The Journal of Emergency Medicine, Vol. 43, No. 3, pp. 472–477, 2012
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0736-4679/$ - see front matter

doi:10.1016/j.jemermed.2011.09.011

Selected Topics: Prehospital Care

# MOBILE PHONE-ASSISTED BASIC LIFE SUPPORT AUGMENTED WITH A METRONOME

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☐ **Abstract—Background: Basic life support (BLS) performed by lay rescuers is poor. We developed software for mobile phones augmented with a metronome to improve BLS. Study Objectives: To assess BLS in lay rescuers with or without software assistance. Methods: Medically untrained volunteers were randomized to run through a cardiac arrest scenario with (“assisted BLS”) or without (“non–assisted BLS”) the aid of a BLS software program installed on a mobile phone. Results: Sixty-four lay rescuers were enrolled in the “assisted BLS” and 77 in the “non-assisted BLS” group. The “assisted BLS” when compared to the “non-assisted BLS” group, achieved a higher overall score (19.2 ± 7.5 vs. 12.9 ± 5.7 credits; *p* < 0.001). Moreover, the “assisted BLS” when compared to the “non-assisted” group checked (64% vs. 27%) and protected themselves more often from environmental risks (70% vs. 39%); this group also called more often for help (56% vs. 27%), opened the upper airway (78% vs. 16%), and had more correct chest compressions rates (44% ± 38% vs. 14% ± 28%; all *p* < 0.001). However, the “assisted BLS” when compared to the “non-assisted BLS” group, was slower in calling the dispatch center (113.6 ± 86.4 vs. 54.1 ± 45.1 s; *p* < 0.001) and starting chest compressions (165.3 ± 93.3 vs. 87.1 ± 53.2 s; *p* < 0.001). Conclusions: “Assisted BLS” augmented by a metronome resulted in a higher overall score and a better chest compression rate when compared to “non-assisted BLS.” However, in the “assisted BLS” group, time to call the dispatch center and to start chest compressions was longer. In both groups, lay persons did not ventilate satisfactorily during this cardiac arrest scenario.** **© 2012 Elsevier Inc.**

☐ **Keywords—basic life support; cardiac arrest; chest compression; resuscitation; training; ventilation**

## INTRODUCTION

Sudden cardiac arrest is a leading cause of death in industrialized countries (1). Irreversible ischemic injury to heart and brain occurs within minutes after untreated cardiac arrest. Although emergency medical services response time may be a few minutes in urban areas, it may be notably longer in rural areas, thus further reducing chances of favorable outcome (2,3). Out-of-hospital cardiac arrest can be treated with prompt and correct Basic Life Support (BLS) measures, such as chest compressions, ventilation, and early defibrillation (4). However, professional rescuers need at least a few minutes to arrive at the scene, resulting in ischemia that may be too profound to avoid fatal hypoxia-related harm to the brain and heart (5). Therefore, bystander BLS is a key factor for a favorable outcome after out-of-hospital cardiac arrest (6). Unfortunately, BLS quality performed by lay rescuers may be low. Lay-rescuer-associated problems include performing only a fraction of the recommended

RECEIVED: 1 August 2010; FINAL SUBMISSION RECEIVED: 26 April 2011;
ACCEPTED: 27 September 2011

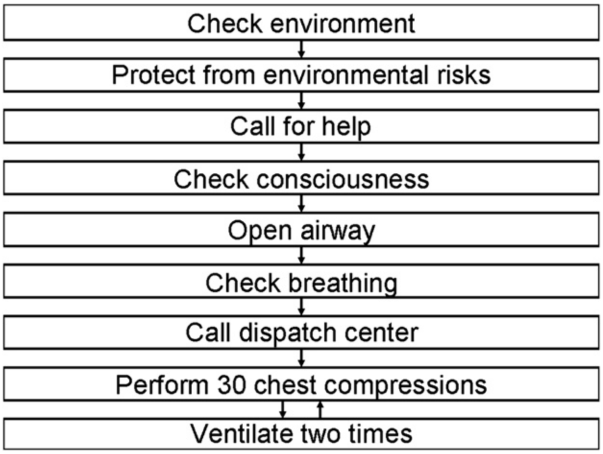


**Figure 1. Basic Life Support algorithm for the scenario of this study: "A ~60-year-old person suddenly collapses while crossing a road with moderate traffic. You are the nearest bystander. Could you please help?"**

steps in BLS, performing chest compressions too slowly and too shallowly, and refraining from ventilating the patient due to a fear of acquiring an infection (7,8). Thus, several programs have been initiated to increase efficient BLS initiated by lay rescuers witnessing cardiac arrest (9–11).

To improve lay rescuer cardiopulmonary resuscitation (CPR), we developed a BLS software program with a metronome incorporated in a mobile phone. The aim of the present study was to investigate differences between mobile phone-assisted and non-assisted BLS provided by lay rescuers. Performance during BLS was evaluated with computer software and a score chart. The overall score during a BLS scenario was the primary endpoint, similarly to prior studies (10,11). The null hypothesis was that there would be no difference between the "assisted BLS" and the "non-assisted BLS" group.

## MATERIALS AND METHODS

The head of the local ethics committee in Bozen, Italy, waived ethics committee approval.

### *Study Setting*

Written informed consent was obtained from medically untrained, unpaid, healthy visitors of a trade fair in Bozen before participation. Volunteers were randomized employing a randomization list generated with a software package (http://randomizer.org/) to run through a cardiac arrest scenario with ("assisted BLS") or without ("non-assisted BLS"; control group) the aid of a BLS software program (co-owners Bruno Mandolesi, Bruneck, Italy and Weisses Kreuz-Croce Bianca, Bozen, Italy; http://www.first-aid-platform.info) based on the 2005 international BLS algorithm, installed on a mobile phone (N74, Nokia, Espoo, Finland) (12). The software explains the BLS approach in nine consecutive figures with integrated text (Figure 1) according to the 2005 BLS guidelines (an update according to the 2010 CPR guidelines is available as of 2011) (13). Within approximately 5 s, a user is guided to call the dispatch center and within 10 s, to start chest compressions. Moreover, the software gives an audible signal for correct chest compression rate (12). The metronome default setting is 100 beats $\text{min}^{-1}$ and is activated only in the chest compression step. During a 10-min introduction, a moderator (coauthors I.P., T.B., E.G., or T.M., Advanced Life Support-certified physicians) showed every volunteer of the "assisted BLS" group how to navigate the software from the first to the last of the nine BLS steps (Figure 1). Then, the volunteer was assisted when he tested the software; the focus of this introduction was exclusively on software handling, not on BLS algorithm learning. On the contrary, volunteers of the "non-assisted BLS" group performed CPR based on their current knowledge only, without the 10-min software introduction, and without any help from the BLS software. Before the start of the scenario, a moderator outlined the scenario to every volunteer: "A ~60 year old person suddenly collapses while crossing a road with moderate traffic. You are the nearest bystander. Could you please help?" Software and scenario explanation were standardized using an instruction flow chart. After answering volunteer's queries, the scenario began; and volunteers had to handle the scenario without any additional help by the moderator. A manikin (Resusci Anne Skill Reporter; Laerdal, Stavanger, Norway) had to be treated as a person in cardiac arrest. The scenario lasted for 10 min, until the supposed arrival of an ambulance. Performance graduation was done after scenario completion with the PC SkillReporting software (Laerdal, Stavanger, Norway) and a score chart (Table 1), similar to previous studies (10,11).

### *Statistics*

Prior data for the primary endpoint overall score in the BLS scenario indicated a difference of seven points, with a common SD of 3 (11). Thus, we planned a study with 60 pairs of subjects, enabling us to reject the null hypothesis that the group difference is zero, with a power of more than 95% at an alpha level of 0.05. To check for normal data distribution, the Kolmogorov-Smirnov-Test was used. Due to significant deviation from linearity of most parameters, non-parametric Mann-Whitney U-Test was used to assess differences of continuous parameters. Categorical data were assessed using chi-squared and Fisher's exact test, as appropriate. All tests were conducted two-tailed with a $p$-value < 0.05 indicating statistical

**Table 1. Score Chart Employed for Evaluation of the Basic Life Support Performance**

| Step | Score - Test | Score (Credits)* |
|---|---|---|
| Check environmental hazard | | 2 |
| Protect from environmental hazard | | 1 |
| Call help | | 2 |
| Check consciousness | | 3 |
| Open airway | | 2 |
| Check breathing | | 3 |
| Call dispatch centre | | 3 |
| Compression depth (Credits; %) | | 6 credits max. (0, 2, 4, or 6 credits for correct quarter) |
| Compression rate (Credits; %) | | 6 credits max. (0, 2, 4, or 6 credits for correct quarter) |
| Compression position (Credits; %) | | 3 credits max. (0, 1, 2, or 3 credits for correct quarter) |
| Tidal volume (Credits;%) | | 6 credits max. (0, 2, 4, or 6 credits for correct tidal volume quarter) |
| Ventilation flow (Credits;%) | | 3 credits max. (0, 1, 2, or 3 credits for correct quarter) |
| Ventilation rate (Credits; %) | | 4 credits max. (4 credits: 4–6/min; 2 credits: 2–3/min or 7–10/min; otherwise 0 credits) |
| Maximum possible score | | 44 |

Start scenario until call of the dispatch centre (seconds): ___________________________
Start scenario until onset of chest compression (seconds): ___________________________

* Credits for compression depth, rate, position, and tidal volume, ventilation flow, and rate were assigned according to the nearest quartile reached by total percent.

significance. SPSS 15.0 (SPSS, Chicago, IL) was used for all statistical analysis.

## RESULTS

Demographics of volunteers are given in Table 2. Regarding the primary endpoint overall score, the "assisted BLS" when compared to the "non-assisted BLS" group achieved a higher score (19.2 ± 7.5 vs. 12.9 ± 5.7 credits; $p < 0.001$; Figure 2). Moreover, rescuers with mobile phones checked (64% vs. 27%; $p < 0.001$) and protected themselves more often from environmental risks (70% vs. 39%; $p < 0.001$; Figure 3). Additionally, they more often called for help (56% vs. 27%; $p < 0.001$) and opened the upper airway (78% vs. 16%; $p < 0.001$), and had more correct chest compression rates (44 ± 38 vs. 14 ± 28%; $p < 0.001$; Figure 3). However, the "assisted BLS" when compared to "non-assisted BLS" group was slower in calling the medical emergency dispatch center (113.6 ± 86.4 vs. 54.1 ± 45.1 s; $p < 0.001$) and initiating chest compressions (165.3 ± 93.3 vs. 87.1 ± 53.2 s; $p < 0.001$; Figure 4). Between the two groups, checking consciousness, chest compression depth, chest compression position, and ventilation parameters were comparable (Figure 3).

**Table 2. Demographics of Volunteers**

| | Assisted BLS (n = 64) | Non-assisted BLS (n = 77) | *p*-Value |
|---|---|---|---|
| Gender (males, females) | 30, 34 | 31, 46 | 0.50 |
| Age (years) | 32.7 ± 13.6 | 33.1 ± 12.2 | 0.68 |
| Height (cm) | 172.7 ± 7.9 | 170.1 ± 9.1 | 0.27 |
| Weight (kg) | 67.7 ± 12.9 | 68.4 ± 10.9 | 0.84 |

BLS = Basic Life Support.

## DISCUSSION

Assisted BLS augmented by a metronome resulted in a higher overall score and a better chest compression rate when compared to BLS without assistance. Nevertheless, both groups achieved less than half of the possible overall score, which is in accordance with other studies investigating software-assisted BLS (10,11). Also, the "assisted BLS" group needed more time to call the dispatch center and to start chest compressions compared to the "non-assisted BLS" group.

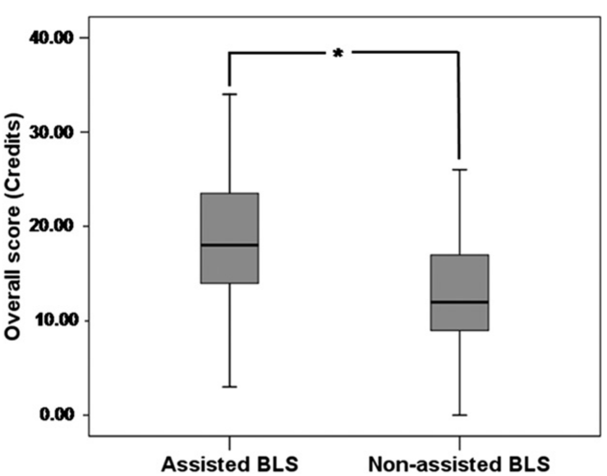


**Figure 2. Overall score achieved in the cardiac arrest scenario in the "assisted BLS" vs. "non-assisted BLS" group. Maximum possible score was 44 credits. BLS = Basic Life Support. *$p$ < 0.001.**

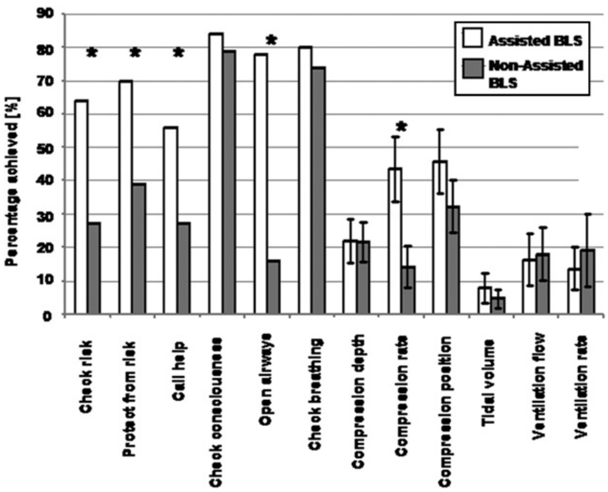


**Figure 3. Cardiopulmonary resuscitation performance. Data are presented in percentages ± 95% confidence intervals when appropriate; percentages indicate correct performance. BLS = Basic Life support. *$p < 0.001$.**

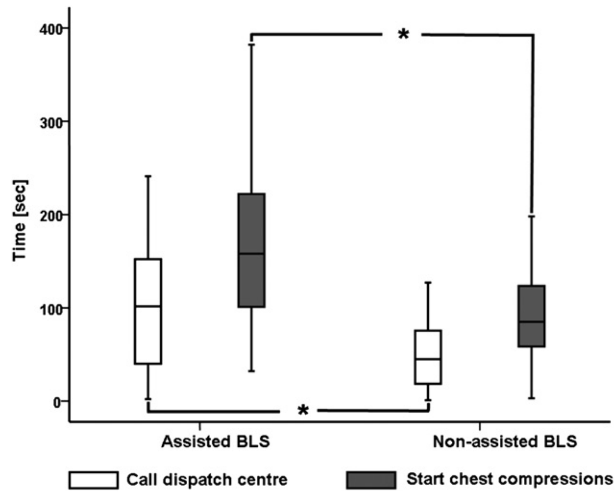


**Figure 4. Time employed by the "assisted BLS" and the "non-assisted BLS" group to call the dispatch center and to start chest compressions. BLS = Basic Life Support. *$p < 0.001$.**

The BLS algorithm was augmented by a built-in metronome indicating the correct chest compression rate, resulting in improved chest compression rates in the "assisted BLS" group compared to the "non-assisted BLS" group. This is a very important finding because defibrillation success and, finally, survival markedly depend upon a sufficient number of chest compressions per minute (14). Although the metronome improved chest compression rate in the "assisted BLS" group, it did not improve chest compression depth, which is in accordance with recently published studies (15,16). Our results are also in accordance with previous studies that underlined the potential benefit of software-assisted BLS to improve CPR quality (10,11). Importantly, this software is not dependent on a mobile phone network; thus, it may be advantageous for remote and mountainous areas when compared to other software depending on a mobile phone network (3,17).

The "assisted BLS" group, compared to the "non-assisted BLS" group, needed more time from "scenario start until call of the dispatch center" and from "scenario start until onset of chest compressions." This is in agreement with previous studies suggesting that lay rescuers may take too long to follow the instructions given by a BLS software program (11). This is potentially harmful, because early defibrillation and chest compressions within the first minutes are essential to reverse ventricular fibrillation (18). Probably, volunteers in the "assisted BLS" group were distracted by handling the software and its hints, thus wasting time until calling the dispatch center and starting chest compressions. Therefore, future software should be easier to handle and incorporate early advice to call the dispatch center, and to start chest compressions.

Between the two BLS groups, checking consciousness, chest compression depth, chest compression position, and ventilation parameters were comparable. Efficient chest compressions are important for good CPR outcome (19). Thus, a method to improve chest compression depth would be an important step forward in improving software-assisted BLS. Recently, the instruction "push as hard as you can" when performing chest compressions resulted in better chest compression depth at no cost to total release or average chest compression rate when compared to the standard approach "push down 5 cm" (20). Thus, including the instruction "push as hard as you can" in a future BLS algorithm could be advantageous. Another option to improve chest compressions could be real-time audiovisual feedback over a video mobile phone (21).

Also, our BLS algorithm guided lay rescuers to open the upper airway more correctly. Unfortunately, this did not result in better ventilation results. This is in agreement with other studies employing a similar software program (22). Also, recent studies suggest that ventilation rate, even by professional rescuers, is too fast, and stomach inflation caused by excessive ventilation efforts during CPR may impair hemodynamic and pulmonary function (23,24). It is of note that ventilation was dismal in both groups. Thus, our study provides further evidence that lay rescuers are not able to ventilate properly during a cardiac arrest scenario, and underlines the call of some authors to renounce ventilations during BLS provided by untrained lay rescuers (13,25). Thus, according to this evidence, mobile-phone based BLS software should omit recommending ventilations and focus on calling the dispatch center early, on initiating chest compressions early, and on efficient chest compressions.

*Limitations*

First, we assessed BLS skills in an experimental setting only; results may vary in a real cardiac arrest scenario due to higher stress levels. Second, the mean age of volunteers was ~33 years; older people may be less able to navigate BLS software on a mobile phone. Third, the "assisted BLS" when compared to the "non-assisted BLS" group had the chance to get accustomed to the BLS software with a moderator during the 10-min introduction before the scenario started. However, this introduction did not result in a better performance, as the "assisted BLS" was notably slower than the "not-assisted BLS" group. Thus, with the BLS software, volunteers performed more BLS steps correctly, but needed more time than without software. Finally, employing telephonic dispatch instructions for the "non-assisted BLS" control group would have been an even more realistic scenario. Further studies with improved software, and assessed in older lay rescuers (e.g., > 50 years), are warranted.

## CONCLUSION

In conclusion, "assisted BLS" augmented by a metronome resulted in a higher overall score and a better chest compression rate when compared to "non-assisted BLS." However, in the "assisted BLS" group, time to calling the dispatch center and to starting chest compressions was longer. In both groups, lay persons did not ventilate satisfactorily during a cardiac arrest scenario.

*Acknowledgments*—We would like to thank the emergency medical system White Cross South Tyrol, especially president Dr. Georg Rammlmair, Marco Comploi, and Lorenz Lintner on behalf of all volunteers of White Cross South Tyrol, for their excellent technical and logistical support.

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## ARTICLE SUMMARY

**1. Why is this topic important?**

Bystander Basic Life Support (BLS) is a key factor for a favorable outcome after out-of-hospital cardiac arrest. Therefore, attempts to improve BLS quality performed by lay rescuers might be beneficial.

**2. What does this study attempt to show?**

The aim of the present study was to investigate differences between mobile phone-assisted and non-assisted BLS provided by lay rescuers.

**3. What are the key findings?**

Mobile phone-assisted BLS provided by lay rescuers improved BLS regarding chest compression rate, protection from environmental risks, and call for help compared to non-assisted BLS.

**4. How is patient care impacted?**

This was a manikin study and no patients were included.