ORIGINAL RESEARCH

Signa Vitae

Challenges in basic life support and automated external defibrillator training of deaf individuals

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Abstract

Objectives: Basic life support (BLS) with the use of an automated external defibrillator (AED) is linked to survival of patients with out-of-hospital cardiac arrest (OHCA). However, the BLS protocol is not tailored to specific needs of the deaf who encounter many challenges during BLS training.
Methods: The BLS and AED protocol was modified according to the challenges faced by deaf people. Pre-course BLS and AED knowledge was tested using a questionnaire. After completion of a practical course, each participant was presented with an OHCA scenario using a manikin. Qualitative and quantitative data on BLS and AED performance were collected with a modified Cardiff test and the QCPR mobile application. Results of the knowledge test and performance scores are presented with values and frequencies. Correlations between pre- and post-course BLS and AED knowledge and performance were analyzed and presented with Spearman's rho.
Results: 51 deaf volunteers from seven Slovenian deaf associations participated in the study. The pre-course knowledge test scores were 3.5 points out of 10 and considered low. The rest of the results were also poor. BLS performance using the modified Cardiff test post-course was as follows: 52.9% of the participants used a safe approach, 58.8% checked responsiveness and 51.0% sent a text message to the rescue service. Only 43.1% opened the airway and 49.0% checked initial breathing. 80.4% of deaf rescuers performed chest compressions on the lower half of the sternum and 52.9% compressed with adequate depth. According to the QCPR application the best performance was achieved with a compression score of 61.1% and flow fraction 74.9%.
Conclusions: This study shows that a comprehensive and assiduous approach is needed for effective BLS and AED training courses for deaf individuals.

Keywords

Automated external defibrillator; Cardiopulmonary resuscitation; Deafness; Education

1. Introduction

An out-of-hospital cardiac arrest (OHCA) is one of the leading causes of death in Europe [1] and the recommended treatment for an OHCA are immediate basic life support procedures (BLS) [2]. Teaching lay people BLS is essential in survival of patients with OHCA [3]. However, guidelines for BLS are not tailored to specific needs of the deaf. There are several steps that deaf individuals have difficulties with or cannot perform: listening to check initial breathing, calling the emergency number 112 or using an automated external defibrillator (AED) with voice instructions [4]. The use of an AED is one of the basic resuscitation procedures to stop malignant arrhythmias [5], but the device itself is often not adapted for use by the deaf, as it provides only voice instructions. The AED must be equipped with visual instructions to shorten the time to defibrillation [6]. To the best of our knowledge, few have studied the BLS performance by deaf individuals. Sandroni *et al*. [6] assessed the capability of deaf rescuers to defibrillate effectively using an AED with visual prompts and Tomasetti *et al*. [7] evaluated the cognitive and psychomotor scores immediately after the course.

Most deaf people use sign language with its own grammar and syntax. It differs markedly from the mother tongue and is not its gestured representation [8]. Therefore, the deaf who use sign language are not fluent in the language of their surroundings leading to low levels of reading comprehension [9]. In addition, low health literacy and knowledge are described in deaf people [10–12]. They are not familiar with the symptoms [10] and vocabulary regarding most common cardiovascular health issues [13]. Therefore, both deaf trainees and their instructors face many challenges during BLS training, from communication issues to inability to follow standard BLS protocols. The aim of the study was to assess hindrances the

TABLE 1. Analysis of questions on pre-course knowledge test (N = 51).

Question	% Correct answers (N)
1. How do you recognize a person in cardiac arrest?	43.1% (22)
2. Who can help in a case of cardiac arrest?	47.1% (24)
3. A person suddenly loses consciousness and collapses. What do you do?	33.3% (17)
4. How do you check if a person is breathing normally?	47.1% (24)
5. What kind of breathing is NOT a sign of life?	33.3% (17)
6. How is basic life support correctly performed?	25.5% (13)
7. On the sketch of the torso below mark with a cross the correct site for chest compressions during basic life support	43.1% (22)
8. How do you perform artificial breaths in an unconscious person?	49.0% (25)
9. What do you do if you are unsure whether a person is in cardiac arrest or not?	39.2% (20)
10. What is an AED (automatic external defibrillator)?	29.4% (15)

deaf population faces in regard to BLS and AED protocols and to modify them accordingly. We measured the effectiveness of the modified BLS training for the deaf by evaluating cardiopulmonary resuscitation (CPR) performance. During the course, we identified specific challenges deaf adults face during BLS training and proposed measures to improve BLS and AED courses for the deaf.

2. Methods

The study was approved by the National Medical Ethics Committee of the Republic of Slovenia (No. 0120-541/2017/6). Before the beginning of the course, participants received a letter describing the purpose and content of the study. An informed consent and a data administration consent form were completed by participants consistent with the Global Data Protection Regulation (EU) 2016/679. Explanation about the study was provided by the research coordinator. All the information was translated into sign language by a certified sign interpreter.

2.1 Study design

In the first step, an occupational medicine specialist (ZŠ) analyzed the BLS and AED protocol from the latest European Resuscitation Council Guidelines [2] and modified it according to anticipated challenges the deaf would face. The following modifications were proposed to enable successful BLS and AED training of deaf individuals: BREATHING - look and feel for normal breathing; UNRESPONSIVE AND NOT BREATHING NORMALLY - ask a helper to call the emergency services or activate them yourself by sending a text message with crucial data to the Regional Emergency Notification Center -112, which transmits the message to the Emergency medical dispatch Center or informs the deaf call center (available 24 hours daily) and asks them to call 112; WHEN AED ARRIVES- switch on the AED, put it into the visual field and follow the visual prompts.

In the second step, a practical course for deaf volunteers was conducted. In each group, there were a maximum of 10 participants, 5 per instructor. At the beginning of the course, each participant filled out a pre-course BLS and AED

knowledge test [14]. After the pre-course test, there was a 30-minute theoretical lecture and a 45-minute practical training in the modified BLS and AED protocol led by a physician accompanied by a certified sign interpreter. Each participant practiced with a cardboard AED prop with adhesive electrode pads on their own torso training manikin (Prestan CPR Torso, Erler Zimmer GmbH & Co. KG, Lauf, Germany). An AED trainer with visual prompts (AED Trainer, Defibtech LLC, Guilford, USA) was used for guidance. Each trained participant was asked to solve an OHCA scenario on a manikin (Little Anne QCPR, Laerdal Medical, Stavanger, Norway) using the AED trainer. Each OHCA scenario lasted 2 minutes and each participant performed one BLS cycle. To evaluate practical skills gained during the course, qualitative and quantitative data on BLS and AED performance were collected with a modified Cardiff test and the QCPR mobile application (QCPR training 4.0.0. by Laerdal Medical, Stavanger, Norway). The Cardiff test was modified to match the modifications for the deaf made to the BLS and AED protocol. Items of both instruments were collected on a joint checklist. Incorrect performance of the task was scored as 1 point, whereas partially correct or correct performance was scored with 2 to 4 points. Additionally every item was graded as correct or incorrect. BLS performance was evaluated by one of the two instructors (VV and ZŠ).

2.2 Statistical analysis

Frequencies are reported to describe sociodemographic characteristics and answers on the pre-course knowledge test and post-course performance analysis. Practical performance analyzed by the QCPR Laerdal mobile application is presented as means with standard deviation. Correlations among variables were tested using Spearman's rho. SPSS software (version 25, SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

3. Results

3.1 Sample

We contacted all 13 Slovenian deaf associations by email and invited them to participate in the study. We asked them

T A B L E 2. Performance of individual tasks of BLS and AED steps on the modified Cardiff test (N = 51).

BLS Step	BLS Task	% Performed Correctly (N)
Step 1: Safety	Safe approach	52.9% (27)
Step 2: Responsiveness	Check responsiveness - shake	58.8% (30)
	Indicate looking for help	29.4% (15)
Step 3: Airway and breathing	Initial airway opening	43.1% (22)
	Initial check/clear airway	49.0% (25)
	Initial breathing check	31.4% (16)
Step 4: Call for help	Send SMS to rescue service	51.0% (26)
	Send someone to find help and AED	31.4% (16)
Step 5: CPR sequence	Hand position	80.4% (41)
	Average number of compressions (100-120/min)	37.3% (19)
	Average depth of compressions	52.9% (27)
	Open airway for rescue breaths	43.1% (22)
	Close the nose	66.7% (34)
	Perform rescue breaths, check for moving of the thorax	33.3% (17)
Step 6: AED usage	Open and turn on AED	84.3% (43)
	AED electrode on right position	92.2% (47)
	AED in visual field	78.4% (40)
	Hands-off check during analysis	64.7% (33)
	Check for safety and push shock button	45.1% (23)
Step 7:	Continue with BLS	72.5% (37)

to forward our invitation to their members. Deafness was defined as hearing loss of more than 95% by Fowler and using sign language for communication. 51 volunteers from 7 deaf associations participated in the study from 30 January 2019 to 15 January 2020. A total of 28 (55%) were males and 23 (45%) were female. Mean age was 53.6 years of age. Most (78%) a BLS and AED course in the past, usually as part of the driving license course (27%), a free public course (19%) or either at school or at work (16% each). Mean educational level was 4 (ranging from 1 - unfinished primary school to 8 - Master of Arts/Master of Science) an equivalent of 3 years of vocational secondary education (43%). Fifteen participants (29%) had a healthcare worker in the family.

3.2 Pre-course

The mean sum of correct answers on the pre-course knowledge test was 3.51 ($\pm$ 2.22; range 0-8 with max 10) Percentages of correct answers for each question are presented in Table 1.

3.3 Post-course

The mean score on the post-course modified Cardiff test was 42.16 ($\pm$ 7.22; range 28-55).

Percentages of correctly performed BLS and AED tasks are presented in Table 2. Score range, means with standard deviation, minimum and maximum scores achieved on individual BLS steps on the modified Cardiff test are presented in Table A in Supplementary material.

A general overview of BLS performance recorded with the QCPR application with quality assessment scores was as fol-

lows: the overall score (based on compressions, ventilations, and flow fraction) was 53.8% with a flow fraction of 75%, compression score of 61% and ventilation score of 41%.

Correct performance of individual tasks of chest compressions and ventilations assessed by the QCPR application is presented in Table 3.

Analysis of correlations between sociodemographic characteristics of the sample, pre-course knowledge of BLS and AED, and post-course BLS and AED awareness gain is presented in Table 4. Younger age and higher education level are significantly associated with higher score on pre-course test. Presence of a healthcare worker is significantly associated with the overall score on the QCPR application.

4. Discussion

4.1 BLS performance

The current study revealed that mere adjustments of the BLS and AED protocol originally designed for hearing people do not suffice for effective training of deaf individuals. Three crucial tasks of the BLS and AED protocol were modified as the first step of the study: breathing check, alerting emergency services and using an AED. Similar limitations were pointed out in research by Unnikrishnan *et al*. [4].

In the present study, BLS and AED knowledge was tested before the course using a previously developed questionnaire for schoolchildren [14]. The results suggest that BLS knowledge by the deaf people is poor (an average score of 3.5/10) compared to hearing peers (7.8/10) [15] and schoolchildren (an

T A B L E 3. Qualitative analysis of BLS performance with QCPR application (N = 51).

BLS Step	BLS Task	% Performed Correctly (N)
Chest Compressions	Average rate 100-120/min	41.2% (21)
	100% correct chest compressions	2.0% (1)
	Average depth 50-60 mm	23% (12)
	Total number: 140-190	23.5% (12)
	Flow fraction > 70%	47.1% (24)
Ventilations	Total number: 12	2.0% (1)
	Ventilations with adequate chest rise: > 50%	49.0% (25)
	Chest compression to rescue breath ratio: 30 : 2	21.6% (11)

T A B L E 4. Correlation coefficients between baseline characteristics, pre-course test and post-course scores.

	Sum of correct answers on pre-course test	Sum of correct answers on Cardiff	Overall score on QCPR
Gender	-0.068	0.042	-0.095
Age	-0.385**	-0.102	0.01
Education	0.452**	0.24	0.225
Healthcare worker in family	0.021	-0.104	0.325*
Sum of correct answers on pre-course test	1	0.143	0.11

*Note: **, correlation significant at the 0.01 level (2-tailed); *, correlation significant at the 0.05 level (2-tailed).*

average score of 6.0/10, data not published yet). The most incorrect answers were given to the basic questions representing the core of BLS, supporting the observation of insufficient BLS and AED knowledge by the deaf.

Our study showed that BLS and AED performance scored and assessed by the modified Cardiff test was also poor compared to lay people who were given the instructor-led BLS training (76.7% vs 87.0%, respectively) [16]. In our observation, merely half of the participants would use a safe approach to the OHCA victim, check responsiveness, and send a text message to the rescue service. Less than half of them would open the airway and check initial breathing or send someone for help or for an AED. Regarding chest compressions, more than 80% of participants would perform chest compressions in the correct position, 53% of them compressing one third of the diameter of the chest, but less than half of them at an adequate rate. Better results were observed by Tomasetti *et al.* [7] where deaf individuals participated in the standard American National Red Cross 4-hour course signed by the course instructor achieved 27/32 points (84%) on an immediate post-test performance score. Slightly better results were yielded by deaf students given the same 4-hour course who were also shown a captioned video with CPR instructions or a video with CPR instructions interpreted into sign language by the course instructor (86% and 84%, respectively). In contrast to Tomasetti *et al.* [7], a 75-minute course was given to the participants in the present study. In addition, there were some differences in the study population (college students compared to participants with low average educational level and higher age in our study) which could also contribute to the better results in the study by Tomasetti *et al.* [7].

The best performance scores yielded on the manikin in the present study were the compression score and flow frac-

tion representing "low-flow" state in cardiac arrest. Overall performance score on the manikin was reduced on account of poorer results in the ventilation score. There were some score discrepancies in BLS performance between the modified Cardiff test and feedback data from the manikin. According to the manikin data, only 23% of participants compressed the chest with the correct average depth of 50 to 60 mm compared to 53% according to the modified Cardiff test. This fact could be due to more accurate and sophisticated measurements provided by the manikin software, whereas the compression depth on the modified Cardiff test was subjective and estimated by observation.

Family conversations about family medical history and other incidental sources of health knowledge are crucial for developing strong health literacy skills [12, 13]. In the present study a family member working as a healthcare provider was associated with better results in the overall QCPR score after the course. It is likely that a healthcare worker stimulates the conversation with other family members about the medical issues and through family communication promotes an interest in a healthy life style including attaining BLS skills.

4.2 AED

Using an AED can be a challenge for the deaf, as many AEDs provide only voice prompts [17]. On the other hand, untrained deaf rescuers are capable of using an AED with visual prompts appropriately after basic training [6]. Only four participants in our study failed to attach the AED pads in a correct position and eight of them forgot to turn it on. Despite the fact that nearly 80% of deaf participants put the AED into their visual field to be guided by visual instructions, 55% of the participants failed to successfully perform the safety check and press the shock button. Sandroni *et al.* described that 22% of participants did

not deliver a shock because they expected the defibrillator to do it automatically [6].

4.3 Challenges during the BLS course

Communication is the basic challenge for educators of deaf individuals. The major differences between BLS instructions for deaf and non-deaf are the need for a sign interpreter, the need to modify the terminology of BLS instructions and careful explanation of terminology [18]. During the pre-test we observed an extensive effort from the sign language interpreter to explain the meaning and the purpose of the questions. This observation and the low score on the pre-test could be due to a low level of reading comprehension by the deaf. It has been shown that an average student with hearing loss graduates from high school with reading comprehension skills at about fourth grade level [9].

In addition, there is growing evidence in the literature regarding health literacy weaknesses by the deaf [10, 11]. Findings from several studies indicate that deaf individuals have weaker functional health literacy and a smaller fund of cardiovascular health knowledge [10–12]. Nearly 40% of the deaf could not list any of the most common symptoms of a heart attack, while over 60% could not list a single stroke symptom [10, 13]. Moreover, more than one third of the deaf would not call the emergency medical number if they thought they were having a heart attack or stroke, thinking that it is not deaf-accessible [10]. This observation is similar to our study where half of the participants would not send a message to the rescue service in the case of an OHCA even though it could be activated through a text message. Although neither reading comprehension nor health literacy were analyzed in the present study, we assume that low level of both in our study group could contribute to the low scores on the pre-test.

Deficits in reading comprehension and low level of health literacy have an impact on the BLS course. Presentation designed for deaf adults should use simpler English grammar and vocabulary, and more visual information [12]. Our BLS course was led by a physician accompanied by a sign language interpreter from a non-medical field. Signed interpretation appears to be the better way to communicate BLS information to the deaf learners. Signed interpretation may eliminate poor reading comprehension as a potential barrier in learning and retention of BLS skills [7]. Other possible helpful additions could be avoiding changing the position of the instructor during the presentation as it distracts the deaf participants. This is due to the enhanced peripheral visual attention [19, 20] making the deaf subjects more susceptible to peripheral distracters [21]. Also, addressing the short attention span of deaf participants is important. During the course, the attention span of the participants was shorter than expected (it lasted between 25-30 minutes). This observation is supported by studies reporting that poor sustained attention in deaf children improved little with increasing years [22, 23].

4.4 Suggestions

Based on observations from our study the following adjustments for BLS and AED training for the deaf are suggested: presentations and tests should be designed for deaf adults using simpler English grammar and vocabulary. More visual information (including graphics/videos) should be included in the course to yield better results (like in the study by Tomasetti *et al.* [7]). The terminology of BLS instructions should be modified and simplified to a lower level of comprehension. The entire course should be prepared in shorter segments and accompanied by a sign interpreter. Peripheral visual distractors should be minimized during the training (an AED should be put into the visual field).

4.5 Limitations of the study

The study has several limitations. Firstly, we had a small sample size. Secondly, the pre-test was designed for schoolchildren and not for deaf individuals. Due to reading comprehension and health literacy issues a specific pre-test should be developed for deaf adults. Thirdly, we used different measuring instruments before and after the course which made comparison of the results before and after an intervention difficult. Furthermore, the duration of the course was short and a 4-hour training with additional visual aids may result in better post-course scores. Finally, we have not tested the retention of BLS and AED skills.

5. Conclusions

This study shows that a more comprehensive approach is needed in BLS and AED training for the deaf. Challenges in this specific population require specific adjustments of BLS and AED courses, extending beyond modifications of the BLS algorithm. An approach in BLS training focusing only on crucial interventions during CPR (chest compressions only guidelines for the deaf performing CPR) should be considered and evaluated. Further studies are needed to determine an effective approach to BLS and AED training courses for the deaf.

AUTHOR CONTRIBUTIONS

MS has contributed in the conception and design of the work, acquisition, analysis and interpretation of the data and has substantively revised the drafted work. ZŠ has contributed substantially to the conception and design of the work, the acquisition and interpretation of the data. BJ has contributed in the design of the work, acquisition, analysis and interpretation of the data. VBL contributed to the design of the work, analysis and interpretation of the data and has substantively revised the drafted work. VV has contributed substantially in acquisition, analysis and interpretation of the data. RP has contributed in the conception and design of the work, acquisition and interpretation of the data and has revised the drafted work. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the National Medical Ethics Committee of the Republic of Slovenia (No. 0120-541/2017/6).

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at `https://oss.signavitae.com/mre-signavitae/article/1355058895624519680/attachment/SV2020120804_Supplementary%20material.pdf`.

DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon request.

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