Use of Selected Telemedicine Tools in Monitoring Quality of In-Hospital Cardiopulmonary Resuscitation: A Prospective Observational Pilot Simulation Study

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Background: The aim of this study was to assess the quality of in-hospital cardiopulmonary resuscitation components performed by nurses under simulated conditions, with the use of selected telemedicine tools.

Material/Methods: This prospective observational pilot simulation study was carried out with a group of 48 nurses working in hospital wards specializing in conservative treatment (HOS/C=22; mean age of 30.27 years; SD 9.30) or interventional therapy (HOS/I=26 nurses; mean age of 30.35 years; SD 9.77). Each nurse performed CPR for two minutes (a sequence of 30 compressions: 2 breaths) on a Laerdal Resusci-Anne manikin that was positioned on an examination couch using a self-inflating bag and face mask in accordance with their knowledge of and skills related to in-hospital resuscitation. The study was conducted in two stages, separated with an intervention (refresh online training by using Polycom RealPresence Group Devices). Analyses of selected chest compression and relaxation parameters were performed with the use of the TrueCPR Coaching Device.

Results: The finding showed improved compression depth (HOS/C: 46.68 mm vs. 51.50 mm; HOS/I: 46.92 mm vs. 50.57 mm), improved full recoil (HOS/C: 81.68% vs. 94.67%; HOS/I: 75.92% vs. 82.13%), and sustained standard compression rate (HOS/C: 115.23/min vs. 105.11/min; HOS/I: 113.65/min vs. 111.04/min) in the study group, 2 months after the intervention. A significant difference between the groups was observed in the rate of chest compressions with complete recoil (HOS/C: 94.67% vs. HOS/I: 82.13%; p<0.042).

Conclusions: The use of selected telemedicine tools leads to improved chest compression and relaxation parameters during in-hospital sudden cardiac arrest.

MeSH Keywords: Cardiopulmonary Resuscitation • Death, Sudden, Cardiac • Nurses • Telemedicine

Abbreviations: BLS – basic life support; CPR – cardiopulmonary resuscitation; ERC – European Resuscitation Council; HOS/C – nurses working in wards specializing in conservative treatment; HOS/I – nurses working in wards specializing in interventional therapies; SCA – sudden cardiac arrest; SD – standard deviation

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Background

Sudden cardiac arrest (SCA), both out-of-hospital and in-hospital, is a leading cause of death. Consequently, hospital personnel are required to ensure an adequate quality of cardiopulmonary resuscitation (CPR), which is a component of basic life support (BLS), as defined in the guidelines of the European Resuscitation Council (ERC) [1]. Because hospital nurses present with a variety of cardiopulmonary resuscitation skills [2,3], researchers continue looking for methods or tools to enable this professional group to retain its competences for as long as possible and to improve related practical skills [4–6].

Nurses exercise professional and comprehensive care of the patient. In the event of threat to the patient's life, it is mainly nursing staff that recognizes SCA and initiates CPR. In addition, a larger number of nursing staff is associated with a lower rate of failure during CPR and a reduction in the frequency of cardiac arrest, pneumonia, shock, and death [1].

In-hospital cardiac arrest occurs in 1–5 patients out of 1000 admissions, with a predicted 15–20% survival rate to hospital discharge [7,8]. Frequently, one of the first links in the chain of survival is the nursing personnel directly in charge of patients experiencing serious health- or life-threatening incidents [9–11]. Hospital guidelines continue to emphasize that good-quality chest compression and relaxation is a priority [12]. The quality of chest compressions and relaxation parameters are affected by a number of factors, which are still being investigated. In addition to the obvious technical aspects, anthropometric parameters are also important, as they may facilitate or impede the effectiveness of resuscitation [13,14].

Quality of CPR is inseparably linked with regularly-held training and the instruction method provided to medical personnel. In addition to the conventional manikin-based practical training supervised by instructors, alternative approaches, which are more and more frequently being investigated by researchers, make use of feedback devices [5,15,16], BLS video self-instruction systems [17–22], e-learning [6,23], and real-time audio-visual feedback systems [24,25]; these methods carry a promise for accessible, affordable, and time-effective training in resuscitation [26].

Medical staff working in various general hospital departments or intensive care units should be taught to recognize SCA and quickly perform CPR. Low quality of chest compressions is common and results both from the wrong depth and intervals during chest compressions. These factors reduce the effectiveness of CPR and decrease the survival rate [27]. Therefore, it seems reasonable to conduct regular training in BLS (basic life support) to repeat and improve acquired skills in the field of resuscitation. In addition, periodic trainings have a real impact on the willingness to undertake CPR and lead to greater confidence during CPR [28].

This study was designed to assess the quality of in-hospital cardiopulmonary resuscitation components (chest compression) in simulated conditions, with the use of selected telemedicine tools. The present study is the first attempt made in Poland to compile selected telemedicine tools to be applied in monitoring the quality of in-hospital BLS-level cardiopulmonary resuscitation.

Material and Methods

Study design

This prospective observational pilot simulation study was carried out with a group of nurses working in hospital wards specializing in conservative treatment or interventional therapy.

Ethical considerations

The study was conducted from April to December, 2016, and all the nurses provided their consent to participate. The design of the study was approved by the University Bioethics Commission (no. 11/10/2016).

Settings and participants

The study involved a group of 48 nurses, active in their profession and certified to perform the job of nursing, working in the selected hospital wards and attending a full-time master's program in nursing. We divided the nurses into 2 groups: HOS/C nurses working in wards specializing in conservative treatment and HOS/I nurses working in wards specializing in interventional therapies. The HOS/I group consisted of nurses from internal medicine, surgery, cardiology, neurology, neurosurgery, anesthesia and intensive care, orthopedics, gastroenterology, pediatrics, hospital emergency department, and interventional cardiology. The HOS/C group consisted of nurses from the rehabilitation ward, hospice, sanatorium, psychiatry, allergology, GP clinics, and care and treatment facility for the elderly.

Exclusion criteria were: lack of consent to participate in the study, lack of authorization to perform the job of a nurse, everyday workplace not a ward specializing in conservative treatment or interventional therapy, and existing disease or dysfunction making it impossible for the person to perform full CPR. Demographic data and professional characteristics are presented in Table 1.

Table 1. Study group characteristics.

Subject characteristics		HOS/C (n=22)		HOS/I (n=26)		p Value
		Mean	SD	Mean	SD	
Age [years]		30.27	9.30	30.35	9.77	.663
Experience [years]		7.13	9.79	7.56	10.33	.933
Specialization(s) [n%]	Yes	2	9.1	5	19.2	.561
	No	20	90.9	21	80.8	
CPR training in preceding 5 years	Yes	5	22.7	8	30.8	.532
	No	17	77.3	18	69.2	
Weight [kg]		61.09	12.11	61.50	8.26	.449
Height [cm]		161.50	5.63	162.62	6.48	.900

HOS/C – nurses working in wards specializing in conservative treatment; HOS/I – nurses working in wards specializing in interventional therapies. * Significantly different between stage I and stage II group, P<0.05.
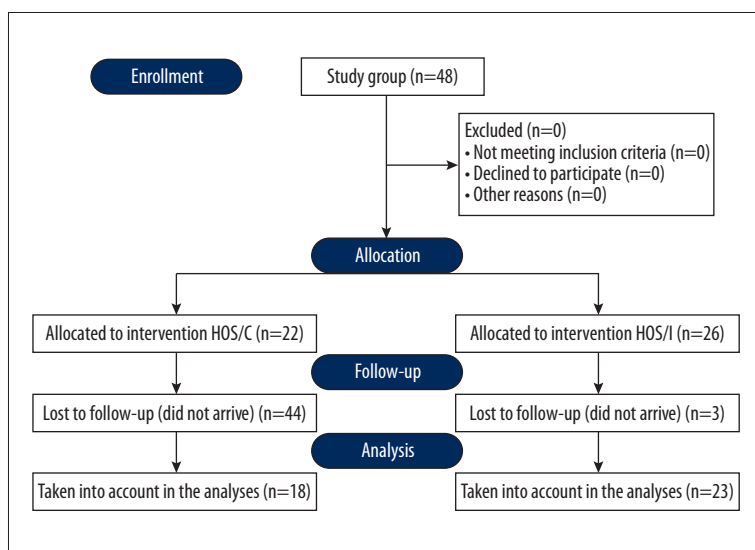

Figure 1. Study sample.

Data collection

We divided the 48 nurses into 2 groups: the HOS/C group (N=22; mean age 30.27 years; SD 9.30) of nurses working in hospital wards specializing in conservative treatment, with average employment duration of 7.13 years (SD 9.79) and the HOS/I group (N=26; mean age 30.35; SD 9.77) of nurses working in hospital wards specializing in interventional therapy, with average employment duration of 7.56 years (SD 10.33). Each nurse (N=48) performed CPR for 2 min (a sequence of 30 compressions: 2 breaths) on a BLS manikin (Laerdal Resusci-Anne®, 50 kg, Laerdal, Norway) that was positioned on an examination couch (51 cm above the floor surface), using a self-inflating bag (Laerdal Silicone Resuscitator for Adults >25 kg, volume 1600 ml) and face mask (Adult 4-5 with Multi-Function, Mask Cover, Laerdal, Norway), in accordance with their knowledge of

and skills related to in-hospital resuscitation. The parameters of compression and relaxation were recorded with a TrueCPR™ device (TrueCPR – Physio Control, Malaysia, 2013) positioned directly on the manikin's chest (with the metronome off, and a cover concealing the display of the current real-time compression parameters). The allocation process is shown in Figure 1.

Immediately after the end of the first stage of the study, the research team introduced a corrective action by conducting a telemedical panel session focusing on the accuracy of CPR performed in accordance with ERC 2015 guidelines. The training was conducted online in 3 seminar rooms connected via a wireless network and designed for teleconferences (Polycom RealPresence Group 300 EagleEye Acoustic and Polycom RPG 500 EagleEye IV/2x, Polycom, Thailand). The applied tool, Resusci-Anne Wireless SkillReporter™ Software

Figure 2. Training process.

(Laerdal, Norway, 2015), allowed participants to see all the compression parameters simultaneously in real time. The training process is shown in Figure 2. Two months after the first stage, the nurses were divided into 2 groups based on the same criteria and again were asked to perform CPR for 2 min.

The results were recorded in a specially designed scientific research report. The specific CPR results were transferred from the recording device (TrueCPR – Physio Control, Malaysia, 2013) to the dedicated computer program, TrueCPR™ Report Generator – Physio Control 2014, to be entered into the template and printed.

Definition of variables

The study focused exclusively on the parameters of chest compression and relaxation. The adopted CPR-related standards were based on ERC 2015 guidelines [Perkins 2015], and the selected normative parameters were defined as follows: chest compression depth 50–60 mm, relaxation with full recoil, compression rate 100–120/min.

Statistical analysis

Statistical analysis of the data was performed using SPSS software (SPSS Statistics 20 package, version 12, IBM Corporation, USA). Continuous data are presented as mean and SD (standard deviation). Differences between 2 groups were analyzed using an unpaired two-tailed t test after checking normality

of distribution by Shapiro-Wilk test and after performing constant variance testing. In case of normality and/or constant variance test failure, the Mann-Whitney rank sum test was performed. The categorical data are presented as numbers and they were compared using the chi-square test. P values of <0.05 were considered statistically significant.

Results

First stage (before telemedicine intervention)

During the first stage of the study, the mean compression depth in both groups was similar (HOS/C: 46.68 mm *vs.* HOS/I: 46.92 mm), and was slightly lower than the recommended value of 50–60 mm. Chest compression rate met the ERC 2015 criteria in both groups, without statistically significant differences. In the case of the nurses working in wards specializing in conservative treatment, every second compression was too shallow, and every tenth compression was too deep. Similar values were recorded in the group of nurses working in wards specializing in interventional therapies (too shallow: HOS/C mean 64.68; SD 36.67 *vs.* HOS/I mean 63.73; SD 43.48; too deep: HOS/C mean 6.09; SD 11.91 *vs.* HOS/I mean 12.04 SD 30.62). The percentage of compressions with full recoil was higher in the group of nurses from wards specializing in conservative treatment (HOS/C: 81.68% *vs.* HOS/I: 75.92%; *p*<0.05). The data are listed in Table 2.

Table 2. Initial qualitative parameters of chest compression and relaxation (Stage I) and qualitative parameters of chest compression and relaxation 2 months after the telemedical training (Stage II).

Stage I (n=48)	HOS/C (n=22)		HOS/I (n=26)		p Value
	Mean	SD	Mean	SD	
Compression depth [mm]	46.68	7.92	46.92	11.35	.967
Too shallow [%]	64.68	36.67	63.73	43.48	.917
Too deep [%]	6.09	11.91	12.04	30.62	.786
% full recoil [%]	81.68	31.48	75.92	31.51	.516
Compression rate [min]	115.23	15.78	113.65	14.66	.474
Too slow [%]	11.05	25.20	14.42	27.93	.178
Too fast [%]	26.55	28.60	26.81	37.35	.571
Stage II (n=41)	HOS/C (n=18		HOS/I (n=23)		p Value
	Mean	SD	Mean	SD	
Compression depth [mm]	51.50	7.76	50.57	5.92	.445
Too shallow [%]	37.56	37.87	45.22	37.64	.485
Too deep [%]	9.28	19.95	4.74	15.77	.293
% full recoil [%]	94.67	16.03	82.13	28.47	.042*
Compression rate [min]	105.11	13.18	111.04	11.13	.120
Too slow [%]	34.61	39.61	15.65	29.34	.056
Too fast [%]	10.44	23.35	16.52	26.51	.277

HOS/C – nurses working in wards specializing in conservative treatment; HOS/I – nurses working in wards specializing in interventional therapies. * Significantly different between stage I and stage II group, P<0.05

Second stage (after telemedicine intervention)

Two months after the first stage trials and the telemedical training, both depth and rate of chest compressions met the criteria recommended by ERC guidelines, with no statistically significant differences between the groups. A significant difference between the groups was observed in the rate of chest compressions with complete recoil (HOS/C: 94.67% *vs.* HOS/I: 82.13%; p<0.042). The relevant data are shown in Table 2.

Comparison of the 2 stages

Comparative analysis of HOS/C group scores in Stage I and Stage II showed a statistically significant increase in the parameters of chest compression depth (46.48 mm *vs.* 51.50 mm; *p*<0.039) and relaxation (81.68% *vs.* 94.67%; *p*<0.025), as well as a retained appropriate compression rate. Analysis of the results scored by HOS/I group showed improvement in the specific parameters of CPR performance, but the change was statistically insignificant. The relevant data are presented in Table 3. Both before and after the training, the nurses performed chest compressions at the rate recommended by ERC 2015 guidelines.

Discussion

The present study demonstrates the effectiveness of a telemedical panel session for improving accuracy of CPR, in accordance with ERC 2015 guidelines. The findings also show that the tool effectively enables retention of the acquired practical skills over a longer period of time (2 months). The study also indirectly shows a high initial quality of CPR, regardless of the speciality of the hospital ward represented by the participants of the study, confirming that the nurses are adequately prepared for performing in-hospital CPR.

CPR trainings are a valuable source of knowledge and at the same time enable nurses to acquire practical skills that have real impact on patient survival after SCA. Basic life support reminders should take place every 12–24 months, and in some circumstances this time should be adjusted and analyzed based on the probability of cardiac arrest in a particular place. Scientific evidence suggests that the fading away of acquired skills occurs within 3–12 months after training [1]. Therefore, it is necessary to periodically train medical staff using various forms of training, from the traditional ones where the on-site training is conducted by the instructor, through the use of

Table 3. Comparison of chest compression and relaxation parameters at both stages in HOS/C group and HOS/I group.

HOS/C	Stage I		Stage II		p Value
	Mean	SD	Mean	SD	
Compression depth [mm]	46.68	7.92	51.50	7.76	.039*
Too shallow [%]	64.68	36.67	37.56	37.87	.023*
Too deep [%]	6.09	11.91	9.28	19.95	.599
% full recoil [%]	81.68	31.48	94.67	16.03	.025*
Compression rate [min]	115.23	15.78	105.11	13.18	.014*
Too slow [%]	11.05	25.20	34.61	39.61	.031*
Too fast [%]	26.55	28.60	10.44	23.35	.022*
HOS/I	HOS/C (n=18		HOS/I (n=23)		p Value
	Mean	SD	Mean	SD	
Compression depth (mm)	46.92	11.35	50.57	5.92	.163
Too shallow [%]	63.73	43.48	45.22	37.64	.165
Too deep [%]	12.04	30.62	4.74	15.77	1.000
% full recoil [%]	75.92	31.51	82.13	28.47	.433
Compression rate/(min)	113.65	14.66	111.04	11.13	.673
Too slow [%]	14.42	27.93	15.65	29.34	.356
Too fast [%]	26.81	37.35	16.52	26.51	.399

HOS/C – nurses working in wards specializing in conservative treatment; HOS/I – nurses working inwards specializing in interventional therapies. * Significantly different between stage I and stage II group, P<0.05.

telemedicine tools, up to modern forms of training using medical simulation, including high-fidelity simulators.

On the other hand, numerous studies worldwide focus on assessing the feasibility of selected CPR teaching methods. For instance, Nielsen et al. investigated the effectiveness of video-based self-instruction (VSI) with a 24-min DVD, and reported an increase in compression and ventilation parameters, important from the perspective of patient survival, which were observed nearly 4 months after the intervention [22]. A randomized simulated study involving first-year medical students compared the effectiveness of 2 video-recording-based methods of self-instruction in BLS, as well as a traditional method (HeartCode BLS System *vs.* BLS Anytime *vs.* Traditional training), and no statistically significant differences were identified in the quality of compression and ventilation [29]. Similar results in compression rates were reported by researchers from the United States who compared the effectiveness of a BLS e-learning course (HeartCode BLS) and a traditional instructor-assisted training in a population of 604 nursing students. Furthermore, the e-learning method produced better results in chest compression depth and in the volume of ventilation [30]. A study by Vestergard et al. assessed the effectiveness of an e-learning course versus a traditional instructor-led pediatric BLS course

administered to a group of nurses, and reported no statistically significant differences in the results produced by the 2 methods [23].

These previous findings suggest that further research is needed to assess the effectiveness of teaching and monitoring resuscitation operations using equipment designed for online tele-transmission of data in view of the low costs, short duration, and accessibility of the methods described here.

Limitations

Our study has some limitations. Although the study indicates the ability of nurses working in different departments (interventional or conservative) to carry out effective CPR, no differences were found in the CPR-related skills among nurses. In addition, despite the slight differences between the initial CPR assessment and the CPR parameters immediately after the training and at 2 months, these differences were at the level of statistical significance, despite the small size of the groups. Currently, we are planning research with more groups, not only among nursing staff, but also among doctors, firefighters, and policemen.

It should be also mentioned that the mannequin does not accurately reflect the conditions of a real patient, but is an important and proven tool for teaching, improving knowledge and skills in the diagnosis of SCA and CPR. It should be emphasized that even a slight improvement in the depth, frequency, and relaxation of CPR can realistically increase patient survival.

Conclusions

The effectiveness of CPR conducted by nursing staff can be improved by using selected telemedicine tools, which was confirmed in the obtained initial and final parameters of compression and relaxation of the chest during in-hospital SCA.

Conflict of interest

None.

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