Improving cardiopulmonary resuscitation (CPR) performance using an audio-visual feedback device for healthcare providers in an emergency department setting in Malaysia: a quasi-experimental study

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ABSTRACT

Introduction: Cardiopulmonary Resuscitation (CPR) remains the primary mechanism of resuscitation for cardiac arrest victims. However, the quality of delivery of CPR varies widely in different settings, possibly affecting patient outcomes. This study is aimed to determine the efficacy of an audio-visual (AV) CPR feedback device in improving the quality of CPR delivered by healthcare providers.

Methods: This pre-post, single-arm, quasi-experimental study randomly sampled 140 healthcare providers working in the Emergency Department of Hospital Ampang, Malaysia. Parameters of CPR quality, namely chest compression rate and depth were compared among participants when they performed CPR with and without an AV CPR feedback device. The efficacy of the AV CPR feedback device was assessed using the Chi-square test and Generalised Estimating Equations (GEE) models.

Results: The use of an AV CPR feedback device increased the proportion of healthcare providers achieving recommended depth of chest compressions from 38.6% (95% Confidence Interval, 95%CI: 30.5, 47.2) to 85.0% (95%CI: 78.0, 90.5). A similar significant improvement from 39.3% (95%CI: 31.1, 47.9) to 86.4% (95%CI: 79.6, 91.6) in the recommended rate of chest compressions was also observed. Use of the AV CPR device significantly increased the likelihood of a CPR provider achieving recommended depth of chest compressions (Odds Ratio, OR=13.01; 95%CI: 7.12, 24.01) and rate of chest compressions (OR=13.00; 95%CI: 7.21, 23.44).

Conclusion: The use of an AV CPR feedback device significantly improved the delivered rate and depth of chest compressions closer to American Heart Association (AHA) recommendations. Usage of such devices within real-life settings may help in improving the quality of CPR for patients receiving CPR.

KEYWORDS:
Cardio Pulmonary Resuscitation, CPR, Healthcare Providers, Resuscitation, Malaysia

INTRODUCTION

Cardiopulmonary resuscitation (CPR) is one of the mainstays of resuscitation protocols for victims of sudden cardiac arrest globally.[1] The American Heart Association (AHA) recommends the administration of CPR as it is a critical factor in determining outcomes.[1] The quality of CPR rendered to a victim by a CPR provider is measured in terms of indicators such as compression rate and compression depth.[2,3] Both these indicators have been associated with improved outcomes following cardiac arrest.[2,3] Unfortunately, research shows that healthcare providers are not as effective as rendering high-quality CPR over time, despite having received basic life support (BLS) or advanced cardiac life support (ACLS) training.[4] When tested, healthcare providers are often unable to deliver adequate compression rate and depth consistent with current guidelines.[5] CPR skills renewal via refresher courses have long been used as a strategy for maintaining the skills of healthcare providers.[6] Recent innovations used for the same purpose include mannikins, metronomes, sirens, video self-instruction as well as audio-visual CPR feedback devices.6 CPR feedback devices provide visual, auditory or both kinds of feedback based on quantitative CPR metrics.[7] The evidence for such devices is growing, with a recent systematic review favourably recommending the use of such devices to improve CPR skill retention.[8]

Currently, audio-visual (AV) CPR feedback devices are used in certain hospital emergency departments (ED) in Malaysia . However, little evidence exists as to whether its' usage is effective at improving quality of CPR delivered by the healthcare providers. This study is aimed to determine the efficacy of an AV CPR feedback device in improving the quality of CPR delivered by healthcare providers working in an ED in Malaysia.

MATERIALS AND METHODS

This study was a single-arm pre-post quasi experimental study and was carried out between August and November 2017 in the ED of Ampang Hospital, a 180-bedded Ministry of Health Malaysia hospital, in Kuala Lumpur.[9] The hospital offers multiple specialty services as well as being the national

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referral centre for the haematological sub-speciality services serves a catchment area of 150,000 people who live in Ampang and two million people who live around Kuala Lumpur.[9]

Study participants were chosen from among the staff of healthcare providers in the hospital. Inclusion criteria were i) ED staff member classified as a healthcare provider and ii) had valid CPR certification. Staff who were returning to work after a long absence of more than six months and those with physically limiting medical conditions or physical disabilities were excluded from the study. An anonymised list of staff was prepared from among those who fit the inclusion criteria. Simple random sampling was then carried out using an online random number generator software (http://stattrek.com/statistics/random-number-generator.aspx) to select the participants. Based on a sample size estimation for a quasi-experimental single arm study with a power of 80%, a confidence level of 95% and a previously conducted study on the subject, a total of 138 patients were required for the study.[10]

Consenting study participants first filled out a form with information on certain variables including demographics such as age, gender, race, job designation, working experience and level of certification of CPR training. An AV CPR feedback device with real-time audio-visual feedback prompt (ZOLL R series Serial No: AF15H048510; ZOLL Medical, Chelmsford, MA) which measured the compression rate (chest compression/min [cpm]) and compression depth (cm) was used as the primary instrument to measure the outcomes. Participants first performed five cycles of 30 chest compressions on a training manikin (AmbuMan mannikin, Ambu; Copenhagen, Denmark) placed on a flat, hard surface without any feedback prompts. The visual screen of CPR feedback device was turned away from participants and visible only to a member of the study team. The audio prompts for the device were also turned off in order to 'blind' participants and obtaining any form of visual or auditory input. This served as the pre-test segment of the study.

After a break of 10 minutes, participants were then briefed and orientated on the use of the AV CPR feedback device before performing another five cycles of 30 chest compressions on the same manikin with the use of the device. During this segment, the device provided real-time audio-visual feedback prompts to the healthcare provider performing the CPR, thus functioning as the intervention segment of the study.

The two main study outcomes were chest compression (CC) depth and CC rate; defined as between 5-6cm and between 100-120 per minute respectively as per the AHA guidelines.[1] The proportion of CCs with depth between 5-6cm and proportion in which the CC rate met the AHA guidelines was measured as an average from the CPR performance cycles of the participants. The outcomes were categorised as dichotomous outcomes of: i) 0-CC depth or CC rate not achieving AHA guidelines; or ii) 1-CC depth or CC rate achieving the AHA guidelines.[1]

Descriptive data was presented in numbers and percentages for the demographic variables. The comparison on depth and rate of compression before and after use of the AV CPR feedback device was measured and the significance of the difference tested using the Chi-Square test.

Efficacy of the AV CPR feedback device on CPR quality in terms of categorical depth and compression rate proportions was subsequently assessed using a Generalised Estimating Equations (GEE) model. The GEE model was used to compute the effect size of the intervention; as the two dependent outcomes were structured as categorical dichotomous variables, also taking into account the study design which used repeated measurements within participants.[11]

Two separate GEE models were constructed to test the associations between participants' CC depth and CC rates with and without the AV feedback mechanism. The models first examined crude association, then adjusted for potential confounders of association as determined from peer-reviewed literature; namely gender, job designation, age, race, working experience and CPR certification.[11]

All statistical analyses were carried out using SPSS Version 20.0 with significance level fixed at $p<0.05$. This study received ethical approval from the Malaysian Research Ethics Committee, Ministry of Health, Malaysia (NMRR-17-1575-3614).

RESULTS

A total of 140 staff participated in this study while six staff members were excluded. Details of the study flow is shown in Figure 1. There was an almost equal ratio of male:female participation in the study and slightly more than three fourths of the participants were Malays. Medical officers and medical assistants made up most of the study participants; consisting of 30.0% and 28.6% respectively. Most of the participants were aged between 25-29 years and 76.5% of them had six years of working experience or less. 81.4% of the participants were certified in Basic Life Support (BLS). Further information on the characteristics of the participants is detailed in Table I.

When study participants were not provided with AV feedback, only 38.6% of them complied with the CC depth requirements. In addition, only 39.3% of them achieved the CC rate of 100-120 compressions per minute as recommended by the AHA guidelines. However, with the use of the AV feedback device statistically significant improvements were noted; with a 46.4% improvement in terms of CC to 85.0% and a 47.1% improvement in CC rate to 86.4% respectively (Table II).

The GEE model for determining the relationship between CC depth with and without the use of the AV feedback machine showed positive significance, with participants being 9.03 times more likely to deliver CC as per recommended guidelines. The strength of this association increased to an Odds Ratio (OR) of 13.01 (95% Confidence Interval, 95%CI: 7.12, 24.01) when controlled for age, gender, race, CPR certification, job designation and working experience. The GEE model for determining the relationship between delivered rates of chest compression also showed a positively significant difference when comparing between using and not using the audio-visual feedback machine. With the use of the AV feedback machine, participants were 9.84 times more likely to perform CPR at the recommended rate. These odds increased to an OR of 13.00 (95%CI: 7.21, 23.44) in a subsequent model controlled for gender, race, age, CPR certification and job designation. The variable for work experience was not a suitable fit in the GEE model for CC rate and was thus discarded from the model.

DISCUSSION

This study found that ED certified healthcare providers were not able to deliver optimum quality of CPR compliant to the established AHA guidelines in a simulated team-based environment. However, the quality of CPR improved significantly via the use of an AV CPR feedback device. With the device, healthcare providers were more likely to deliver chest compressions depth and rate as per the recommended guidelines.

Table I: Demographics of participants

Variable (N=140)	n	(%)
Gender		
Male	68	48.6
Female	72	51.4
Race		
Malay	108	77.1
Chinese	12	8.6
Indian	20	14.3
Job Designation		
House Officer	18	12.9
Medical Officer	42	30.0
Specialist	4	2.8
Medical Assistant	40	28.6
Staff Nurse	34	24.3
Nursing Sister	2	1.4
Age		
20-24	19	13.6
25-29	70	50.0
30-34	34	24.3
35 and above	17	12.1
Working Experience		
1-3 years	61	43.6
4-6 years	46	32.9
7-9 years	20	14.3
10 years and above	13	9.2
CPR Certification		
Basic life support	114	81.4
Advanced cardiac life support	2	1.4
Advance life support	24	17.2

Table II: Proportion of chest compressions (CC) meeting American Heart Association guidelines for cc depth between 5-6cm and CC rate of 100 to 120 per minute with and without audio-visual feedback

Criteria	Without CPR feedback device n1 (%)	95% CI	With CPR feedback device n2 (%)	95%CI	Difference (n2-n1) (%)	Chi-Square	p-value
CC depth between 5-6cm	38.6	30.5-47.2	85.0	78.0-90.5	+46.4	8.798	0.003
CC Rate 100-120/min	39.3	31.1-47.9	86.4	79.6-91.6	+47.1	10.669	0.001

Table III: Unadjusted and adjusted effect size associations between chest compression (CC) depth and CC rate within participants with and without audio-visual feedback using generalised estimating equations (GEE) models

Model Number	Type of model	Coefficient (B)	95% CI	Odds Ratio (OR)	95% CI	p-value
Outcome: CC depth effect size						
Model 1	Unadjusted	2.20	1.70-2.71	9.03	5.46-14.91	<0.001
Model 2	Adjusted*	2.57	1.96	13.01	7.12-24.01	<0.001
Outcome: CC rate effect size						
Model 1	Unadjusted	2.29	1.78-2.79	9.84	5.92-16.36	<0.001
Model 2	Adjusted**	2.57	1.98-3.15	13.00	7.21-23.44	<0.001

*Adjusted for gender, race, age, CPR certification, job designation and working experience
**Adjusted for gender, race, age, CPR certification, job designation

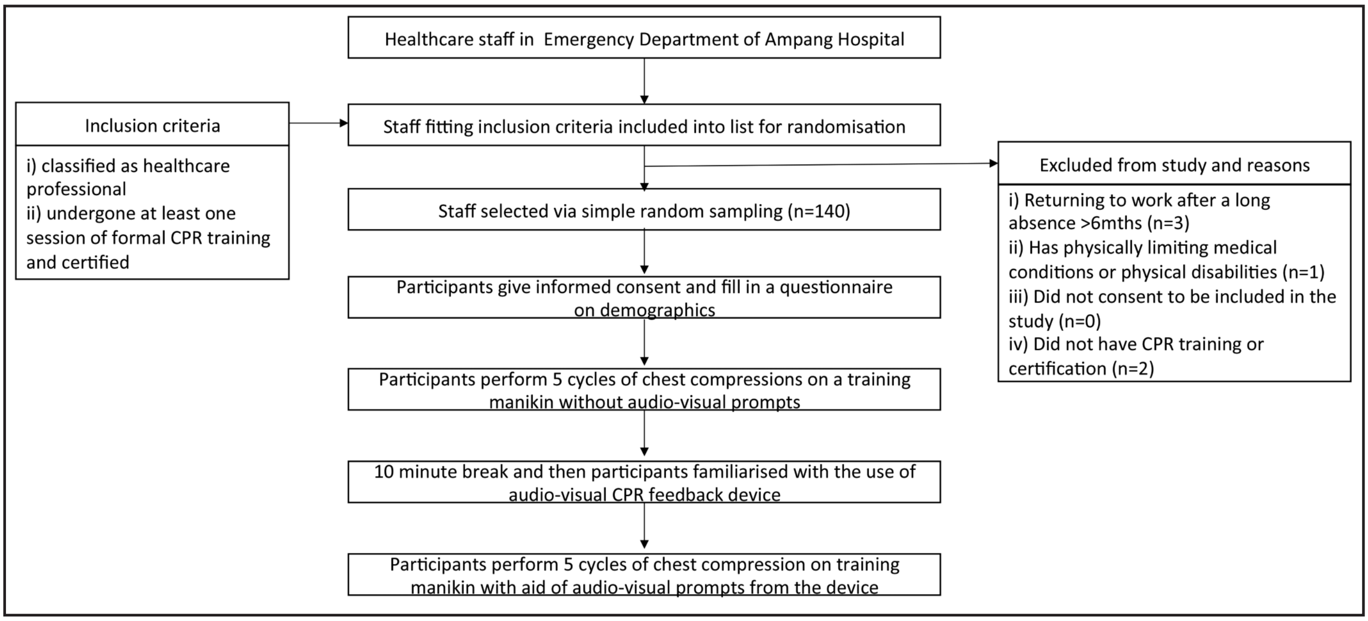

Fig. 1: Study Flow Diagram.

Delivering good quality CPR by certified healthcare providers has been found to be inadequate in multiple settings, with results similar to those found in this study.[12,13] This is of concern as even when delivered according to guidelines, CPR is inherently inefficient, providing only up to a third of normal cardiac blood flow and only up to 40% of cerebral blood flow.[14] It is thus critical that trained rescuers deliver the highest-quality CPR possible amidst the already challenging task of enabling return-of-spontaneous-circulation (ROSC).[13] The delivery of low-quality of CPR has been identified as one of the factors connected to poorer survival in the National Health Service in the United Kingdom[15,16] for example, and could be postulated to also play a similar causative role in the Malaysian setting which also has poor CPR survival rates.[17,18]

Poor retention of CPR skills despite receiving training in basic life support is a gap in health service delivery that multiple strategies have been designed to address.[6] Audio-visual CPR feedback is one of these strategies and has been already shown to improve the quality of CPR by healthcare staff in a simulated environment like that shown in this study.[8] In this case greater improvements in the proportion of CC rates were seen compared to the improvements observed in the proportion of CC depth. Similar results were seen in a Singaporean study as well, and the limited improvement in CC depth there was attributed to the lack of additional focused training.[19] This explanation may have been true in this study too.[19] In fact, a combination of site or scenario specific training (termed as Just-in-Time or JIT training) and audio-visual feedback has been shown to be more efficacious at increasing CPR quality compared to any one of the interventions alone.[10] Positive evidence in this direction may also have spurred the AHA to launch the Resuscitation Quality Improvement program which consists of an integrated JIT training and audio-visual feedback intervention.[20] The concept of JIT training hinges on the idea that the doer gets a refresher of the learning material or skill just as he or she is about to perform the task.[20] Used in combination with online CPR coaching tutorials as part of a 'blended' workplace learning strategy, this could be an effective and efficient way to provide continuous professional development amidst challenging conditions such as during this current COVID-19 pandemic.

One of the challenges in this study was that it was carried out in a simulated environment; and it remains unclear whether the gains observed in CPR quality would translate with patients needing CPR. Only a trial set in clinical setting would be able to confirm this hypothesis and future research needs to be carried out in this direction. Evidence supports such a hypothesis, as there are trials with AV feedback in real clinical settings which have improved CPR quality and patient survival.[21] Another limitation was a lack of randomisation on the sequence of intervention and control. CPR quality may have improved in the second attempt (with AV feedback) due to the effect of participants having 'practised' during the first control attempt; with the effects of this attempt acting as a confounder.

Despite these limitations major strengths of the study was that this was the first experimental trial carried out in a Malaysian setting assessing the effect of audio-visual CPR feedback on CPR quality with a large sample. Though the results of this single centre study cannot be generalised as reflective of Malaysian clinical setting achievements, it serves to highlight two important points. First is that the AV CPR feedback machine may serve as a useful learning to enhance the teaching of CPR in Malaysian clinical settings. The second point is that further research is needed in order to improve rates of ROSC for patients presenting with cardiac arrest to Malaysian hospitals, and effectiveness studies utilising audio-visual CPR feedback could comprise a part of that body of research. Indeed, poor CPR quality has been labelled as a 'preventable harm' and as such, should become part of a monitoring index to determine quality of care in hospital settings.[12] Failure to identify the quality of CPR delivered in institutional settings may create unacceptable disparities in the quality of resuscitative care given to patients and cause the loss of lives.

CONCLUSION

An AV feedback device used during CPR training with mannikins was shown to significantly improve depth and rate of CC being delivered by healthcare providers, bringing them closer to AHA recommended guidelines. Introducing such devices in real-life CPR delivery settings may help in improving the quality of CPR for patients receiving CPR.

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