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Blended Distance-classroom Training as an Alternative to the Traditional Classroom Training in Basic Cardiopulmonary Resuscitation and Automated External Defibrillation

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INTRODUCTION Early bystander cardiopulmonary resuscitation (CPR) is a critical factor in out-of-hospital cardiac arrest survival, and the readiness of bystanders to provide the first aid is known to be positively influenced by effective training. It is recommended to use alternative teaching methods in order to increase the accessibility of CPR training. The study was carried out to assess the effectiveness of the blended approach to resuscitation training, where classroom training hours are partially substituted with remote learning.

MATERIAL AND METHODS This prospective randomized study was conducted in November-December 2018. Nursing students and nonmedical university students underwent classroom training (1 hour of lecture, 3 hours of hands-on training) or blended training (1 hour of on-line course, 3 hours of hands-on training) in basic CPR with automated external defibrillation (AED). CPR knowledge and willingness to attempt resuscitation were evaluated before and after the training, and resuscitation skills were assessed as well after training in a simulation scenario. CPR quality measures were registered using the skills checklist when analyzing video recordings, and automatically by means of the Resusci Anne QCPR manikin.

RESULTS The training and the study assessments were completed by 94 participants: 55 — classroom training, 39 — blended training. The mean age was 19 years and 17 years, respectively, 24% and 31% were male. Whereas there were more participants with previous training in CPR in the classroom training group (36% vs. 13%; $p<0.05$), the baseline levels of knowledge and readiness to perform resuscitation on a stranger were generally comparable between the groups. After the training, there was an increase in willingness to perform resuscitation (from 3.6 to 4.4 points in both groups) and improvement in self-perceived CPR knowledge (from 2.4 to 4.0 points in the classroom training group and from 2.6 to 4.3 in the blended training group). The assessment of the CPR quality in the simulation scenario revealed no significant differences between groups, excepting higher rate of chest compressions in the blended training group (116.0 vs. 109.4, $p<0.01$).

CONCLUSION The suggested method of blended training in basic CPR with AED is no less efficient than traditional classroom training, and it can be recommended for increasing access to high-quality training in first aid.

Keywords: cardiac arrest, cardiopulmonary resuscitation, first aid, automated external defibrillation, population, blended learning, remote training, massive open online courses

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AED – automated external defibrillator
CPR – cardiopulmonary resuscitation
OHCA – out-of-hospital cardiac arrest

BACKGROUND

Out-of-hospital circulatory arrest (OHCA) occupies a leading position in the worldwide mortality [1–3]. Survival rates for OHCA as a whole do not exceed 10% [4, 5], but with the immediate implementation of basic cardiopulmonary resuscitation (CPR) by bystanders, the chances of a favorable outcome increase several times [6].

However, in most cases, bystanders do not perform CPR today [2, 3, 7]. According to foreign and domestic sociological studies, one of the main obstacles for bystander's resuscitation is the lack of appropriate knowledge and skills, as well as the fear of harm caused by incompetence [7–10].

Massive learning of basic CPR contributes to increasing the population's readiness to provide the first aid, has a proven positive effect on survival rates for OHCA and is highlighted by existing international recommendations on resuscitation as a key educational task [11]. However, traditional classroom (full-time) basic CPR training for non-specialists is not readily available and does not satisfy existing needs in Russia [8, 12–14]. The availability of CPR training may be improved through the use of alternative teaching technologies, including blended learning, which involves the partial replacement of classroom teaching with remote training [11].

The aim of the study was to compare the effectiveness of blended learning and traditional full-time study of basic CPR using an automatic external defibrillator (AED).

MATERIAL AND METHODS

The prospective, single-center open randomized study using a blind method in assessing the obtained results was conducted from November to December, 2018. Initially, 133 volunteers were included in the study — students of the Crimean Medical College (*n*=100) and non-medical students of the V.I. Vernadsky Crimean Federal University (*n*=33). As a result of randomization (random number generation in *MS Excel*; *Microsoft Corporation*, USA) participants were divided into two groups:

- a group of full-time study (*n*=66) under the guidance of 4 qualified instructors (phycisians) specialized in "Emergency Medical Aid" of the Crimean Simulation Center for Emergency Medicine, within the four-hour lesson, studied theoretical basics (lecture, 1 hour) and skills (simulation training, 3 hours) of basic CPR using AED;

- a blended learning group (*n*=67) underwent independent theoretical training remotely prior to simulation training with the help of an open online course "First Aid for Cardiac Arrest (Basic Resuscitation)" developed by the center (mini-lectures in text format, photos, drawings, videos, test items, the average duration of the course was 1 hour) [15]. Full capturing of the theoretical material was confirmed by a personal certificate of completed online course. Training of CPR and AED skills was performed with an instructor the same way as in a full-time group (3 hours).

Full-time and blended learning programs were developed in accordance with the current recommendations of the European Resuscitation Council [16]. For practical training, the following simulation equipment was used: Resusci Anne Manikin (Laerdal Medical AS, Norway), AED XFT-120C+ (DISIYING, China).

Immediately after completing the training, the participants of both groups independently performed the complex of basic CPR with AED on a manikin simulating sudden cardiac arrest in an adult. The resuscitation attempt included sequential 4 basic CPR cycles, defibrillation, and one CPR cycle after the discharge. Resuscitation skills were assessed when analyzing video recordings of simulation sessions using a validated checklist of a structured assessment (Table 1) [17]. For each of the 36 points of the checklist, an expert assessment of "completed"/"not completed" was made. In addition to the total score (the total number of correctly performed actions, max. 36) indicators on sets of skills were included for the further study — "Primary actions" (items 1–8 of the cheklist), "Compression" (9–19), and "Ventilation" (21–29), "Defibrillation" (31–35).

Table 1

The checklist of structured skills assessment of cardiopulmonary resuscitation and AED

No	Actions to be evaluated	Yes	No
1	Evaluates the safety of the environment		
2	Shakes the shoulders		
3	Hails		
4	Throws back the head lying the hand on the forehead		
5	Raises chin with fingertips		
6	Puts the head to the patient's mouth and nose, assesses breathing (up to 10 seconds)		
7	Asks an assistant to call the amblulance (112)		
8	Asks the assistant to bring a defibrillator.		
9	Places the arm on the midline on the lower half of the sternum.		
10	Places the second hand over the first one, puts the fingers into the lock.		
11	Rises above the patient		
12	Applies pressure only with the base of the palm.		
13	Performs 30 compressions		
14	Does not bend elbows		
15	Compression depth 5-6 cm		
16	Compression frequency 100-120 per minute		
17	After each compression, the chest returns to its original position.		
18	Does not lose contact with the chest between compressions		
19	Performs compression continuously		
20	Uses protective device (face mask)		
21	Throws back the patient's head putting the hand on the forehead		
22	Raises the chin with fingertips		
23	Closes the nostrils of the patient		
24	Inhales and covers the patient's mouth with lips		
25	Exhales		
26	Duration 1 sec.		
27	While inhaling, looks at the chest.		
28	Holding the head in the thrown back position, draws back, allows air to leave the lungs		
29	Correctly performs a second breath		
30	Resumes compression and ventilation without delay		
31	Turns the defibrillator on		
32	Applies electrodes correctly		
33	Provides safety of others when working with a defibrillator		
34	Does not touch the manikin or the surface on which the it rests		
35	Makes a discharge		
36	Resumes compression and ventilation without delay		
	The total number of correct actions		

Note: for items 15 and 16, the assessment was made on the basis of objective indicators registered by the manikin.

During simulation sessions QCPR module of Resusci Anne (Laerdal Medical AS, Norway) performed automatic registration of objective indicators of CPR quality. Further analysis included the following indicators:

- average frequency and average depth of chest compressions, the percentage of compressions with the correct frequency, depth, full return of the chest to its original position, the correct position of hands on the chest;
- fraction of compressions (percentage of time occupied by compressions);
- average time of absence of compressions, average inspiratory volume and percentage of breaths of the correct volume.

Before and after completion of the study, questionnaires were conducted. The initial survey included the collection of demographic data (gender, age), information about previous resuscitation training, assessment of knowledge (two closed questions about the correct position of the arms on the chest and the correct frequency of chest compressions), assessment of readiness for resuscitation to a stranger on a 5-point basis according to the *Lickert* scale (from 1 — "I will definitely not perform CPR" to 5 — "I will certainly perform CPR") and self-assessment of knowledge on resuscitation (from 1 — "I don't know anything" to 5 — "very good knowledge"). In the blended learning group, the initial survey was conducted remotely in electronic format. The final survey included an assessment of the readiness for resuscitation of a stranger, a self-assessment of knowledge, an assessment of satisfaction with the course (from 1 — "very bad" to 5 — "very good"), and a number of questions for an objective assessment of knowledge (Table 2).

To limit the influence of subjective factors on the results of the experiment, the following approach was used: 1) volunteers and instructors were not informed about the purpose and design of the study; 2) full-time and blended learning groups were trained separately (on different days); 3) when analyzing videorecords for the purpose of assessing the skills of participants identified only by individual numbers, their affiliation with research groups was hidden.

Statistical analysis. We used methods of descriptive statistics for data presentation. Checking for the presence of a normal distribution was performed using the Kolmogorov–Smirnov test. Statistic comparison of quantitative variables was performed using Student's *t*-test *(*for a normal distribution) or *U-Mann* Whitney-test *(*distribution different from the normal), the comparison

qualitative variables using chi-square test) and *Fisher's* exact test. The *IBM SPSS Statistics* 23.0 software package (*IBM Corporation*, USA) was used for statistical analysis. The differences were regarded as statistically significant with the value of $p<0.05$.

RESULTS

Due to nonappearance at the simulation center for training (n=36), incomplete passing of the distance course (n=2) or lack of key assessment results (broken video, n=1), 39 participants were removed from the study. The final analysis included data from 94 participants: 55 from the full-time study group, 39 from the blended learning group.

The average age of participants was 19 years (median 17, range 16–35 years) in the full-time study group and 17 years (median 17, range 16-21 years) in the group of blended learning ($p<0.01$). There were 24% (n=13) and 31% (n=12) male participants, respectively ($p>0.05$). In the full-time study group, there were significantly more participants who passed CPR training in the past (36%, n=20 versus 13%, n=5; $p<0.05$). At the same time, the initial groups did not differ in the level of knowledge according to the self-assessment data ($p>0.05$; Fig. 1) and the level of readiness for performing CPR in a stranger (3.6 points in both groups, $p>0.05$).

With the initial test assessment of knowledge, the correct answer to the question about the location of the palms on the chest for compressing was given by 62% (n=34) of participants from the full-time study group and 82% (n=32) of participants rom the group of blended learning ($p<0.05$), and the correct frequency range was indicated respectively by 25% (n=14) and 13% (n=5; $p>0.05$).

After training, both groups gave a high appraisal of the courses completed (average score on a 5-point scale of 4.7 for full-time study and 4.8 for blended learning, p>0.05). Willingness to assist a stranger increased to 4.4 points (0.8 points) in both groups. The assessment of own knowledge of CPR has increased, with an advantage in the blended learning group (Fig. 1).

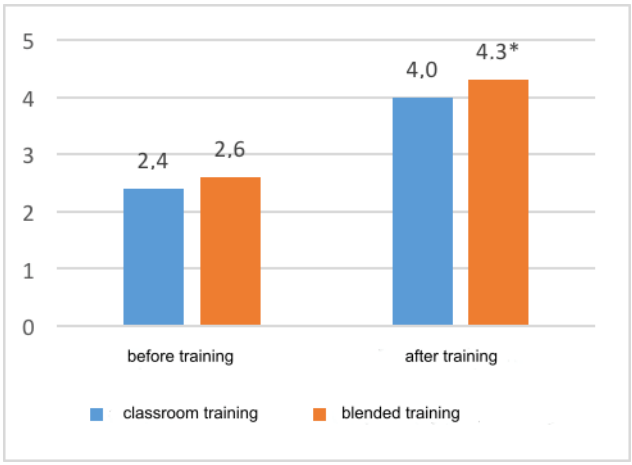

Fig. 1. The average level of knowledge of cardiopulmonary resuscitation according to self-assessment.
Note: * — statistically significant difference between classroom and blended learning groups (p<0.05)

The results of the final knowledge test are shown in Table 2.

Table 2

The distribution of study participants who correctly answered to the questions at the final assessment of cardiopulmonary resuscitation

N	Question and answer options	Classroom training	Blended training	*P* value
1	**In your presence, a person suddenly loses consciousness. What will you do first?** *(To answer, circle one number.)* 1. I will throw the victim's head back, lift the chin and check the breath 2. Making sure everything is safe, I will call him and gently shake him by the shoulders † 3. I will call 112 and I wait for the ambulance to arrive, without leaving the victim 4. Pat on the cheeks, feel the pulse on the neck (carotid artery) 5. I will initiate resuscitation immediately	91%	100%	0.074
2	**Where should your palms be located during a closed heart massage?** *(Put a cross in the picture.)** In the center of the chest on the lower half of the sternum †	80%	82%	1,000
3	**How fast should you press on the chest (how many compressions per minute)?*** 100-120 per minute †	69%	77%	0.403
4	**After how many chest pressures should artificial respiration be performed when assisting an adult victim?*** 30 †	96%	92%	0.646
5	**Select the CORRECT statement regarding defibrillators available in crowded places (at airports, cinemas, train stations, etc.).** *(To answer, circle one number.)* 1. Independently determines the need for an electrical discharge † 2. Allows you to apply a discharge when applying electrodes over clothing 3. It should not be used by individuals without medical education. 4. It should be used only if all other resuscitation measures are ineffective.	84%	77%	0.437
6	**Where should the electrodes of an automatic external defibrillator be located?** *(To answer, circle one number.)* 1. Under the clavicle on the right and under the scapula on the left. 2. On the sternum and under the right scapula 3. Under the clavicle on the left and on the lateral side of the chest on the right 4. On the lateral side of the chest on the left and under the clavicle on the right † 5. On the lateral side of the chest on the left and abdomen	42%	41%	0,939

Note: data is presented in the format “mean ± standard deviation”

The Table 3 shows the quality indicators for CPR and AED according to the results of the assessment of skills in the simulation scenario, recorded by analyzing video and using manikin sensors.

Table 3

The comparison of practical skills assessment after completion of training

Parameter	Classroom training (*n*=55)	Blended training (*n*=39)	*P* value
Expert assessment of videos using the checklist			
Overall score	31.6±3.3	32.0±2.7	0.687
Block "Primary actions"	7.0±1.1	7.2±1.0	0.897
Block "Compressions"	9.4±1.3	9.5±1.1	0.658
Block "Ventilation"	7.9±1.6	7.9±1.2	0.269
Block "Defibrillation"	4.5±0.7	4.5±0.7	0.712
Automatic registration of indicators by the manikin			
The frequency of chest compressions (per min)	109.4±11.7	116.0±10.5	0.006
Compressions of the chest with the correct frequency (%)	62.6±34.3	57.7±34.1	0.414
Chest compression depth (mm)	52.8±6.5	51.2±4.9	0.080
Compressions of the chest with the correct depth (%)	60.0±33.3	63.4±29.4	0.756
Compressions with a full return of the chest to its original position (%)	64.4±32.8	60.2±29.0	0.272
Compressions with correct position of hands on the chest (%)	97.4±12.6 (*n*=55)	97.6±14.6 (*n*=38)	0.154
Compressions fraction (%)	37.3±5.6 (*n*=50)	36.0±6.2 (*n*=39)	0.321
No compression time (sec)	22.5±5.9 (*n*=51)	23.4±8.3 (*n*=38)	0.510
Ventilation volume (ml)	576.9±148.8 (*n*=54)	602.5±157.2 (*n*=39)	0.426
Ventilations with correct volume (%)	41.7±32.8 (*n*=54)	43.2±40.1 (*n*=39)	0.922

Notes: data is presented in the format "mean ± standard deviation"

DISCUSSION

The current possibilities for acquiring the knowledge and skills of CPR in the Russian Federation are sharply limited despite the extreme importance of effective and mass education of the first aid in OHCA [8, 12–14]. A survey of the Crimean population showed that 47% of the inhabitants of the peninsula had never been trained in intensive care, and among those trained, 44% were trained only once and for 72% the duration of study at the time of the survey exceeded one year [14]. When analyzing offers for training the population in basic CPR skills represented in the Russian-speaking segment of the Internet, it was found that the training courses are few, mostly commercial (95%), and while more than 95% of the courses involve full-time education, their geographical prevalence limited to 2% of urban settlements in Russia [13].

Increasing the availability of CPR training is an important task for which leading resuscitation communities recommend using alternative teaching technologies in addition to the traditional full-time education, including distance learning in electronic environments [11].

The introduction of blended CPR training, which combines the advantages of distance and classroom training, seems reasonable and promising by increasing the availability of effective resuscitation training. The advantages of blended learning compared to purely full-time education include reduction of financial costs, workload for instructors, improvement of convenience and autonomy of training and providing a standardized pedagogical approach based on the latest generally accepted recommendations in this area [11].

This study was aimed at assessing the effects of blended CPR training using the AED, in which the full-time theoretical training was completely replaced by open online courses. Both after the traditional full-time training and after the blended one, the level of readiness to assist in the event of cardiac arrest in a stranger and self-confidence raised. Representatives of the group of blended learning evaluated their own knowledge of resuscitation higher than the participants from the group of full-time study after training, but an objective final assessment of knowledge using test control did not reveal the advantages of full-time or blended education. The assessment of practical skills in the simulation scenario also demonstrated a similar level of proficiency in CPR and AED techniques in study groups. According to the results of the automatic registration of the quality of resuscitation, representatives of the blended learning group performed chest compressions with a greater frequency. However, it did not significantly affect the total proportion of compressions that corresponded to the recommended frequency range (100–120 per minute) [16], and other indicators characterizing the effectiveness of a closed heart massage. Both groups expressed a high level of satisfaction with the training.

Studies of the effects of blended learning CPR are few. According to a pilot study by *Moule et al*. (2008), the online training of psychiatric specialists of basic CPR and AED with the subsequent development of skills on a manikin under the guidance of an instructor provided learning and reanimation skills at least equal to classroom training [18]. In the experiment with the participation of medical students, *Lehmann et al*. (2015) found that, compared with full-time training for basic CPR in children, the blended approach based on interactive simulation of cardiac arrest in virtual patients contributed to a more efficient development of theoretical material and the best results of practical training [19]. According to *Park et al*. (2016), the combination of distance and full-time training of basic CPR and defibrillation provided a significant improvement in the ability of nursing students to solve problems on their own, increased confidence in their own skills, as well as improved CPR and defibrillation skills according to the results of an objective assessment [20].

Significant methodological differences in training programs do not allow a direct comparison of the published data with the results of our research to be performed. However, the results confirm the effectiveness of the blended form of education compared to full-time CPR and AED in general. As far as the authors know, today the course "First Aid at Cardiac Arrest (Basic Resuscitation)" [15], hosted on the platform of massive open online courses by *Stepik*, is the only constantly functioning reviewed online free course on CPR in Russian [13]. Given the demonstrated effectiveness, this course can be recommended

as a component of CPR training programs with the use of the AED for the replacement or addition of full-time theoretical training.

RESTRICTIONS

Since both study groups were trained under the guidance of the same instructors, we cannot exclude that the instructors guessed about the planned comparison of the effectiveness of the training, which could affect the results of the study.

The sample size of this study was limited to the actual number of people willing to participate. The additional research with higher number of participants, having more statistical power, may improve the accuracy of the identified differences.

FINDINGS

1. The suggested form of blended learning basic cardiopulmonary resuscitation using an automated external defibrillator, combining remote theoretical training and full-time practical training, is as much effective as traditional classroom resuscitation training.

2. Reducing the duration of classroom training due to the remote development of theoretical material can help reduce the load for instructors, training-related financial costs and increase the availability of training.

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