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From Public Access Defibrillator to Personal Access Defibrillator: Proposal of Prompts to Optimize Automated External Defibrillation Use by Laypeople

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Abstract

Aim: This study aimed to assess whether integrating additional prompts to the automated external defibrillator (AED) interface could reduce common errors among untrained laypeople.

Materials and Methods: An observational before-after design was employed. The Control group (pre-cohort) consisted of 36 participants from previous research, whereas the after cohort included 36 participants with similar characteristics. All participants were evaluated in a simulated out-of-hospital cardiac arrest (OHCA) scenario. After one minute of chest compressions, an AED was used to deliver shock. In the follow-up cohort, a smartphone provided voice prompts encouraging proper chest compressions and advising against removing the pads or turning off the AED.

Results: In the Control group, six participants turned off the AED (p=0.010), and four removed the pads (p=0.040), while none in the after-cohort group made these errors. Regarding other mistakes, no participants in the after cohort performed compressions in the stomach (two participants in the Control group), two participants did not find the sticky part of the pads (three in the Control group), and two placed the pads in the wrong place (four in the Control group).

Conclusions: Simple voice prompts during the 2-minute interval between AED analyses improved the performance of untrained laypeople in a simulated OHCA scenario.

Keywords: Bystander, cardiopulmonary resuscitation,chest compressions, hands-off time; no-flow time, training

Introduction

The use of an automated external defibrillator (AED) is the third link of the chain of survival (1); it is crucial in the public and expert assistance of out-of-hospital cardiac arrest (OHCA), especially in cardiac arrests (CAs) with shockable rhythms. In these events, early use of AED can triple the chances of survival with good neurological outcomes (2).

The assistance of a CA should not be limited to healthcare professionals, as bystanders also play an essential role in initiating life support manoeuvres that could increase the survival rates of OHCA patients (3). This is the rationale for training the community in basic life support (BLS) and AED use skills (4).

AEDs are designed for laypeople to use safely without prior training. They typically feature two main buttons: one to turn

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on or off and the other to deliver a shock, which is activated only when the AED detects a shockable heart rhythm after analyzing the electrocardiogram. Additionally, AEDs should offer clear visual and auditory instructions to guide users through the defibrillation process, signalling when to administer a shock on the basis of the analyzed rhythm.

However, in practice, some barriers may interfere with optimal use of public defibrillation. In this sense, previous research from our group revealed that naïve laypeople found some relevant problems while using AEDs tested under simulated scenarios, which suggests that the proper use of the device might be less intuitive (5,6). We observed severe or critical errors, such as turning off the AED or removing the pads immediately after an AED shock.

To address these issues, adding prompts to current AED sound messages has been proposed (6). These prompts include 1) "active" advice, given every 30 seconds during the 2-minute chest compression period after a shock, and 2) "reactive" advice, triggered by user errors (i.e., prompting, "Are you sure that the AED is no longer needed?" when the user tries to turn off the AED).

We hypothesize that adding specific active advice on the AED during the 2-min chest compression period between any AED rhythm analysis would improve laypeople's AED performance in terms of potential efficacy. The objective of this study was to analyse whether this improvement in AED function was associated with fewer inappropriate actions, namely, using the AED incorrectly: 1) turning off the AED and 2) removing the pads after shock.

Materials and Methods

Study Design and Ethics

This study followed a before-after design (Figure 1). The study received ethical approval from the Bioethics Committee of the University of Santiago de Compostela on 19 December 2019. In accordance with the institutional policy of the committee, no numerical ethical approval code is issued for research projects. Therefore, while the study was formally approved, there is no associated approval number. The ethical review process was duly completed, and the committee confirmed that the study met all relevant scientific, ethical, and methodological standards.

Population

A convenience sample of 72 university students participated in this study. The inclusion criterion was not having previously undergone any BLS training. Written informed consent was obtained from all participants, who stated that they were participating voluntarily and that they could withdraw at any stage of the research.

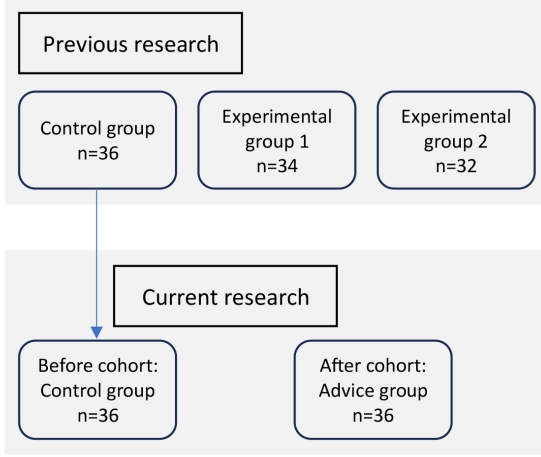

Figure 1. Flow-chart of the before-after design

Pre-intervention

The participants in the "before" cohort (Control group) of this study were 36 individuals extracted from previous research by our team (6). In this research, 102 university students with no prior BLS training were involved, then split into three groups: one Control group (without intervention) and two experimental groups that received two hours of BLS training. Finally, all the participants were exposed to an OHCA simulation scenario with the aim of comparing the no-flow time between groups. Of those 36 participants who composed the Control group, six had to be excluded from the final analysis because they turned off the AED, and four had to be excluded because pads were removed after AED shock during the tests (6).

Intervention

Thirty-six university students were invited to participate in the "after" cohort (advice group) of the present study. None of them had previously participated in any type of BLS training. They were exposed to the same OHCA simulated scenario as the previous cohort. The only change between the preintervention and intervention stages was the implementation of active advice during AED use.

In the OHCA scenario, all participants had to use an AED Trainer 2 (Laerdal). As this device does not emit any prompts during the 2 minutes of cardiopulmonary resuscitation (CPR) between AED analyses, a smartphone was used in the intervention cohort to simulate the voice prompts for active advice during the BLS and AED scenarios, as explained in the BLS assessment subsection.

BLS Assessment

Both cohorts were evaluated by means of a standard OHCA simulated scenario, as described in our previous research (6). In brief, participants were placed in front of a mannequin torso and told that a person had collapsed while crossing a crosswalk. They were then asked, "What would you do?". After that, proficiency in performing the BLS protocol was checked. 1) checking safety; 2) assessing response; 3) opening the airway and checking breathing; 4) alerting the emergency medical services; 5) sending for an AED; 6) starting CPR; and 7) using the AED. The simulated scenario required the delivery of a shock, for which an AED was provided after 1 min of chest compressions. The AED was programmed to recommend two shocks but not a third one, since the casualty was presumed to be breathing spontaneously at that moment.

The AED used in the simulation was AED Trainer 2 (Laerdal, Norway). This type of AED, after shocking and recommending chest compressions, does not provide any prompt during the two minutes between heart rhythm analyses. To simulate active advice from the AED, an audio recording previously recorded by a smartphone was relayed during the 2-min CPR. The voice note was relayed just after the shocking messages shown in Table 1. The participants were told that they should interpret the messages from the smartphone to determine if they were prompted by the AED.

The manikin (Laerdal, Norway) used was a torso able to provide real-time feedback on compression and ventilation quality. The manikin was connected to a Simpad SkillReporter, which was not shown to the participants at any time.

Outcomes

The primary outcome was the number of participants who were able to complete the scenario without turning off the AED or removing the pads from the chest of the manikin. The secondary outcomes included other AED use errors, which were not directly influenced by active advice, such as incorrect tablet allocation or not finding the sticky part of the pads. In addition, the compression fraction was recorded and analysed as a secondary outcome, defined as the percentage of time during which participants were performing chest compressions: 1) during the complete scenario, 2) from the start of chest compressions, 3) from the start of chest compression to the third analysis, and 4) from providing the AED to the third AED analysis.

The results from the BLS and chest compressions, and ventilation quality variables were registered as controls to verify that confounding variables did not influence primary or secondary outcomes.

Statistical Analysis

Categorical variables related to primary outcomes and the BLS sequence were described as absolute and relative frequencies. The compression fraction and CPR quality variables are expressed as medians with interquartile ranges (IQRs). Frequencies were analysed with the chi-square test, while continuous variables were analysed with the Mann-Whitney U test. Statistical analyses were performed with IBM SPSS Statistics v.25 for Macintosh. A significance level of $p<0.05$ was considered for all analyses.

Results

Demographics

Data from the 72 participants were analysed, regarding the mistakes made during AED use. The compression fraction was analyzed only for those participants who completed the OHCA scenario. Table 2 shows the demographic data of the whole sample and of those participants who completed the OHCA scenario. Demographics are presented in this way because the analysis was performed using the data of the whole sample and the participants who completed the scenario.

No significant differences were found in the proportion of females between the groups or in the time spent by each group to complete the OHCA scenario ($p>0.05$ in both analyses). The participants in the advice group were slightly younger than the participants in the Control group ($p<0.05$).

Primary Outcomes

The primary outcomes were the participants who turned off the AED or removed the pads from the chest of the manikin. All the errors associated with AED use are shown in Table 3.

Table 1. Voice advice embedded in the AED procedure

Type of advice	Time related	Text/message
Active	After shocking	Perform chest compressions; push hard and fast in the center of the chest. Do not remove the pads
Active	After 30 seconds	Remember to maintain chest compressions: push hard and fast in the center of the chest
Active	After 60 seconds	Continue with chest compressions until next advice and do not turn-off the AED at any moment
Active	After 90 seconds	Remember to maintain chest compressions: push hard and fast in the center of the chest

AED: Automated external defibrillator

No participants from the advice group turned off the AED or removed the pads during the OHCA simulation, whereas 10 Control group participants made some of these mistakes (p=0.001).

Secondary Outcomes

The secondary outcomes were the errors that were not directly influenced by the active advice and the compression fraction. Table 3 shows no significant differences between the groups in terms of errors related to not finding the sticky part of the pads and incorrect allocation of pads.

Regarding compression fraction, this variable was registered in four-time intervals, and the results are shown in Table 4. Although a trend toward an increase in the compression fraction was observed at all intervals in the advice group, no significant differences were found.

Controls

The BLS sequence proficiency and chest compression quality in the control and advice groups are shown in Additional file 1, Tables 1 and 2. The BLS sequence performance was poor in both groups, with less than half of the participants able to correctly perform most of the steps. Only significant differences between groups were observed in the starting chest compressions step [Control group: 10 participants (52.6%); advice group: 28 participants (90.3%); p=0.002].

With respect to the quality of chest compressions, no differences in the number of compressions performed, median compression depth, median compression rate, or percentage of correct chest compressions by hand position were found between groups. The median compression depth was shallower than the 50 mm recommended by the European Resuscitation Council Guidelines 3 in both groups [Control group: 33 mm (IQR: 26-46); advice group: 36 mm (IQR: 26-42)]. Although the median compression rate was between 100 and 120 com·min^{-1}, the first quartile was lower than 100 com·min^{-1} in both groups (Control group median: 110 com·min^{-1}; IQR: 85-126; advice group median: 103 com·min^{-1}; IQR: 80-117).

Table 2. Sample demographics

	Whole sample		Participants who completed the scenario	
	Control group (n=36)	**Advice group** (n=36)	**Control group** (n=19)	**Advice group** (n=32)
Female[a]	23 (63.9)	25 (69.4)	13 (68.4)	23 (71.9)
Age[b] in years	21 (21-21)	20 (19-21)	21 (21-21)	20 (19-21)
Time to complete the scenario[b] in s	--	--	555 (520-592)	525 (504-560)

[a]: Absolute frequencies (relative frequencies), [b]: median (interquartile range)

Table 3. Errors registered within AED use

Error	**Control group (n=36)**	**Advice group (n=36)**	**Chi-square**
Turning-off the AED	6 (16.7)	0 (0)	0.011
Removing the pads	4 (11.1)	0 (0)	0.040
Compressions on the stomach	2 (5.6)	0 (0)	No sig.
Not finding the sticky part of the pads	3 (8.3)	2 (5.6)	No sig.
Wrong pads allocation	4 (11.1)	2 (5.6)	No sig.

AED: Automated external defibrillator

Table 4. Chest compression fraction showed as median (IQR)

Interval	**Control group (n=19)**	**Advice group (n=32)**	**Mann-Whitney U test**
Complete scenario	52.0 (43.0-58.0)	58.0 (49.0-62)	No sig.
From starting compressions	63.4 (52.7-68.9)	65.5 (58.7-69.4)	No sig.
From compressions to the third analysis	66.9 (57.2-74.0)	70.2 (61.1-76.1)	No sig.
From providing the AED to the third analysis	61.6 (49.9-70.0)	65.4 (55.7-71.5)	No sig.

AED: Automated external defibrillator, IQR: Interquartile range

Discussion

AEDs have been designed to be applied quickly and with minimum advice both by health professionals and the public (3), but our study has shown that simple audio prompts may even enhance AED function.

In 1995, the American Heart Association published the first statement of public access defibrillation (PAD), with the goal of increasing early defibrillation in patients with OHCA (7). For instance, significant efforts have been made to increase public awareness and make AEDs more accessible. Some strategies to improve bystander defibrillation rates include deploying publicly available AEDs, implementing citizen responder programs, or dispatching mobile AEDs (8), including the use of drones to deliver AEDs, which is a hot topic of research (9-11). However, there is still a low rate of bystander defibrillation (12) even in states where onsite availability of AEDs is mandatory (13,14), with regional variability in AED accessibility (15). In addition, although most OHCAs occur at home, AEDs are not available 24/7. A study performed in Canada reported that AEDs are available only 44% of the time, mainly from 10:00 am to 4:30 pm (15). Consequently, bystander defibrillation is even less common in patients experiencing OHCA at home (16).

Almost three decades after the first statement of PAD, the goal of significantly increasing bystander defibrillation has not been achieved. Brooks noted that instead of working around the technology, an AED technology that has barely changed in recent decades, we should consider changing it (17). Thus, it is necessary to focus not only on technological factors but also on human factors to increase awareness, knowledge, and competencies that allow laypeople to perform CPR and use AED during OHCA. Brooks advocates shifting the paradigm from public access defibrillators to personal access defibrillators, while developing new models that are more affordable and ultraportable (17). In addition, it was assumed that AEDs are easy to use and that anyone without training can successfully use them. However, according to simulated studies, this might be only partially true, as laypeople find it difficult to solve OHCA simulated scenarios that require the use of AED (5,6), even with the assistance of a dispatcher (18).

Our study revealed that only the implementation of simple active messages during a two-minute period of chest compressions between AED analyses was sufficient to increase the number of participants who successfully solved the simulation scenario (from 52.8% in the Control group to 88.9% in the advice group). The active messages reduced critical mistakes that could prevent the delivery of a shock in a real-life situation, such as turning off the AED or removing the pads. This approach involves simple messages every 30 seconds encouraging laypeople to keep compressing the chest, since the 2 min between AED analyses might be perceived as much longer, making the silence uncomfortable and resulting in uncertainty about what to do during that time (5).

The implementation of active messages or new prompts in the current functions of the AED could be considered feasible measures to change the paradigm mentioned above. In the design of a teaching-learning process, it is important to consider the characteristics, motivations, and capacities of the students. If the goal is to increase bystander AED use, it is necessary to adapt new models and their functions to the public, in addition to public initiatives. Previous research has recommended changing from the current AED to an automated intelligent external defibrillator (AiED), in which not only the active messages assessed in the present study are recommended but also reactive messages (e.g., “Are you sure that the AED is no longer needed?” If the device is attempting to turn off) (5,6). Other advice was proposed, for example, to activate the paediatric mode and to place the pad (19).

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Study Limitations

This study is not free of limitations. A before-after design was chosen, which could introduce potential confounding factors inherent to this type of methodology. However, control variables revealed that both arms of the study were comparable. Although the simulation scenarios try to be as realistic as possible, there are psychological variables that are not present. For instance, the pressure to assist in real CA the fear of failure or other emotional factors might influence the results, which means that our results cannot be directly extrapolated to real OHCA patients. Future studies should provide further evidence to corroborate our findings, as this study was carried out on a specific sample, which limits its generalizability.

Conclusion

The implementation of simple active voice prompts during the 2-min interval between consecutive AED analyses improved the performance of laypeople in a simulated OHCA scenario. None of the participants made critical mistakes, such as turning off the AED or removing the pads during the simulation, which meant that more participants successfully completed the scenario.

Ethics

Ethics Committee Approval: The study received ethical approval from the Bioethics Committee of the University of Santiago de Compostela on 19 December 2019. In accordance with the institutional policy of the committee, no numerical ethical approval code is issued for research projects. Therefore, while the study was formally approved, there is no associated approval number. The ethical review process was duly completed, and the committee confirmed that the study met all relevant scientific, ethical, and methodological standards.

Informed Consent: Written informed consent was obtained from all participants, who stated that they were participating voluntarily and that they could withdraw at any stage of the research.

Footnotes

Authorship Contributions

Concept: C.A-G., Design: C.A-G., A.C.F., A.R.N., Data Collection or Processing: C.A-G., A.C.F., C.P.D., C.G.R., Analysis or Interpretation: C.A-G., Literature Search: C.A-G., Writing: C.A-G., A.C.F., C.P.D., C.G.R., A.R.N.

Conflict of Interest: No conflict of interest was declared by the authors.

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