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Original Article

The Impact of Medical Students Teaching Basic Life Support to Laypersons

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Basic life support (BLS) courses for laypersons, including cardiopulmonary resuscitation (CPR) training, is known to improve outcomes of out-of-hospital cardiac events. We asked medical students to provide BLS training for laypersons as a part of their emergency medicine education and evaluated the effects of training on the BLS skills of laypersons. We also used a questionnaire to determine whether the medical students who provided the BLS training were themselves more confident and motivated to perform BLS compared to students who did not provide BLS training. The proportions of laypersons who reported confidence in checking for a response, performing chest compressions, and automated external defibrillator (AED) use were significantly increased after the BLS training. The proportions of medical students who reported increased confidence/motivation in terms of understanding BLS, checking for a response, chest compression, use of AED, and willingness to perform BLS were significantly greater among medical students who provided BLS instructions compared to those who did not. BLS instruction by medical students was associated with an improvement in laypersons' CPR accuracy and confidence in responding to cardiac arrest. The results indicate that medical students could gain understanding, confidence, and motivation in regard to their BLS skills by teaching BLS to laypersons.

Key words: BLS, medical education, emergency medicine, resuscitation

High quality cardiopulmonary resuscitation (CPR) performed by bystanders is a confirmed effective strategy to manage out of hospital sudden cardiac arrest [1,2]. Basic life support (BLS) courses for laypersons, including training for CPR in the prehospital setting, have been well established in industrialized countries for decades [3]. With accurate knowledge and experience, laypersons may gain more confidence in performing BLS for cardiac arrest patients [4]. The training program in BLS has been shown to significantly impact knowledge after training [5].

Although educational BLS courses for laypersons in Japan are widely available, the proportion of bystander CPR remains significantly lower in Japan compared with European countries, and implementation problems remain [6,7]. A low participation rate in BLS courses, and therefore a lack of training and confidence in performing CPR, is one possible reason for the low proportion of CPR administered by bystanders [8]. Despite attempts to raise the number of laypersons who complete BLS training, barriers including lack of instructors or opportunities for training, lack of recognition of need, and long duration or high cost of train-

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ing have prevented success [9,10]. Training medical students to become BLS instructors could help overcome these barriers. Accordingly, at our department we have begun to require medical students to provide BLS training for laypersons as a part of their emergency medicine education, which may help to reduce the shortage of BLS instructors.

In this study, we first examined whether the provision of BLS training by medical students would increase the motivation, confidence, and accuracy of laypersons with respect to BLS. Conversely, we examined whether the medical students themselves would experience an increase in confidence and motivation with respect to BLS compared to students who did not teach BLS to laypersons.

Material and Methods

Participants and study design. Resuscitation courses based on Japan Resuscitation Council guidelines were offered by 5th and 6th year Okayama University Medical School students between June of 2017 and October 2021. Eighty-eight medical students were enrolled as instructors for 18 individual BLS courses enrolling a total of 294 laypersons during this period. Between June of 2017 and June of 2020, a CPR skill report system (X-series; ZOLL Medical Corporation, Chelmsford, MA, USA) was available at Okayama University Hospital. Each BLS course was led by four or five medical students who had trained in BLS and was supervised by one attending physician. Immediately before and after the BLS course, the confidence of laypersons in performing CPR tasks was assessed by means of a questionnaire.

Between September of 2021 and October of 2021, a separate group of 24 medical students who were not enrolled in the above-described analysis participated in an analysis of their confidence and motivation in regard to CPR tasks before and after teaching BLS to laypersons. This analysis was also conducted using questionnaires (see below for details).

Informed consent was obtained from the students and laypersons. The study was conducted as a part of an initiative for improving the quality of medical education. Ethical approval was waived according to the policies of our institutional review board.

BLS training program and evaluation of chest compression. Using a Little Anne CPR manikin (Laerdal Medical AS, Stavanger, Norway), 60-minute BLS courses that included training in chest compression, use of an automated external defibrillator (AED), recovery position, and the Heimlich maneuver (abdominal thrusts) were conducted. All laypersons attended one of these 60-minute courses. Eighty of the 294 participants were randomly selected to perform chest compression-only CPR for 2 minutes on a manikin before and immediately after the 60 minutes of BLS training for skill evaluation. The chest compression depth and rate were automatically recorded by a CPR skill report system. Using accelerometer technology, a sensor inside of the ZOLL system automatically captures interruptions in chest compression rate and depth. Accurate chest compression is defined as compression depth between 5 and 6 cm (Figure 1A: the gray band shows accurate compression depth). An accurate compression rate is defined as 100 to 120 compressions per minute (gray band in Fig. 1B) [11].

Questionnaires. All laypersons who attended the BLS course answered a questionnaire immediately before and after the BLS course; answers were anonymous. The following questions were included: "Are you confident in your ability to check for a response?" "Are you confident in your ability to perform chest compression?" "Are you confident in your ability to use the AED?" "Are you willing to perform CPR on an unconscious victim?" As part of the same analysis, the medical students who provided the training were administered a questionnaire that asked a single question: "Are you willing to perform CPR on an unconscious victim?"

In a separate analysis, in order to determine the changes in the confidence and motivation of the medical students following their provision of BLS training to laypersons, questionnaires were given to 12 medical students who were not enrolled in the above analysis and taught BLS to laypersons (BLS Instruction Group) and 12 medical students who did not teach BLS to laypersons (No-BLS Instruction Group). All students in both groups received passive orientation of BLS and BLS training using a manikin on the first curriculum day of emergency medicine education. The following questions were included. "How well do you understand BLS?" "Are you confident in your ability to perform chest compression?" "Are you confident in your ability to use AED?" "Are you willing to perform CPR on an unconscious victim?" A visual analog scale was used to

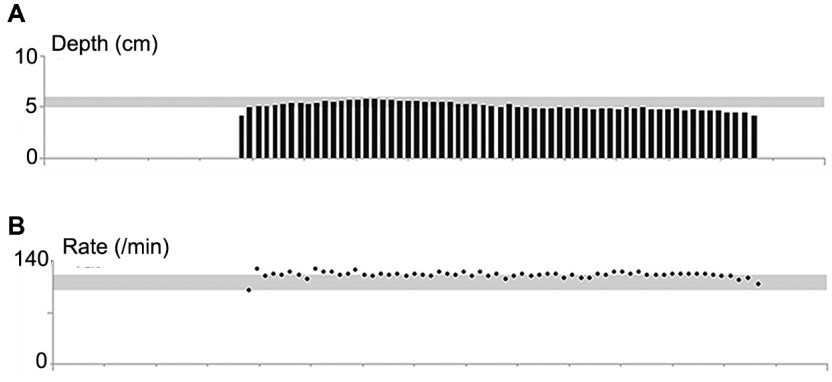

Fig. 1 Example of a recorded CPR skill report system. **A**, Depth is recorded with each chest compression. The gray band is set to the accurate depth of 5-6 cm; **B**, The rate is recorded at each chest compression based on the interval (time) of the previous compression. The gray band is set to the accurate rate of 100-120 compressions per minute.

evaluate the understanding, confidence and motivation of the medical students to perform BLS components before and after teaching BLS in both the BLS Instruction Group and the No-BLS Instruction Group. Responses were given using a scale ranging from 1 (not at all likely) to 10 (very likely).

Statistical analysis. Questionnaire answers were analyzed using the χ-square test. Changes in the confidence of medical students were compared between the BLS Instruction Group and the No-BLS Instruction Group by using a Student's *t*-test. Chest compression depth and rate were analyzed using a Wilcoxon signed rank test. A *p*-value below 0.05 was considered statistically significant. Statistical analyses were performed using Stata/IC version. 16.1 statistical software (StataCorp LLC, College Station, TX, USA). The bee swarm plot was drawn using R statistical software (R: A Language and Environment for Statistical Computing version 4.1.0; R Foundation for Statistical Computing, Vienna, Austria).

Results

Laypersons. Characteristics of the 294 laypersons who participated in the BLS course and responded to the questionnaire are shown in Table 1. The proportion of male laypersons was 61.6%. The most common occupation was non-medical college student (131 participants, 44.6%), followed by teacher (42, 14.3%), university staff (36, 12.2%), and parent of a student (22, 7.5%). Sixty-three laypersons (21.4%) did not respond to the questionnaire. A total of 198 laypersons (67.3%) had past experience with participation in the BLS course.

Instruction by medical students increased layperson confidence. Table 2 shows the confidence of laypersons in their ability to perform CPR techniques before and after the training. The proportions of laypersons who reported confidence in their ability to check for a response, perform chest compressions, and used AED before the BLS session were 32.3%, 18.7%, and 5.4%, respectively. The BLS course resulted in increases in confidence in 91.8% ($p<0.01$), 67.3% ($p<0.01$) and 52.0% ($p<0.01$) of laypersons in terms of their ability to check for a response, perform chest

Table 1 Baseline characteristics of laypersons enrolled in the BLS course

N = 294	No. (%)
Sex	
Male	181 (61.6)
Female	113 (38.4)
Occupation	
Non-medical college student	131 (44.6)
Teacher	42 (14.3)
University staff	36 (12.2)
Student parent	22 (7.5)
Unanswered	63 (21.4)
Previous BLS course	198 (67.3)

BLS: basic life support.

Table 2 Confidence of laypersons in their CPR skills before and after the training

N = 294	Before (%)	After (%)	*P* value
Check for response	95 (32.3)	270 (91.8)	<0.01
Chest compression	55 (18.7)	153 (67.3)	<0.01
AED use	16 (5.4)	153 (52.0)	<0.01

CPR, cardiopulmonary resuscitation; AED, automated external defibrillator.

compressions, and use the AED, respectively. These results revealed that laypersons were significantly more confident in their ability to perform CPR after training by medical students.

Instruction by medical students motivated both laypersons and the medical students themselves. The motivating effects on both the medical students and laypersons were confirmed by the self-assessed willingness to perform CPR for a victim. Most medical students and laypersons showed hesitation to perform CPR before the BLS training. The proportion of medical students and laypersons with high willingness increased from 15.9% to 93.2% ($p<0.01$) and from 12.6% to 78.2% ($p<0.01$), respectively (Table 3).

Instruction by medical students improved the quality of CPR skills in laypersons. Eighty randomly selected laypersons from among the 294 participants were evaluated in regard to their CPR skills using a manikin. Figure 2 shows a bee swarm plot of chest compression depth (2A) and rate (2B) before and after BLS training, with each plot corresponding to an individual participant. The mean chest compression depth was deeper after the training (Figure 2A). The mean chest compression rate did not change, but it showed lower variance after the training (Figure 2B).

Table 4 shows the chest compression quality before and after BLS training. The average chest compression depth was significantly deeper after (before: 5.59 cm; after: 6.07 cm; $p<0.01$) the BLS course. However, there was no significant difference in the proportion of accurate depth (before: 21.1%; after: 27.3%; $p=0.14$). There was also no significant difference in average compression rate before and after training (before: 116.7/min; after: 120.0/min; $p=0.22$). However, a significant improvement was observed in the proportion of individuals who achieved an accurate chest compression rate after training (before: 41.2%; after: 57.7%, $p<0.01$).

Medical students experienced gains in their understanding, confidence and motivation in regard to BLS skills by teaching BLS to laypersons. Table 5 compares the confidence and motivation of medical students in regard to their BLS skills between the BLS

Table 3 Positive attitude toward CPR before and after the training

	Before (%)	After (%)	*P* value
Medical students	14/88 (15.9)	82/88 (93.2)	<0.01
Laypersons	37/294 (12.6)	230/294 (78.2)	<0.01

CPR, cardiopulmonary resuscitation.

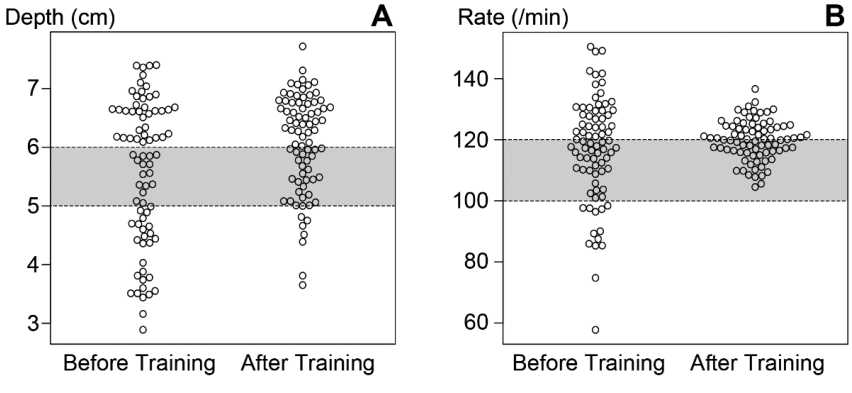

Fig. 2 Bee swarm plot comparing chest compressions before and after the BLS training. **A**, Chest compression depth; the gray band is set to the accurate depth of 5-6 cm; **B**, Chest compression rate; the gray band is set to the accurate rate of 100-120 compressions per minute.

Table 4 Quality of chest compressions before and after BLS training

	Before	After	*P* value
Mean depth (cm, mean ± SD)	5.59 ± 1.22	6.07 ± 0.84	<0.01
Accurate depth (%, mean ± SD)	21.05 ± 26.31	27.28 ± 28.53	0.14
Mean rate (/min, mean ± SD)	116.71 ± 17.21	119.83 ± 6.55	0.22
Accurate rate (%, mean ± SD)	41.20 ± 36.84	57.70 ± 34.51	<0.01

BLS, basic life support; SD, standard deviation.

Instruction Group and No-BLS Instruction Group. A visual analog scale was used to evaluate confidence. Compared to the medical students who did not provide BLS instruction for laypersons, a significant increase in confidence and motivation was seen in the medical students who gave BLS instructions for laypersons in terms of all BLS components: understanding of BLS (BLS Instruction Group: 2.2 ± 1.2; No-BLS Instruction Group: 0.8 ± 1.2; $p < 0.01$), checking for a response (BLS Instruction Group: 2.3 ± 1.9; No-BLS Instruction Group: 0.8 ± 1.3; $p < 0.05$), chest compression (BLS Instruction Group: 2.6 ± 1.7; No-BLS Instruction Group: 1.0 ± 1.1; $p < 0.05$), use of AED (BLS Instruction Group: 2.5 ± 1.6; No-BLS Instruction Group: 0.8 ± 1.3; $p < 0.01$), and willingness to perform BLS (BLS Instruction Group: 3.0 ± 1.8; No-BLS Instruction Group: 0.4 ± 1.2; $p < 0.01$).

Discussion

We demonstrated that BLS training for laypersons provided by medical students significantly improved the accuracy of CPR skills and the confidence in performing CPR in laypersons as measured by the CPR skill evaluation system. BLS training provided by medical students had a favorable effect, increasing the confidence of laypersons in their CPR skills and their motivation to perform CPR. Also, our study indicated that medical students felt more confident and motivated in regard to their BLS skills when they participated in BLS instruction for laypersons than when they did not.

In medical emergencies, lay bystanders are often the first link in the "chain of survival." They can recognize emergencies, call for help, and provide early BLS as needed. Since each additional minute before CPR reduces the chance that a cardiac arrest victim will survive, early and effective CPR performed by bystanders while waiting for an ambulance can save lives. Trained laypersons give emergency victims higher quality first aid, ultimately leading to better victim survival [12-14]. Further investigations will be needed to address the barriers for laypersons who are unwilling to perform CPR, and to identify ways to encourage laypersons in their provision of CPR, use of AEDs, and calling for help for cardiac arrest victims. It will be critical to establish the best methods for BLS trainers to help laypersons overcome their reluctance to perform CPR.

Despite the critical importance of early bystander CPR, there is still too little attention given to teaching CPR skills in a way that attracts students within the curriculum at medical universities [15]. Medical students with only conventional training lack confidence in dealing with cardiac arrest situations. Although medical students feel that the public expects them to respond to such emergencies, they consistently report that they are not sufficiently prepared [16]. We trained medical students to give BLS courses and sent them to teach laypersons, which offered our students the benefits of "learning by teaching" [17]. We believe that having medical students teach BLS may force them to more deeply and actively study and practice resuscitation, which could simultaneously translate to longer-lasting benefits than regular BLS lecture instruction [18]. Medical students need to feel sufficiently trained to

Table 5 Comparison of medical student confidence between the BLS Instruction Group and the No-BLS Instruction Group

	BLS instruction	VAS (Before)	VAS (After)	Difference between VAS (before and after)	*P* value
Understanding of BLS	BLS instruction	6.8 ± 1.7	8.9 ± 1.0	2.2 ± 1.2	<0.01
	No-BLS instruction	7.6 ± 0.7	8.3 ± 1.4	0.8 ± 1.2	
Check for response	BLS instruction	6.3 ± 2.0	8.7 ± 1.1	2.3 ± 1.9	<0.05
	No-BLS instruction	7.3 ± 1.1	8.1 ± 1.1	0.8 ± 1.3	
Chest compression	BLS instruction	6.3 ± 2.1	8.9 ± 1.2	2.6 ± 1.7	<0.05
	No-BLS instruction	7.8 ± 1.2	8.8 ± 0.8	1.0 ± 1.1	
AED Use	BLS instruction	6.6 ± 2.0	9.1 ± 1.0	2.5 ± 1.6	<0.01
	No-BLS instruction	7.8 ± 1.4	8.6 ± 0.9	0.8 ± 1.3	
BLS willingness	BLS instruction	5.9 ± 1.8	8.9 ± 1.1	3.0 ± 1.8	<0.01
	No-BLS instruction	7.8 ± 1.0	8.2 ± 0.9	0.4 ± 1.2	

The data were shown as mean ± standard deviation (SD).
BLS, basic life support; VAS, visual analog scale; AED, automated external defibrillator.

manage emergency situations both inside and outside the hospital. Therefore, senior supervision may be important to maintain teaching quality, especially for the transfer of positive attitudes to learners. Simulation is an effective and popular training tool utilized in medical education across many specialties, including emergency care, and our university is well equipped for simulation-based training. The objective structured clinical examination (OSCE) is now used widely in medical education, and medical students required to take an OSCE are known to be more proficient in their BLS knowledge than their peers not given an OSCE. However, the knowledge acquired through the OSCE does not last long; therefore, re-education in BLS is still necessary for students after passing the OSCE [19]. A previous study demonstrated that students who taught BLS were able to retain knowledge and practical skills [20].

The concept of "learning by teaching" encourages students to play a pivotal role in the education system while simultaneously improving their competency. Active learning by teaching can facilitate intrinsic motivation and provide a more favorable educational effect than passive learning, and cannot be achieved without actual teaching [21]. When learners actually explain, they gain. When learning by teaching, the teacher must obtain a deeper and more lasting understanding, evaluate their knowledge, and confirm that their explanations make sense and are logical [22]. Answering questions asked by learners can also integrate new knowledge with existing knowledge [23]. Occasionally, we adopt a support program incorporating "multi-layered style" education, where 6th-year students provide support and instruction to 5th-year students. Such a program might also promote the learning and retention of BLS skills as part of the medical school curriculum.

Enrollment of medical students to conduct BLS training for laypersons may have several advantages. Medical students are more inclined to strictly follow BLS guidelines and emphasize providing the correct information [10]. Not only is BLS training by medical students less costly, it also overcomes problems with the availability of certified instructors, who generally include registered nurses, emergency medical technicians and other medical professionals [10, 24].

High-quality, accurate CPR is achieved when the compression depth is between 5 and 6 cm, allowing complete chest recoil after each compression; the compression rate is between 100 and 120 compressions per minute; excessive ventilation is avoided; and chest compression interruptions are minimized [11]. In our training course, the proportion of accurate chest compression depth did not change; however, chest compression depth was deeper after the training, which may have been due to the benefit of the medical student instruction. Deeper chest compression may be associated with potential complications such as rib fractures, pneumothorax, or pulmonary contusions. However, some studies have suggested better outcomes with deeper compression depth [25]. Furthermore, our present analysis showed that medical student instruction improved the proportion of learners who achieved an accurate chest compression rate.

Our study has several limitations. It is based on simulation using manikins, and chest compressions may not need to be as forceful in manikins as in a real human body. We did not evaluate complete chest recoil after each compression or excessive ventilation, which are important components of high-quality CPR. In addition, since the study was conducted as a part of a quality improvement initiative, we compared BLS course effectiveness before and after the training, but did not set a control group without student (instructor) education. Our study had a potential lack of generalizability, since it was conducted at a single facility where the number of students was not high. Additional groups of medical students for evaluation of "learning by teaching" were not enrolled in the analysis of improvement of laypersons' CPR quality and confidence of laypersons. Lastly, the study only measured short-term improvement, not retention.

In conclusion, BLS provided by medical students significantly contributed to an improvement in the CPR quality and confidence of laypersons in responding to cardiac arrest. At the same time, by teaching a BLS course, the medical students themselves gained understanding, confidence, and motivation in regard to their own BLS skills and became more actively involved in their emergency medical education. We believe that the involvement of medical students in BLS training courses for laypersons may be a valuable methodology for medical university education to engage learners as teachers.

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