентов медико-диагностического факультета и предназначено для самостоятельной подготовки студентов к практическим занятиям и экзаменам. Изложенный материал может быть использован также клиническими ординаторами, педиатрами и врачами общей практики при аттестации на рабочих местах и сдаче квалификационных экзаменов.

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