Original Article

Effect of Using an Audiovisual CPR Feedback Device on Chest Compression Rate and Depth

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Abstract

Introduction: The aim of the study is to investigate the effect of using Automated External Defibrillator (AED) audiovisual feedback on the quality of cardiopulmonary resuscitation (CPR) in a manikin training setting. Materials and Methods: Five cycles of 30 chest compressions were performed on a manikin without CPR prompts. After an interval of at least 5 minutes, the participants performed another 5 cycles with the use of real time audiovisual feedback via the ZOLL E-Series defibrillator. Performance data were obtained and analysed. Results: A total of 209 dialysis centre staff participated in the study. Using a feedback system resulted in a statistically significant improvement from 39.57% to 46.94% (*P* = 0.009) of the participants being within the target compression depth of 4 cm to 5 cm and a reduction in those below target from 16.45% to 11.05% (*P* = 0.004). The use of feedback also produced a significant improvement in achieving the target for rate of chest compression (90 to 110 compressions per minute) from 41.27% to 53.49%; (*P* <0.001). The mean depth of chest compressions was 4.85 cm (SD = 0.79) without audiovisual feedback and 4.91 (SD = 0.69) with feedback. For rate of chest compressions, it was 104.89 (SD = 13.74) vs 101.65 (SD = 10.21) respectively. The mean depth of chest compression was less in males than in females (4.61 cm vs 4.93 cm, *P* = 0.011), and this trend was reversed with the use of feedback. Conclusion: In conclusion, the use of feedback devices helps to improve the quality of CPR during training. However more studies involving cardiac arrest patients requiring CPR need to be done to determine if these devices improve survival.

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Key words: Cardiopulmonary resuscitation, Chest compression, Quality

Introduction

There is increasing evidence to show that good quality cardiopulmonary resuscitation (CPR) is important in achieving better resuscitative outcomes.[1,2] One of the determinants for successful defibrillation is the effectiveness of chest compressions.

The 2005 International Liaison Committee on Resuscitation (ILCOR) guidelines for CPR and Emergency Cardiovascular Care (ECC) recognised the importance of early CPR with an emphasis on chest compressions. The guidelines recommended providing high quality CPR that included chest compressions at an adequate rate (of about 100 per minute), with adequate depth (4 cm to 5 cm) while allowing complete chest recoil. There should be minimal interruptions to compressions while avoiding excessive ventilation.[3] ILCOR has published a set of guidelines in 2010 which recommended a chest compression depth of least 2 inches (5 cm) and at a rate of at least 100 compressions per minute, allowing full chest recoil after each compression, and minimising interruptions in chest compressions.[3] Some studies show that the quality of CPR being performed both in-hospital and out-of-hospital is suboptimal.[4,5] This further highlights the importance of CPR training and constant practice.

A number of audiovisual feedback devices have been designed to improve the quality of CPR and resuscitation outcomes.[6,7] These vary from being a beeping timer to more complex devices. Data can be obtained from some

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of these devices and can be used in further training and to achieve a higher standard of CPR. A systemic review done by Yeung et al[7] showed good evidence supporting the use of CPR feedback/prompt devices during CPR training to improve CPR skill acquisition and retention.

Haemodialysis patients have an incidence of cardiac related death 10 to 20 times higher than that of the general population. In the United States, Karnik et al[8] showed a frequency of 7 cardiac arrests per 100,000 haemodialysis sessions, with ventricular tachycardia/fibrillation being the predominant abnormal recorded rhythm. In Singapore, from October 2001 to September 2004, there were 19 out-of-hospital cardiac arrests (OHCA) occurring in dialysis centres.[9] Only 2 of these patients survived.

As part of this study, we introduced Automated External Defibrillators (AEDs) to all National Kidney Foundation (NKF) dialysis centres in Singapore, as well as a programme to train all NKF staff in CPR and AED skills. This would allow their nursing staff first responders to give life-saving defibrillation in the event of a cardiac arrest, even in the absence of a doctor. This upgrading of defibrillators was in parallel to the training of staff described in this study.

The aim of this observational prospective manikin study is to investigate if the use of an AED audiovisual feedback device could objectively improve the quality of CPR in a manikin training setting.

Materials and Methods

Setting

An observational prospective manikin study was conducted to look at the effect of introducing an audiovisual feedback device for NKF staff on the quality of CPR.

The NKF is a registered charity and is Singapore's largest provider of outpatient dialysis services and rehabilitative care to patients with renal failure at affordable rates. Its 24 dialysis centres are staffed by health care personnel (registered/enrolled nurses, healthcare assistants) who are trained in provision of dialysis services. Before this study, staff were only equipped with manual defibrillators which require the presence of a doctor for operation. This meant that in most cases, attending first responders were not able to give life-saving defibrillations as doctors are not usually present in the dialysis centres. The quality of CPR being performed was also unknown. In the previously mentioned study, none of the cardiac arrests that occurred in dialysis centres received pre-ambulance defibrillation.[9]

Participants

Participants involved were from 14 of the 24 NKF dialysis centres. Between January 2010 and December 2010, a study coordinator travelled to these 14 dialysis centres to perform data collection. Participants also filled out an anonymous survey form with included information on demographics; knowledge and attitude towards CPR and AED.

Data Collection

During data collection, a training manikin (AmbuMan manikin, Ambu; Copenhagen, Denmark) was used. A defibrillator with an accelerometer (ZOLL E Series; ZOLL Medical, Chelmsford, MA) was used for measuring of compression rate (chest compression/min [cpm]) and compression depth (cm). Data were recorded via the defibrillator, which has a real-time audiovisual feedback prompt, and Code Review software (ZOLL Data Systems, Broomfield, CO) was used to analyse the collected data. Data variables collected were compression rate and compression depth.

The participants performed 5 cycles of 30 chest compressions on a training manikin placed on firm, flat ground without feedback prompts. Subsequently, after a break of at least 5 minutes the participants were orientated on the real-time audiovisual feedback feature in the defibrillator. Participants were then instructed to perform another 5 cycles of 30 chest compressions on the same manikin with the use of real time audiovisual feedback prompts.

A chest compression rate of 90 to 110 compressions per minute and a chest compression depth of 4 cm to 5 cm was considered to be in compliance with the ILCOR 2005 guidelines.[3] Compliance to the ILCOR 2010 guidelines was not assessed as that was not yet adopted in the centers studied.

Statistics

Statistical analysis was performed using SPSS 18.0 with statistical significance set at $P < 0.05$. Basic descriptives for numerical data were presented as mean (SD) and n (%) for categorical data. The comparison on depth and rate of compression before and after feedback were analysed using paired t-test if normality assumptions were satisfied. Otherwise the non-parametric Wilcoxon Signed rank test was used. McNemar's test was performed to assess the efficacy of feedback against no-feedback on the categorical depth and compression rate targets. Differences between gender on the compression rate and depth were analysed using 2 Sample t-test if normality and homogeneity assumptions were satisfied. Otherwise the Mann Whitney test was performed. A general linear model was performed to determine the predictors for depth and rate compression subgrouped by with and without feedback.

Results

A total of 209 NKF personnel were approached to participate in this study with a participation rate of 100%. Most of the participants fell between 20 and 39 years of age and were female (75%). The majority had at least a nursing Diploma and held a valid Basic Cardiac Life Support (BCLS) and AED certificate. In the study group, most had not attended to any cardiac arrest patients previously (Table 1).

Table 1. Characteristics of Study Participants

Characteristics	n = 209 (%)
Mean Age (SD)	32.9 (8.0)
Age Group (years)	
20 – 29	85 (40.7)
30 – 39	88 (42.1)
40 – 49	28 (13.4)
≥ 50	8 (3.8)
Gender	
Male	51 (24.4)
Female	158 (75.6)
Profession	
Registered Nurse	122 (58.4)
Enrolled Nurse	62 (29.7)
Health care assistant/ Patient care assistant	17 (8.1)
Patient care technician/ Senior patient care technician	3 (1.4)
Others	5 (2.4)
Qualification (n = 205)	
Diploma	70 (34.1)
Advance Diploma	20 (9.8)
Degree	99 (48.3)
NITEC	12 (5.9)
Others	4 (2.0)
Basic Cardiac Life Support	
Trained	188 (90.0)
Valid Certificate	174 (83.3)
Automated External Defibrillation	
Trained	177 (84.7)
Valid Certificate	177 (84.7)
Attended to cardiac arrest cases	29 (13.9)
No. of cardiac arrest cases attended to (%) (n = 29)	
1	20 (69.0)
2	6 (20.7)
Unknown	3 (10.3)

Without audiovisual feedback, the overall mean depth of chest compressions was 4.85 cm (SD = 0.79) and rate of chest compressions was 104.89 (SD = 13.74). With the use of audiovisual feedback, the overall mean depth of chest compressions was 4.91 (SD = 0.69) and mean rate of chest compressions was 101.65 (SD = 10.21). There was a statistically significant difference in the overall mean compression rate with the use of feedback compared to without (Table 2).

When chest compressions were performed without feedback, only 39.57% of the participants were in compliance with the 2005 ILCOR guidelines for compression depth. When feedback was available, there was a statistically significant improvement to 46.94% (P = 0.009) of the participants being within the target depth. Of note, there was a statistically significant decrease in the number of participants below the target depth. The use of feedback also produced a statistically significant improvement in achieving the target for the rate of chest compression (from 41.27% to 53.49%; P <0.001). (Table 3)

There was no statistical difference between male and female participants in mean compression rate without feedback (P = 0.788). With feedback there seemed to be a greater difference, which was statistically significant (P = 0.069). Interestingly, the mean depth of chest compression was less in males than in females and this trend was reversed with the use of feedback. Without feedback, the male participants had a significantly lower compression depth as compared to females (P = 0.011); with feedback there was no statistically significant difference (Table 4).

There was no statistically significant difference in mean chest compression rates and depth with and without feedback among groups with different qualifications, training and age. Although there was a statistically significant difference in the mean compression rates with and without feedback between groups with different qualifications, that is unlikely to be clinically significant (Table 5).

Discussion

In this study, we found that with audiovisual feedback, there was a statistically significant improvement from 39.57% to 46.94% (P = 0.009) of the participants being within the target compression depth of 4 cm to 5 cm and a reduction in those below target from 16.45% to 11.05% (P = 0.004). The use of feedback also resulted in a statistically significant improvement in achieving the target for the rate of chest compression (90 to 110 compressions per minute) from 41.27% to 53.49% (P <0.001).

Recent research indicates that the quality of CPR is an important factor in affecting survival[10,11] and the ILCOR Advanced Cardiac Life Support Guidelines 2005 suggest

Table 2. Comparison of Depth and Rate of Compressions with and Without Feedback

	Without Feedback	With Feedback	Mean difference	95% Confidence interval	*P* value
Mean Depth (cm) (SD)	4.85 (0.79)	4.91 (0.69)	– 0.06	– 0.06 to 0.05	0.280
Mean Rate (cpm) (SD)	104.89 (13.74)	101.65 (10.21)	3.24	1.57 to 4.91	<0.001

Table 3. Comparison of Compression Depth and Rate with and Without Feedback

	Without Feedback (%)	With Feedback (%)	Difference	95% Confidence interval	*P* value
Depth					
Below target	16.45	11.05	5.41	1.76 to 9.05	0.004
In target	39.57	46.94	– 7.37	– 12.90 to – 1.84	0.009
Above target	43.98	42.02	1.96	– 4.17 to 8.08	0.530
Rate					
Below target	15.16	15.55	– 0.39	– 3.96 to 3.18	0.829
In target	41.27	53.49	– 12.22	– 17.63 to – 6.80	<0.001
Above target	43.56	30.96	12.61	7.41 to 17.80	<0.001

Table 4. Mean Compression Depth and Rate Between Different Genders

	Without feedback (SD)	95% Confidence interval	With feedback (SD)	95% Confidence interval
Mean Depth				
Male	4.61 (0.91)	4.36 – 4.86	4.92 (0.71)	4.72 – 5.13
Female	4.93 (0.73)	4.82 – 5.05	4.90 (0.68)	4.80 – 5.01
Mean Rate				
Male	105.34 (14.08)	101.38 – 109.30	99.38 (12.37)	95.90 – 102.87
Female	104.74 (13.67)	102.59 – 106.89	102.38 (9.34)	100.91 – 103.85

that good quality CPR can be as important as the presence of bystander CPR.[12] Insufficient depth of chest compressions is associated with poorer outcome from cardiac arrest.[13] It is shown that the use of audiovisual feedback devices can improve the quality of CPR where chest compression depth and rate are concerned, and these devices can be used as part of training and during actual CPR during a real cardiac arrest scenario. Furthermore, if the quality of CPR is deteriorating, it may be a sign of fatigue and the person performing CPR should be swapped. Rescuer fatigue has been shown to adversely affect the quality of CPR.[14] Perberdy et al[15] showed improvements with the use of a similar accelerometer based audiovisual feedback device and had concluded that these devices can be used to improve the quality of CPR.

In contrast to these studies, we found that there was no statistically significant difference in chest compression rates and depth when groups of different gender, age, profession and training were compared. This could mean that the proficiency or ability of the participants to meet the ILCOR guideline targets are not significantly affected by any of the above variables, and that most can adequately achieve good quality chest compressions.

It is interesting to note that unlike in Perberdy's and other similar studies,[15,16] our male participants had a lower depth of chest compression without feedback. It may be because there may be a fear among the males that having a greater muscle mass and strength,[17] they may injure the victim if they push with too much force and thus practice restraint. With feedback, this trend was reversed, as the male participants would know if they are pushing too hard and could perform compressions without undue worry.

A limitation of the study would be the lack of randomisation of the order of CPR with and without feedback. There may be an element of "learning" whereby after the first attempt at CPR the performers get better because of practice and the study could have been improved with randomisation of the order of the intervention and control.

The ILCOR published a new set of CPR guidelines in 2010[18] and recommended that chest compression depth should at least be 5 cm and that the rate should be more

Table 5. Mean Compression Rate and Depth with and Without Feedback

		Mean Compression Rate (cpm)						Mean Compression Depth (cm)					
		Without feedback			With feedback			Without feedback			With feedback		
	n	Mean	Std Deviation	*P* Value	Mean	Std Deviation	*P* Value	Mean	Std Deviation	*P* Value	Mean	Std Deviation	*P* Value
Gender													
Female	158	104.74	13.67	0.788	102.38	9.34	0.069	4.93	0.73	0.011	4.90	0.68	0.858
Male	51	105.34	14.08		99.38	12.37		4.61	0.91		4.92	0.71	
Age group (years)													
20 to 29	85	106.51	12.64	0.522	102.47	10.49	0.589	4.77	0.74	0.645	4.92	0.68	0.869
30 to 39	88	103.85	13.83		101.62	9.42		4.92	0.84		4.92	0.69	
40 to 49	28	102.97	17.25		100.15	12.09		4.90	0.76		4.91	0.78	
≥50	8	105.84	10.44		98.46	9.25		4.78	0.75		4.71	0.55	
BCLS													
Trained	188	105.17	13.72	0.382	101.78	9.96	0.569	4.88	0.77	0.160	4.92	0.68	0.622
Not trained	21	102.40	14.00		100.44	12.51		4.76	0.90		4.84	0.77	
AED													
Trained	177	105.19	13.81	0.464	102.22	10.32	0.056	4.87	0.77	0.465	4.89	0.70	0.309
Not trained	32	103.25	13.45		98.48	9.14		4.76	0.86		5.02	0.60	
Attended to cardiac arrest cases													
Yes	29	106.71	11.70	0.443	101.94	12.44	0.870	4.76	0.85	0.511	4.75	0.77	0.180
No	176	104.60	14.05		101.60	9.85		4.87	0.78		4.94	0.67	
Profession													
RN	122	105.25	14.20	0.806	101.49	10.07	0.942	4.90	0.78	0.448	4.89	0.70	0.540
EN	62	104.84	13.70		101.73	10.38		4.84	0.79		4.98	0.65	
Others	25	103.26	11.79		102.25	10.88		4.68	0.81		4.81	0.72	
Qualification													
Diploma	70	108.55	12.06	0.045	103.72	10.05	0.004	4.88	0.79	0.915	4.87	0.70	0.390
Advance Dip	20	104.56	9.77		105.23	9.51		4.93	0.79		5.02	0.72	
Degree	99	102.15	15.32		99.32	9.97		4.83	0.81		4.90	0.69	
NITEC	12	105.81	11.02		101.05	10.41		4.77	0.65		5.10	0.64	
Others	4	110.44	11.37		112.60	9.65		4.58	0.82		4.37	0.42	

BCLS: Basic Cardiac Life Support; AED: Automated External Defibrillation; RN: Registered Nurse; EN: Enrolled Nurse

than 100 per minute. As the study was conducted before the publication of the 2010 guidelines, the targets were those of the 2005 guidelines. Our feedback devices were prompting to the 2005 but not the 2010 guidelines. However, by calibrating the feedback devices in accordance with 2010 guideline targets, they can be used for CPR and we would expect the results to be similar, though such a conclusion must be borne by another study using the new chest compression guidelines.

We intend to follow up on this study by performing a comparison on whether these devices make a difference in rates of return of spontaneous circulation and survival during real cardiac arrest situations.

Conclusion

In conclusion, the use of real time audiovisual feedback during chest compression training with manikins improves the quality of CPR. We recommend the use of audiovisual feedback during training and during actual CPR to improve the quality of CPR. More studies are required to show that audiovisual feedback devices can improve survival in patients with cardiac arrest receiving CPR.

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