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The effectiveness of teaching chest compression first in a standardized public cardiopulmonary resuscitation training program

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Abstract

Effectiveness of bystander cardiopulmonary resuscitation (CPR) is known to provide emergency medical services which reduce the number of deaths in patients with out-of-hospital cardiac arrest. The survival at these patients is affected by the training level of the bystander, but the best format of CPR training is unclear. In this pilot study, we aimed to examine whether the sequence of CPR instruction improves learning retention on the course materials.

A total of 95 participants were recruited and divided into 2 groups; Group 1: 49 participants were taught firstly how to recognize a cardiac arrest and activate the emergency response system, and Group 2: 46 participants were taught chest compression first. The performance of participants was observed and evaluated, the results from 1 pre-test and 2 post-tests between 2 groups were then compared.

There was a significantly better improvement of participants in Group 2 regarding the recognition of a cardiac arrest and the activation of the emergency response system than of those in Group 1. At the post-test, participants in Group 2 had an improvement in chest compression compared to those in Group 1, but the difference was not statistically significant.

Our study had revealed that teaching CPR first in a standardized public education program had improved the ability of participants to recognize cardiac arrest and to activate the emergency response system.

Abbreviations: AED = automated external defibrillator, CPR = cardiopulmonary resuscitation.

Keywords: automated external defibrillation, cardiopulmonary resuscitation, emergency response system

1. Introduction

According to the Ministry of Health and Welfare in Taiwan, heart disease is the second leading cause of death.[1,2] Sudden cardiac arrest is responsible for causing deaths from heart disease and mostly occurred out of hospital. Cardiopulmonary resuscitation (CPR) is an emergency procedure that combines chest compressions often with artificial ventilation and used in a person suffers sudden cardiac arrest. The success rate of administering an electric shock as part of CPR within 1 minute of a sudden cardiac arrest caused by an arrhythmia is over 90%, but the success rate falls by 7% to 10% per minute after.[3] Previous studies had revealed that effective bystander CPR can significant improve pre-hospital mortality rate.[4–7]

The American Heart Association has issued guidelines for CPR. These emphasize high quality chest compression including rate and depth, compression-breath ratio, and utilization of an automated external defibrillator (AED).[8]

Many studies have investigated strategies to improve the quality of CPR training in the community. These include various traditional classroom protocols including films, reference books, instrumented manikin training, and human modeling,[9,10] traditional classroom vs self-instruction including manuals, videos, and homemade manikins,[11–14] and refresher education.[15] Traditional instruction has focused primarily on chest compression (rate, ratio, depth, and ventilation-compression ratio),[16] feedback devices (verbal, instrumented manikins, videotape),[16,17] and instructor-led vs video AED training.[18]

To the best of our knowledge, no previous study has looked at the order in which the elements of traditional training were presented. The aim of this pilot study was to determine if learning CPR first were more effective than didactic recognition of a cardiac arrest and activation of the emergency response system in terms of skill acquisition and long-term retention.

2. Methods

This study was approved by the Institutional Review Board of Chang Gung Memorial Hospital, and all participants provided informed consent prior to the study.

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The authors report no conflicts of interest.

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Twenty CPR training sessions for the general public were held in 7 cities in Taiwan over a 3-month period. Participants were included if they provided consent, were willing to complete the questionnaires and the training, and to return in 6 months for a retest. Physicians and nurses were excluded. There were up to 48 learners at each site; five of these were selected randomly to participate in the study. At least 38 subjects were required in each group in order to reject the null hypothesis when the improvement in the experimental and control groups would be equal with a probability of 0.99 and a type 1 error probability of 0.05. The entire group at each site received either the lecture or the hands-on practice first. The random subjects were evaluated on CPR procedure before the program started. Group 1 included 49 participants who were first taught to recognize a cardiac arrest and then activate the emergency response system. Group 2 included 46 participants who were taught chest compression first.

The lecturer to learner ratio was 1:8 and the teaching equipment to learner ratio was 1:2. The lecturers in this study are qualified instructors approved by the American Heart Association. Lecturers used the video and answered questions and corrected errors in CPR techniques of the leaners. Evaluators who did not participate in the course marked the participants' skills blindly to the order in which they were presented in the course.

Participants completed a pre-test questionnaire, a post-test questionnaire immediately after the instruction, and a second post-test questionnaire 6 months later the course.

Pre-Test: Participants completed the CPR Attitudes Checklist (Appendix I, http://links.lww.com/MD/C887) first. They then started the CRP procedure when a patient fell to the ground. The correctness of their response was observed and recorded on the "CPR+AED Course Evaluation Form" (Appendix II) by the evaluator. The built-in CPR quality monitoring function of Resusci-Annie manikin recorded the pressure quality for 2 minutes. The whole process was recorded by cameras.

Post-Test 1: After the 90-minute course, participants completed the other questionnaire (Appendix III, http://links.lww.com/MD/C887) and again demonstrated CPR from the time when a patient fell to the ground. The evaluation process including the video-recording was repeated.

Post-Test 2: Participants returned to their original training site 6 months later. They then completed the follow-up questionnaire (Appendix IIII, http://links.lww.com/MD/C887) and the CPR evaluation process was again repeated.

2.1. Statistical analysis

Continuous data were shown as median (lower quartile, upper quartile) and these differences were calculated with the Wilcoxon rank sum test. Categorical data were presented as numbers and compared by the Chi-square tests. All tests were 2-tailed and P value $<.05$ was statistically significant. All analyses were performed using Statistical Analysis Software (SAS), version 9.4 (SAS Institute Inc., Cary, NC, USA).

3. Results

Demographics and basic characteristics of the 2 groups are detailed in Table 1. No significant differences were found between the 2 groups with respect to age, gender, marital status, education or religion. There were also no significant differences between the 2 groups in government employment, work experience in a medical clinic, living with an elderly family member, previous CPR courses, or willingness to perform hand-only CPR on a stranger. However, Participants in Group 2 have a significantly higher percentage of chronic diseases than those in Group 1 ($P=.043$).

Table 1

Demographics and basic characteristics.

	Group 1 (n = 49)	Group 2 (n = 46)	*P*-value
Age (years)	42.5 (33.5, 50)	48 (40.25, 53.75)	.109
Gender			.469
Male	21 (42.9%)	16 (35.6%)	
Female	28 (57.1%)	29 (64.4%)	
Marital status			.946
Married	33 (70.2%)	32 (69.6%)	
Single	14 (29.8%)	14 (30.4%)	
Education			.902
Junior high school and below	7 (15.9%)	9 (19.6%)	
Senior high school	28 (63.6%)	28 (60.9%)	
College, university or above	9 (20.5%)	9 (19.6%)	
Religion			.143
Non	11 (23.9%)	18 (40%)	
Buddhism	24 (52.2%)	13 (28.9%)	
Folk beliefs	8 (17.4%)	11 (24.4%)	
Christian or Catholic	3 (6.5%)	3 (6.7%)	
Government employee			
Yes	32 (71.1%)	31 (70.5%)	.946
No	13 (28.9%)	13 (29.5%)	
Chronic condition			.043
Yes	4 (8.7%)	12 (27.3%)	
No	42 (91.3%)	32 (72.7%)	
Work experience in a medical clinic			.267
Yes	6 (13.3%)	2 (4.4%)	
No	39 (86.7%)	43 (95.6%)	
Live with elderly family member*			.646
Yes	16 (34.0%)	18 (40.9%)	
No	31 (66.0%)	26 (59.1%)	
Any previous CPR course			.246
Yes	19 (40.4%)	13 (28.9%)	
No	28 (59.6%)	32 (71.1%)	
Willingness to perform hand-only CPR on a stranger			.292
Yes	26 (56.5%)	19 (43.2%)	
No	20 (43.5%)	25 (56.8%)	

Group 1: Taught recognition of arrest with activation of emergency response first.

Group 2: Taught chest compression first.Medians (lower quartile, upper quartile) for continuous variables were calculated using the Wilcoxon rank sum test for differences.

Counts (proportion) were shown and the Chi-square test was performed to examine the differences in categorical data.

Bold values indicate a statistically significant difference between groups, $P<.05$.

CPR = cardiopulmonary resuscitation.

* Elderly family member means aged 65 or over.

Comparisons between groups in first aid steps and chest compression steps are shown in Table 2. On the pretest, participates in Group 1 were scored significantly higher than those Group 2 on total score for first aid steps ($P=.027$). Participates in Group 2 had a significantly better score in the "full rebound" step in chest compression than those in Group 2 ($P=.047$). However, there were no differences between groups immediately after training (in Post-Test 1). After 6 months follow-up, the scores for participates in Group 2 were higher for "confirmation of site safety" and "get AED" at AED the first aid steps ($P=.041$ and $P=.039$, respectively). There was no significant difference in the quality of the CPR between these 2 groups after the instruction.

Table 3 summarizes the post-training changes in the first aid and chest compression steps. Comparing between Group 1 and Group 2, the results showed that there was a statistically

Table 2

Comparison between group 1 and group 2 in first aid and chest compression steps.

	Pretest			Posttest			Following-up after 6 months		
	Group 1 (n = 49)	Group 2 (n = 46)	*P*	Group 1 (n = 49)	Group 2 (n = 46)	*P*	Group 1 (n = 29)	Group2 (n = 35)	*P*
AED first aid steps									
Confirmation of site safety	1 (2.0%)	1 (2.2%)	.999	40 (81.6%)	40 (87.0%)	.578	14 (48.3%)	26 (74.3%)	**.041**
Pat patient	22 (44.9%)	17 (37.0%)	.532	48 (98.0%)	45 (97.8%)	.999	28 (96.6%)	34 (97.1%)	.999
Loudly call the patient	23 (46.9%)	12 (26.1%)	.055	48 (98.0%)	45 (97.8%)	.999	29 (100.0%)	34 (97.1%)	.999
Confirm no breath	10 (20.4%)	6 (13.0%)	.416	37 (77.1%)	39 (84.8%)	.435	25 (86.2%)	25 (71.4%)	.226
Confirm no breath for 5–10 s	1 (2.1%)	0 (0.0%)	.999	36 (75.0%)	39 (84.8%)	.307	17 (58.6%)	17 (48.6%)	.460
Call for help	9 (18.8%)	7 (15.6%)	.786	39 (81.3%)	42 (91.3%)	.232	27 (93.1%)	34 (97.1%)	.586
Call 911	20 (40.8)	11 (23.9%)	.086	41 (83.7%)	42 (91.3%)	.358	28 (96.6%)	35 (100.0%)	.453
GetAED	1 (2.0%)	0 (0.0%)	.999	41 (83.7%)	41 (89.1%)	.555	25 (86.2%)	35 (100.0%)	.037
Perform CPR	2 (4.1%)	1 (2.2%)	.999	46 (93.9%)	46 (100.0%)	.243	28 (96.6%)	34 (97.1%)	.999
Start CPR within 10 sec	5 (10.2%)	2 (4.4%)	.438	47 (95.9%)	45 (100.0%)	.59	28 (96.6%)	33 (94.3%)	.999
Total score of 10 first aid steps*	2 (1, 3)	1 (0, 2)	**.027**	10 (8.25, 10)	10 (8, 10)	.123	8.5 (8, 10)	9 (8, 10)	.413
Procedures for chest compression									
Continuous compression, %	55 (22, 96)	47 (19, 97)	.964	100 (100, 100)	100 (100, 100)	.327	100 (100, 100)	100 (100, 100)	.881
Correct position, %	89 (2, 100)	96 (12, 100)	.88	100 (77.5, 100)	100 (86, 100)	.502	100 (95, 100)	100 (99, 100)	.930
Full rebound, %	86 (50, 96)	97 (67, 100)	**.047**	47 (6, 86)	65 (31, 90)	.325	96 (52, 100)	99 (94, 100)	.352
Correct depth, %	0 (0, 48)	0 (0, 45)	.602	72.5 (3.5, 98)	75 (8, 99)	.752	11 (0, 99)	7 (0, 95)	.365
Correct rate, %	1 (0, 18)	15 (0, 33)	.114	39.5 (5.5, 92)	73 (19, 97)	.169	24.5 (0, 83)	17 (0, 79)	.898
Average correct percentage of five-steps in chest compression	38.0 (26.0, 48.2)	42.0 (30.6, 55.2)	.206	47.2 (38, 61.2)	50.8 (40.2, 60.0)	.706	56.2 (43.2, 66.8)	57.4 (42.4, 72.4)	.889

Group 1: taught recognition of arrest with activation of emergency response first.

Group 2: taught chest compression first.

Medians (lower quartile, upper quartile) for continuous variables were examined using the Wilcoxon rank sum test.

Counts (proportion) were shown and the Chi-square test was performed to examine the differences in categorical data.Bold values indicate a statistically significant difference between groups, $P < .05$.

AED = automated external defibrillator, CPR = cardiopulmonary resuscitation.

* Total score was the summation of the aforementioned 10 steps.

Table 3

Comparison between groups in post-training differences in first aid and chest compression steps.

	CPR/AED skill improved after training (vs pre)*		CPR/AED skill declined at follow-up (vs pre)†		CPR/AED skill declined at follow-up (vs post)†	
Label	**Group 1 (n = 49)**	**Group 2 (n = 46)**	**Group 1 (n = 29)**	**Group 2 (n = 35)**	**Group 1 (n = 29)**	**Group 2 (n = 35)**
Confirmation of site safety§	39 (79.6)	39 (84.8)	1 (2)	0 (0)	10 (20.4)	6 (13)
Pat psatient§	26 (53.1)	28 (60.9)	0 (0)	0 (0)	1 (2)	1 (2.2)
Loudly call the patient§	25 (51)	33 (71.7)*	0 (0)	0 (0)	0 (0)	1 (2.2)
Confirm no breath§	29 (59.2)	34 (73.9)	0 (0)	1 (2.2)	4 (8.2)	8 (17.4)
Confirm no breath for 5–10 s§	35 (71.4)	39 (84.8)	0 (0)	0 (0)	10 (20.4)	17 (37)
Call for help§	29 (59.2)	34 (73.9)	0 (0)	1 (2.2)	2 (4.1)	1 (2.2)
Call 911§	24 (49)	32 (69.6)*	1 (2)	0 (0)	1 (2)	0 (0)
Get AED§	40 (81.6)	41 (89.1)	0 (0)	0 (0)	4 (8.2)	0 (0)
Perform CPR§	44 (89.8)	45 (97.8)	0 (0)	0 (0)	1 (2)	1 (2.2)
Start CPR within 10 s§	44 (89.8)	45 (97.8)	0 (0)	0 (0)	1 (2)	1 (2.2)
Change in total score‡,¶	7 (5, 8)	8 (7, 9)*	7 (5, 8)	8 (6, 9)*	0 (−1, 1)	0 (−2, 0)
Continuous compression§, %	21 (−2, 52)	13 (1, 47)	−2 (−56, 4)	−10.5 (−46, 6)	51 (0, 79)	30 (0, 72)
Correct position§, %	0 (0, 73.5)	0 (0, 38)	0 (0, 0)	0 (0, 0)	0 (0, 66.5)	0 (0, 38)
Full rebound§, %	4 (−3, 20.5)	0 (−2, 12)	14 (1, 42)	16.5 (3, 51)	−15.5 (−44, −0.5)	−15 (−45, −1)
Correct depth§, %	1 (0, 29)	0 (0, 14)	0 (−30, 1)	−2 (−17, 0)	16.5 (0, 60.5)	10 (0, 73)
Correct rate§, %	0 (−5, 50.5)	1 (−4, 45)	−9 (−54, 18)	−18.5 (−93, 11)	21 (0, 83)	57 (1, 83)
Change in average correct percentage of five-step chest compression‡	18.8 (3.9, 27.1)	12.6 (−3.4, 26.0)	16.4 (−10.0, 26.8)	4.8 (−1.4, 19.2)	5.1 (−11.7, 30.3)	7.4 (−2.0, 22.2)

Group 1: taught recognition of arrest with activation of emergency response first.

Group 2: taught chest compression first.

An asterisk indicates a statistically significant difference between groups, $P < .05$.

AED = automated external defibrillator, CPR = cardiopulmonary resuscitation.

* Number and percentage of people with improvement after training are shown. Improvement was defined as failing the pretest but doing well on the posttest.

† Number and percentage of people with degradation in skills after training or follow-up are shown. Degradation was defined as doing well on the pretest but failing the posttest.

‡ Medians (lower quartile, upper quartile) for continuous variables were tested using the Wilcoxon rank sum test.

§ Counts (proportion) were shown and the Chi-square test was performed to examine the differences in categorical data.

¶ Total score was the summation of the aforementioned 10 steps (0 = fail and 1 = do well on a step). A minus score means a lower score after training or at follow-up.

significantly better improvement in steps include "loudly call the patient" and "call 911" and a slightly greater improvement in the other steps after the training. Six months post-training fellow-up, there were no significant declines in skills at the first aid steps with participants in Group 1 and 2; yet those in Group 2 had a slight skill-decline than those in Group 1. No significant differences between groups were found in skill changes of the chest compression steps in participants; however, those in Group 2 showed have a less decline in skills at all parameters.

4. Discussion

This pilot study had showed that teaching chest compression first rather than the recognition of cardiac arrest and activation of the emergency response system was more effective in improving long-term learning retention of the steps in first-aid and chest compression trainings. Participants were evaluated in terms of the first-aid steps by ensuring scene safety, checking for a response by tapping the victim, shouting at the victim, checking for breathing, confirming no breathing for 5 to 10 seconds, calling for help, activating the emergency response system (911), getting the AED, starting CPR, and starting CPR within 10 seconds. The elements of chest compression (continuousness, correct position, full rebound, correct depth, correct rate) were also monitored.

Motivation, self-confidence, and skill retention vary by teaching methods. Restructuring a course and rearranging the sequence of content can improve learning outcomes of the course.[19] It appears to be the case in this study. A classical work by Dowling and Braun[20] concluded that meaningfulness facilitated learning retention. Hands-on CPR experience may have enhanced the motivation to apply it and remembered the emergency sequence in which it was used. It may also have focused the attention of participants. Mindfulness involves intentionally bringing attention of individuals to the internal and external experiences occurring at a given time without judgment or attachment to outcomes. Sufficient mindfulness trainings may help participants focus on the task at hand and perform appropriately in a high-stress situation.[21] This may be enhanced by breaking the content to be learned into multiple segments and adding relaxation techniques to the program.[22]

Future studies might consider studying the characteristics of the bystanders such as gender and BMI who may require further personalized trainings when determining which compression to ventilation ration to perform in order to maximize patient outcome.[23] The background knowledge and motivation of participants may be the important factors in CRP training which should be further explored.[24] Consequently, the lecturers with the same teaching materials may have different teaching techniques, the quality of lecturers in CPR may also be considered.[25] Previous studies had suggested that when learning a complex skill, it would be better if the student watches others perform the skill first so that the observational learning is combined with physical guidance.[26] Therefore, a practice-while-watching video and the voice advisory manikin training may facilitate CPR skill acquirement.[27] This should be further measured. Additional learner feedback in respect with the quality of instruction should also be further investigated.[28] Data on whether CPR was performed by trainees would require a much larger cohort followed over a longer period, which we hope to accomplish in future work.

There are limitations to this study. The number of participants available for the 6-month follow-up was small to detect some effects, so that the true scope of retention remained unclear. The quality of the lecturers who had provided CPR training was not evaluated even though all lecturers had completed the AHA's CPR course. Although the participants had not received previous formal CPR training, some of them had received simple CPR education before participating in our study. We considered all participants as initial CPR students.

In conclusion, teaching CPR first as part of a standardized public education program improved the ability of participants to recognize cardiac arrest and activate the emergency response system. Further studies are required to identify the ideal sequence of the teaching materials and to explore learning retention and trainee confidence over a longer timeframe.

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Author contributions

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