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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

The impact of the use of a CPRMeter monitor on quality of chest compressions: a prospective randomised trial, cross-simulation

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Abstract

Background: Drowning is a common issue at many pools and beaches, and in seas all over the world. Lifeguards often act as bystanders, and therefore adequate training in high-quality cardiopulmonary resuscitation (CPR) and use of adequate equipment by lifeguards is essential.

Aim: The aim of this study was to evaluate the impact of the recently introduced CPRMeter (Laerdal, Stavanger, Norway) on quality of CPR, if used by moderately experienced CPR providers. In particular, we tested the hypothesis that using the CPRMeter improves quality of chest compression by lifeguards compared to standard non-feedback CPR.

Methods: The study was designed as prospective, randomised, cross-over manikin trial. Fifty lifeguards of the Volunteer Water Rescue Service (WOPR), a Polish nationwide association specialised in water rescue, participated in this study. Participants were randomly assigned 1:1 to one of two groups: a feedback group and a non-feedback group. Participants swim a distance of 25 m in the pool, and then they were asked to haul a manikin for the second 25 m, simulating rescuing a drowning victim. Once participants finished the second 25-m distance, participants were asked to initiate 2-min basic life support according to the randomisation.

Results: The median quality of CPR score for the 2-min CPR session without feedback was 69 (33–77) compared to 84 (55–93) in the feedback group ($p < 0.001$). Compression score, mean depth, rate of adequate chest compressions/min, and overall mean rate during the CPR session improved significantly in the feedback group, compared to the non-feedback group.

Conclusions: Using the visual real-time feedback device significantly improved quality of CPR in our relatively unexperienced CPR providers. Better quality of bystander CPR is essential for clinical outcomes, and therefore feedback devices should be considered. Further clinical studies are needed to assess the effect of real-time visual devices, especially in bystander-CPR.

Key words: chest compression, cardiopulmonary resuscitation, quality, drowning, lifeguard

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INTRODUCTION

Sudden cardiac arrest is one of the leading causes of death in Europe, affecting about 350,000 up to 700,000 individuals a year [1]. High-quality cardiopulmonary resuscitation (CPR), including high-quality chest compression, defibrillation, access to advanced cardiac life support, and standardised post-arrest care, is indicated in these patients and significantly affects patients' outcome [1–5]. Early start of high-quality CPR by bystanders is of crucial importance because a higher rate of bystander-initiated CPR is associated with a 3.5-fold decrease in one-year mortality [6].

Drowning is a common issue at many pools and beaches, and in seas all over the world. Lifeguards often act as bystanders, and therefore adequate training in high-quality CPR and use of adequate equipment by lifeguards is essential. The recently proposed drowning chain of survival clearly indicates that stopping the drowning process and starting CPR as early as possible are the key elements for improving the patient's outcome [7].

Several CPR feedback devices have been introduced into the clinical practice during the last few years. These feedback devices provide visual and/or auditory feedback based on quantitative CPR metrics and have been reported to improve the quality of CPR [8, 9]. Furthermore, real-time feedback devices have been proven to improve CPR skill acquisition and retention, and enhance quality of chest compression, even if used by inexperienced providers [10–13]. Therefore, use of real-time feedback devices might be particularly advantageous, especially if used by low to moderately experienced CPR providers, including lifeguards.

The aim of this study was to evaluate the impact of the recently introduced CPRMeter (Laerdal, Stavanger, Norway; Fig. 1) on quality of CPR, if used by moderately experienced CPR providers. In particular, we tested the hypothesis that using the CPRMeter improves quality of chest compression by lifeguards compared to standard non-feedback CPR.

METHODS

This study was approved by the Institutional Review Board of the Polish Society of Disaster Medicine (approval No. 22.11.2016.IRB). Each lifeguard participating in this study received verbal and written information about the study and participated on a voluntary base. Written, informed consent was obtained from all participants.

Participants

Fifty lifeguards of the Volunteer Water Rescue Service (WOPR), a Polish nationwide association specialised in water rescue, participated in this study. All participants were active lifeguards, working in one of the waterparks in Wroclaw or Warsaw, Poland. All participants were trained in basic life support during the previous three years.

Figure 1. CPRMeter feedback device

Protocol

All participants underwent a standardised basic life support training, according to current CPR guidelines, within two months before the study [1]. During the study visit, participants underwent a standardised training programme. First, all participants followed a 10-min training video consisting of basic elements of basic life support and introducing the CPRMeter. Second, participants were able to practice CPR according to basic life support guidelines and using the CPRMeter real-time feedback system on a manikin (Resusci Anne manikin, Laerdal, Stavanger, Norway). Participants were supervised by skilled emergency physicians and were able to interact with the physicians whenever necessary.

Once participants felt familiar with the CPRMeter they were guided to another testing room. In this room, another manikin (Resusci Anne manikin, Laerdal, Stavanger, Norway) was placed on the floor. The manikin was already equipped with the CPRMeter, which was connected to a laptop with the software made available by the producer of the CPRMeter (Laerdal, Stavanger, Norway).

Participants were randomly assigned 1:1 to one of two groups:

- feedback group — basic life support according to current CPR guidelines. Participants were able to see the information on the screen and adapt the CPR according to this information;
- non-feedback group — basic life support according to current CPR guidelines. The screen of the CPRMeter was covered, and participants were not able to see the information displayed on the monitor.

Randomisation was performed by using the research randomiser programme (randomizer.org) (Fig. 2).

After randomisation, participants were asked to swim a distance of 25 m in the pool, twice. After finishing the first

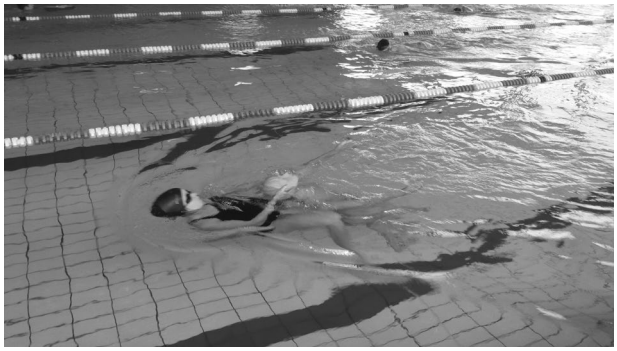

Figure 2. Randomisation flow chart

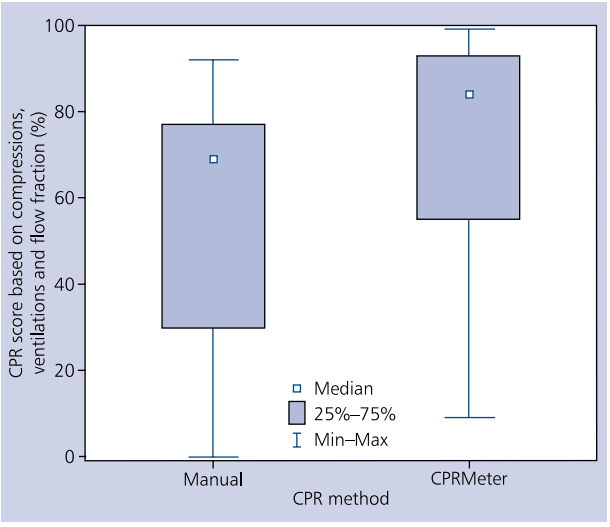

Figure 3. The median quality of cardiopulmonary resuscitation (CPR) score with and without feedback device

25 m, participants were asked to haul a manikin for the second 25 m, simulating rescuing a drowning victim. Once participants finished the second 25-m distance, they were asked to initiate basic life support according to the randomisation.

Chest compressions and mouth-to-mouth ventilation with a ratio of 30:2 was applied for an overall time of 2 min.

After finishing the first CPR setting, participants were allowed to rest for about 1 h. Afterwards participants were asked to repeat the study setting in the previously randomised sequence (group).

CPRMeter device

The CPRMeter is a recently introduced real-time feedback device. The CPRMeter characteristics and functionalities have been previously described [12]. Metrics automatically obtained by the device during the CPR session are displayed in real-time on the monitor. The monitor does not have any additional acoustic features or feedback functions. All obtained data are automatically stored and processed by the Laerdal PC Skillreporting System (Laerdal Medical AS, Stavanger, Norway).

Measurements

The primary outcome of the study was the quality of CPR score (QCPR). This score is calculated based on predefined target values by the manufacturer (Laerdal, Stavanger, Norway) and depends on current CPR guidelines.

Secondary outcomes included several chest compression parameters:

- compression score;
- ongoing chest compressions per minute during 2-min CPR session (%);
- mean no-flow time (seconds) [14–16];
- correct hand position, relative to total compressions (%);
- mean depth (mm);
- chest adequately released;
- adequate depth (49–61 mm) relative to total compressions (%);
- adequate rate per minute (100–120 min^{-1}) relative to total compressions (%);
- mean rate per minute during 2-min CPR session.

Statistical analysis

We calculated the necessery sample size with at least 50 participants using G*Power 3.1 (two-tailed t-test; Cohen's d: 0.8; alpha error: 0.5; power: 0.95).

For analyses, data were extracted from a Laerdal PC Skillreporting System and transferred into Excel XP (Microsoft, USA). Statistica (version 13.1EN; StatSoft, Tulsa, OK, USA) was used for all analysis. A two-sided p-value < 0.05 was considered statistically significant.

Data are presented as median and interquartile range (IQR); mean ± standard deviation (SD); or number and percentage (%). The occurrence of normal distribution was confirmed by the Kolmogorov-Smirnov test. T-test for paired observations was applied for data with normal distribution, and the Wilcoxon test for paired observations in the case of data with non-normal distribution.

RESULTS

Fifty lifeguards (six female, and 44 male) voluntarily participated in this study. The median age was 23 years (IQR 21–32), and median work experience was five years (IQR 1–11). All lifeguards participated in both CPR settings.

Primary outcome

The median QCPR score for the 2-min CPR session without feedback was 69 (30–77), compared to 84 (55–93) in the feedback group ($p = 0.001$; Fig. 3).

Secondary chest compression outcomes

Compression score, mean depth, rate of adequate chest compressions/min, and overall mean rate during the CPR session

Table 1. Chest compression parameters

	No-feedback group	Feedback group	p
Cardiopulmonary resuscitation score [%]	69 [30–77]	84 [55–93]	**< 0.001**
Chest compression score [%]	61 [17–89]	82 [43–97]	**0.005**
Ongoing chest compressions [%]	74 [65–83]	75 [67–83]	0.373
Mean no flow time [s]	4 [4–6]	5 [4–7]	0.315
Correct hand position [%]	100 [100–100]	100 [100–100]	0.860
Mean depth [mm]	51 [43–55]	55 [48–57]	**0.003**
Chest adequately released [%]	30 [3–65]	40 [12–83]	0.117
Adequate depth [%]	70 [7–97]	96 [27–99]	0.097
Adequate rate [/min]	5 [0–18]	78 [54–93]	**< 0.001**
Overall mean rate [/min]	125 [112–130]	115 [105–117]	**0.003**

Data are presented as median and interquartile range.

Table 2. Ventilation parameters

	No-feedback group	Feedback group	p
Ventilation score [%]	91 [45–96]	93 [86–98]	0.053
Mean volume/ventilation [mL]	383 [320–628]	439 [304–619]	0.743
Mean rate [/min]	14 [4–16]	12 [7–16]	0.479
Ventilations exceeding the maximum volume limit [%]	0 [0–38]	0 [0–27]	0.368
Ventilations with adequate volume [%]	33 [0–47]	45 [0–67]	0.066
Ventilations not reaching the minimum volume limit [%]	56 [0–89]	33 [7–92]	0.567
Mean rate of all ventilations [/min]	5 [2–7]	5 [7–92]	0.796

Data are presented as median and interquartile range.

improved significantly in the feedback group, compared to the non-feedback group (Table 1).

Percentage of ongoing chest compression/min, mean of no-flow time, correct hand position, adequate chest release, and percentage of adequate depth of chest compression did not differ significantly between the two groups (Table 1).

Secondary ventilation outcomes

Ventilation score, mean volume/ventilation, mean rate per minute, and percentage of ventilations exceeding maximum or reaching minimum volume did not differ significantly between the two groups (Table 2).

DISCUSSION

Data of our randomised manikin study support previous findings, showing that real-time feedback devices improve QCPR. In detail, using the feedback device improved mean depth of chest compression, adequate rate per minute, and mean rate per minute.

Several studies in recent decades have clearly demonstrated that early start of high-quality CPR is mandatory to improve survival and is therefore the main determinant in the chain of survival. Although considered pivotal for clinical outcome, CPR is initiated by bystanders in only about 50% of CPRs [11]. Drowning is a common cause of accidental death. Nowadays, lifeguards are frequently used in public swimming pools and beaches. As a consequence, lifeguards often act as bystanders and are taught in CPR on a regular basis. Therefore, lifeguards are an ideal target group to improve clinical outcome after drowning accidents.

Generally, increasing quality of bystander basic life support is an important topic of current CPR research. Feedback devices have been introduced into the clinical setting in order to improve CPR quality and compliance to CPR guidelines. Whether feedback devices actually improve or worsen quality of CPR is a topic of ongoing debate. For example, Zapletal et al. [17] reported feedback devices to be not associated with improved CPR quality. This study disagrees with our findings because using the feedback device was clearly associated with better chest compressions, therefore supporting several previous studies [11, 12, 18–20]. Discrepancies might be based mostly on divergent definition of "better quality" of chest compression and using different CPR scores. Finally, the level of experience of the CPR providers differed between these studies.

Zapletal et al. [17] also reported that use of a feedback device was associated with a delay of starting CPR and consequently concluded that this might be one of the major disadvantages. Although we did not investigate the time to initiation of CPR in this study, we disagree with this statement. The quality of CPR was 69% in the non-feedback group, indicating moderate CPR quality. Using the feedback device was associated with a CPR score of 84%, representing a substantial improvement. We therefore conclude that using the feedback device potentially delayed start of CPR of a couple of seconds, but led to better CPR quality, which might ultimately be even more important for patient's outcome.

The major advantage of the CPRMeter is the possibility to provide real-time feedback and guidance for depth, chest release, and rate of chest compression [18]. Furthermore, the CPRMeter can be fixed to the correct chest compression point of the patient's chest by using the adhesive band provided by the manufacturer. Unsurprisingly, fixing the CPRMeter to the correct position on the chest allowed correct hand positioning in both study groups.

Several CPR scores including the QCPR score are currently used [21]. The QCPR score was previously validated and used in many studies [12, 22–25].

Secondary ventilation parameters were documented in both the feedback and the non-feedback groups. Unsurprisingly, ventilation did not differ between these groups because the CPRMeter only provides visual feedback on chest compressions, but not for any ventilation parameters.

Limitations of the study

Our study has some limitations. First, this study was performed on manikins. Although manikins are considered an optimal training and teaching tool, the findings of manikin studies cannot be generalised for all clinical settings. Second, the duration of the CPR setting was limited to 2 min, which was sufficient for the primary outcome, but we did not investigate any effect on rescuers' fatigue and potential delayed start of CPR.

CONCLUSIONS

Using the visual real-time feedback device significantly improved QCPR in our relatively inexperienced CPR providers. Better quality of bystander CPR is essential for clinical outcomes, and therefore feedback devices should be considered. Further clinical studies are needed to assess the effect of real-time visual devices, especially in bystander CPR.

Conflict of interest: *none declared*

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