© Malaysian Journal of Anaesthesiology 2023; 1:41-55
Original article
https://doi.org/10.35119/myja.v2i1.38

Quality of chest compressions performed by anaesthetic trainees with and without audiovisual feedback

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Abstract

Introduction: The use of audiovisual feedback devices on chest compression (CC) metrics such as the rate and depth has been proven to improve resuscitation quality. This study compared the quality of CC performed by anaesthetic trainees on manikins with audiovisual feedback and subsequent skill retention without the feedback.

Methods: CC metrics measured were the compression rate and depth recorded and reviewed by RescueNet® Code Review software, which recorded compressions in target. Fifty participants performed 2 minutes of CC without audiovisual feedback (CC1), followed by another 2 minutes of CC with audiovisual feedback (CC2), separated by 5 minutes of rest. Those who achieved at least 70% of compressions in target during CC2 performed another 2 minutes of CC without audiovisual feedback at 30 minutes (CC3) and 5–7 days (CC4) later.

Results: The baseline compressions in target during CC1 was 14.43 ± 20.18%, improving significantly to 81.80 ± 7.61% ($p < 0.001$) with audiovisual feedback (CC2). Forty-five (90%) participants achieved compressions in target of at least 70% during

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CC2. However, without the feedback, compressions in target decreased significantly to 56.33 ± 27.02% ($p < 0.001$) and 49.32 ± 33.86% ($p < 0.001$) at 30 minutes (CC3) and 5–7 days (CC4) later, respectively. The overall effect size for the compressions in target was 0.625.

Conclusion: Audiovisual feedback device usage significantly improves CC performance, but improved skills were not fully retained when CC was performed without the device afterwards. Therefore, real-time audiovisual feedback may ensure better CC, a component of cardiopulmonary resuscitation.

Keywords: anaesthetic trainees, basic life support, chest compression, feedback device, simulation

Introduction

High-quality chest compression (CC) is one of the main components of effective cardiopulmonary resuscitation (CPR), influencing survival from cardiac arrest.[1] The latest American Heart Association (AHA) Guidelines for CPR and Emergency Cardiovascular Care (ECC) released in 2020 continue to emphasise on high-quality CPR, which include a CC rate of 100–120 per minute, compression depth of 5–6 cm, minimal interruption in compressions (< 10 seconds), and full chest wall recoil in between compressions.[2] The quality of CPR has been reported to be suboptimal despite being performed by healthcare professionals.[3]

Patients in critical care areas, such as the intensive care unit (ICU) are generally more seriously ill with a higher chance of developing cardiac arrest compared to those in the general wards.[4] As such, it is of utmost importance for healthcare professionals in the ICU to acquire and practice high-quality CPR skills as recommended in the AHA guidelines for CPR and ECC. To maintain this skill, all healthcare professionals working in critical care areas should undergo regular training and be certified as Basic Life Support (BLS) and Advanced Life Support (ALS) providers according to local policy, such as every 12–24 months as recommended by the Ministry of Health (MoH), Malaysia.[5]

The use of audiovisual (AV) CPR feedback devices has been proven to significantly improve CPR quality on CC metrics, such as CC rate from 17.2% to 30.0%, and depth from 37.9% to 65.0%.[6,7] Hence, it is recommended to use AV feedback devices during CPR for real-time optimisation of CPR performance.[2] Furthermore, the AHA currently recommends the use of CPR feedback devices in resuscitation training to assist in CPR skill acquisition and retention.[8]

As cardiac arrest is a life-threatening event, studies assessing the quality of CC with AV prompts and subsequent skill retention without the feedback are best simulated. In this study, we assessed the quality of CC on a manikin with and without AV feedback by anaesthetic trainees working in the ICU of a tertiary hospital.

Materials and methods

This prospective, observational simulation study was approved by the institution's research and ethics board. Written informed consent was obtained from recruited anaesthetic trainees who were randomly chosen from a list of all trainees during the study period using an application from Random.org. Anaesthetic trainees who were physically unable to perform CC or tired easily, including pregnant trainees, were excluded from the study after the randomisation process.

Demographic data obtained from the participants were their age, gender, height, weight, total years of postgraduate training in anaesthesia, and years of overall working experience. They were also asked whether they had undergone BLS, ALS, or any other resuscitation training within the last 2 years.

Participants were then given 7 validated questions to be completed, 6 of which had to be answered prior to performing the CC. The 6 questions comprised their personal real-life experience in CPR and knowledge of high-quality CC as per current AHA guidelines. After performing the CC, they were asked on their satisfaction with the AV feedback device.

All participants were then instructed by a single instructor to perform 2 minutes of CC on a manikin equipped with a CPR sensor (CPR-D Training padz®, Zoll Medical, Chelmsford, MA, USA) and placed on an ICU bed with a CPR board to simulate a real working environment. For the baseline metrics (CC1), the real-time AV CPR feedback device (ZOLL® R Series® Monitor/Defibrillator, Zoll Medical, Chelmsford, MA, USA) audio prompt was muted, and the screen turned away for blinding. The prompt device utilises the software RescueNet® Code Review to measure the mean compressions per min (cpm) and mean CC depth (cm) (Fig. 1). The software also records the compressions in target (percentage), which refers to the fraction of CC that has both the correct rate and depth as per the 2020 AHA guidelines within a duration of 2 minutes (Fig. 2). These CC metrics were documented for data analysis. At least 70% of compressions in target was taken as the cut-off point to achieve high-quality CC.[1] Prior to the study, the device was examined and calibrated by the supplier to ensure proper functionality.

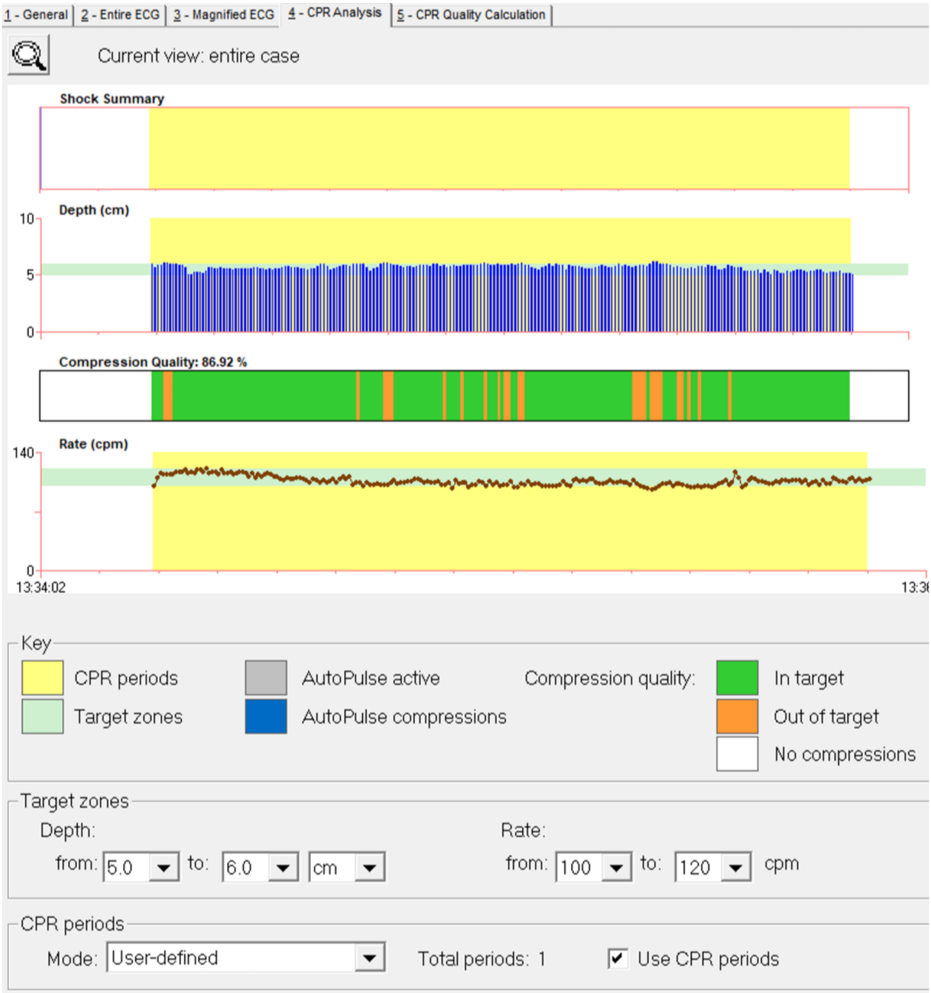

Fig. 1. Screenshot of visual data displayed using the software RescueNet® Code Review.

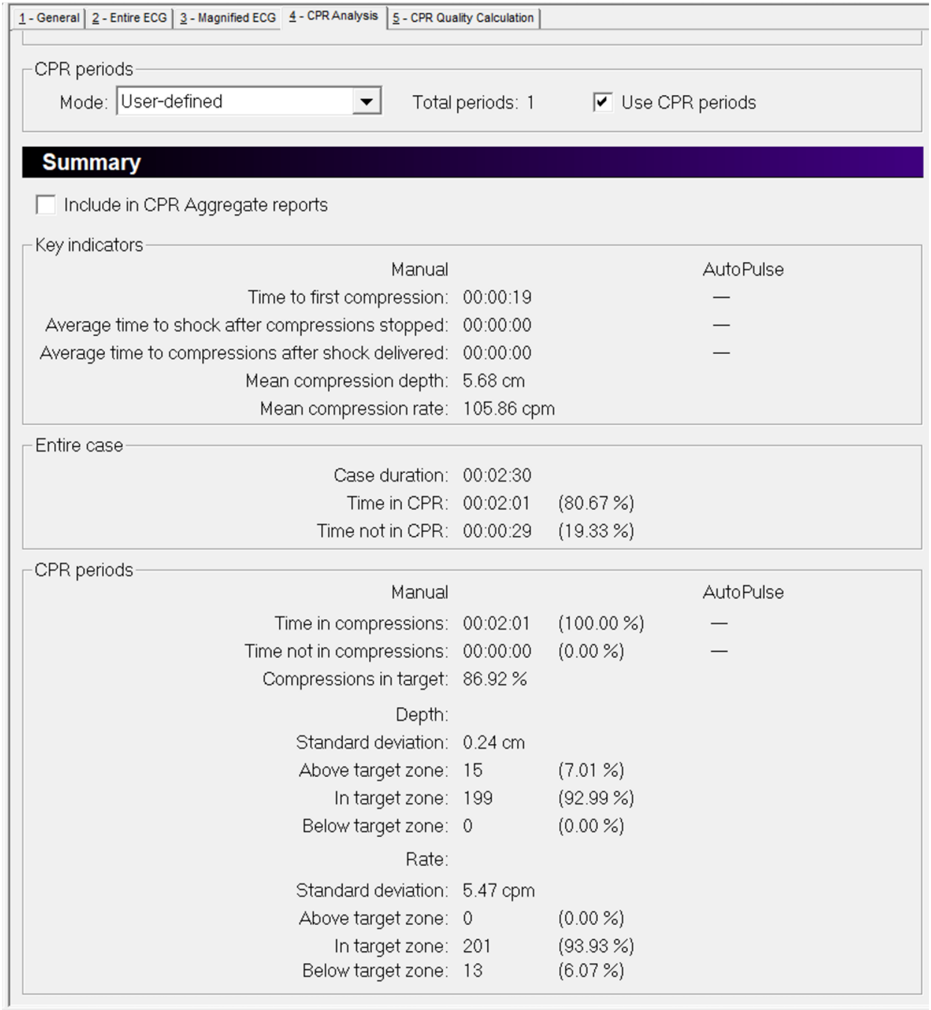

Fig. 2. Screenshot of the summarised data displayed using the software RescueNet® Code Review.

Participants were then given 5 minutes of rest and then orientated to the feedback device prior to performing another 2 minutes of CC on the same manikin with the real-time AV feedback prompt activated and the screen visible to them. The same CC metrics were recorded during this session, which was labelled as CC2. The participants were allowed to perform 2 minutes of CC up to 3 times with 5 minutes of rest between cycles to achieve at least 70% of compressions in target.

Those who achieved at least 70% of compressions in target were asked to perform CC in 2 further occasions, 30 minutes (CC3) and 5–7 days later (CC4) with the AV feedback muted and screen turned away from them. The same variables were again recorded.

The sample size calculation was done using the Snedecor and Cochran's formula, based on similar studies.[9,10] The power of this study was set at 90%, with an α-value of 0.05 and a standard deviation of 33.5 for the calculation of sample size. A total of 40 participants were required for this study. Anticipating a 20% dropout rate, 50 participants were recruited.

Data were cleaned, explored, and analysed using SPSS version 26.0 (IBM Corp, Armonk, NY, USA). Numerical data were presented as mean and standard deviation (SD) after normality checking using skewness, kurtosis, and histogram; otherwise median and interquartile range were used. Categorical variables were presented as frequency and percentage. The difference in percentage of compressions in target range across time (CC1, CC2, CC3, and CC4) between genders was explored using Mann-Whitney U test and independent t test. The difference in percentage of compressions in target range at baseline between duration of postgraduate training and knowledge of BLS was explored using one-way ANOVA and Mann-Whitney U test, respectively. The relationship between the percentage of compressions in target range at baseline with the duration of experience in anaesthesiology and intensive care were further tested using Spearman correlation. Changes in mean rate, depth, and compressions in target across time were explored using repeated measure ANOVA, and further analysed for the effect size, partial eta squared, η^2. Assumptions of sphericity were checked, and Greenhouse-Geisser correction was used as the assumption was found violated with Mauchly's W less than 0.75. Pairwise comparisons with Bonferroni adjustments were performed following the analysis. All the tests were 2-sided and statistical significance was denoted as $p < 0.05$.

Results

The participants' demographic data and their attendance at life support courses are shown in Table 1. Table 2 shows the experience of performing CC in real life, the knowledge of high-quality CC, and participants' satisfaction with the AV feedback device. Of the 11 participants who responded correctly to all the current properties of high-quality CC, which included the rate, depth, and minimal interruption, 2 had attended BLS within the last 2 years.

Table 1. Demographic data and life support courses attendance (*n* = 50)

Variables	**(*n* = 50)**
Age (year)	33.78 ± 1.79
Gender Male Female	 26 (52.0) 24 (48.0)
Duration of postgraduate training (year)	2.64 ± 1.23
Duration of experience in anaesthesiology (year)	6.64 ± 1.97
Are you BLS-certified? No Yes	 0 (0.0) 50 (100.0)
If yes for above, BLS certification was Within the last 2 years More than 2 years previously	 8 (16.0) 42 (84.0)
Are you ACLS-certified? No Yes	 1 (2.0) 49 (98.0)
If yes for above, ACLS certification was within last 2 years more than 2 years previously	 18 (36.0) 31 (62.0)
Do have certification from other life support courses? No PALS	41 (82.0) 9 (18.0)

BLS: Basic Life Support; ALS: Advanced Life Support; PALS: Paediatric Advanced Life Support
Data analysed using Mann-Whitney U test and independent t test. Data presented as mean ± SD or frequency with percentage, as appropriate.

Table 2. CPR experience, knowledge of high-quality CC, and satisfaction with the AV feedback device

Questions		**(n = 50)**
Real-life chest compression skills		
1. Have you ever performed chest compressions on a patient?	No	0 (0.0)
	Yes	50 (100.0)
2. How often do you perform chest compressions on a patient?	0–2 per month	46 (92.0)
	2–5 per month	4 (8.0)
3. How confident are you towards your chest compressions skill?	Not confident	1 (2.0)
	Less confident	3 (6.0)
	Neutral	18 (36.0)
	Confident	27 (54.0)
	Very confident	1 (2.0)
Chest compression knowledge as per the 2020 BLS guideline		
4. According to the 2020 BLS guideline for adult, what is the recommended chest compression rate?	< 100 per minute	1 (2.0)
	> 100 per minute	5 (10.0)
	100–120 per minute	43 (86.0)
	> 120 per minute	1 (2.0)
5. According to the 2020 BLS guideline for adult, what is the recommended chest compression depth?	Approximately 5 cm	18 (36.0)
	5–6 cm	21 (42.0)
	> 6 cm	2 (4.0)
	1/3 chest depth	9 (18.0)
6. According to the 2020 BLS guideline for adult, what is the recommended duration for CPR interruption and pulse check?	No interruption	4 (8.0)
	< 10 seconds	32 (64.0)
	> 10 seconds	1 (2.0)
	< 5 seconds	13 (26.0)
Satisfaction with the AV prompt device		
7. Are you satisfied with the feedback device?	Unsatisfied	3 (6.0)
	Neutral	4 (8.0)
	Satisfied	36 (72.0)
	Very satisfied	7 (14.0)

CPR: cardiopulmonary resuscitation; CC: chest compression; AV: audiovisual; BLS: Basic Life Support
The correct answers for the 2020 guidelines appear in **bold**.
Data analysed using one-way ANOVA and Mann-Whitney U test. Data presented as frequency with percentage.

Table 3 shows that there were significant changes in mean rate, mean depth, and mean compressions in target across time. Taking 0.14 as the cut-off for median and large effect size, the mean rate had a medium effect size, whereas both the mean depth and mean compressions in target displayed large effect size. During both CC3 and CC4, all 45 participants had a mean rate and mean depth of CC within the recommended parameters. However, the compressions in target were below 70% for the latter 2 sessions, as seen in Figure 3.

Table 4 paired and compared the mean rate, mean depth, and compressions in target for the different sessions of CC. The compressions in target were significantly better at CC3 and CC4 when compared to the baseline, CC1. Further analysis of the CC performance in relation to gender, knowledge of 2020 CC guidelines, duration of postgraduate training, and duration of experience in anaesthesiology were not statistically significant.

Further analysis of the CC performance in relation to gender, duration of post-graduate training, duration of experience in anaesthesiology, and knowledge of the CC metrics in the 2020 BLS guidelines were not statistically significant.

Table 3. Changes in mean rate, mean depth, and compressions in target across time ($n = 45$)

	Mean rate	***p***	**Effect size, η^2**	**Mean depth**	***p***	**Effect size, η^2**	**CC in target**	***p***	**Effect size, η^2**
CC1	115.50 ± 13.93	0.004	0.130	6.14 ± 0.16	< 0.001	0.245	14.43 ± 3.01	< 0.001	0.625
CC2	109.36 ± 4.85			5.43 ± 0.03			81.80 ± 1.13		
CC3	108.56 ± 6.73			5.50 ± 0.07			56.33 ± 4.03		
CC4	109.69 ± 7.85			5.41 ± 0.08			49.32 ± 5.05		

CC: Chest compression; CC1: Baseline chest compression without audiovisual feedback; CC2: Chest compression with audiovisual feedback; CC3: Chest compression without audiovisual feedback 30 minutes after CC2; CC4: Chest compression without feedback 5-7 days after. Data analysed using repeated measure ANOVA. Data presented as mean ± SD.

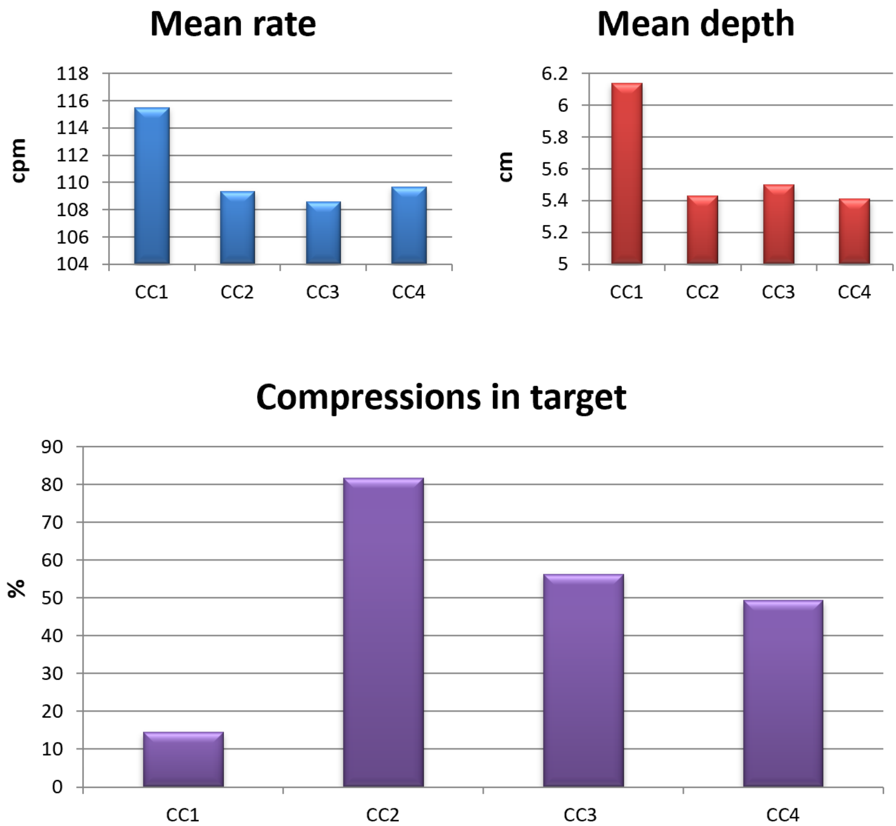

Fig. 3. Changes in mean rate (compressions per minute), mean depth (cm), and compressions in target (%) across time (n = 45). CC1: Baseline chest compression without audiovisual feedback; CC2: Chest compression with audiovisual feedback; CC3: Chest compression without audiovisual feedback 30 minutes after CC2; CC4: Chest compression without audiovisual feedback 5¬–7 days after.

Table 4. Post-hoc pairwise comparison for repeated measure ANOVA for mean rate, mean depth, and compressions in target

Time point A	Time point B	Mean rate			Mean depth			Compressions in target		
		Diff (A-B)	95% CI	*p*	Diff (A-B)	95% CI	*p*	Diff (A-B)	95% CI	*p*
CC1	CC2	6.13	0.52, 11.75	**0.025**	0.71	0.28, 1.14	**< 0.001**	-67.38	-75.54, -59.21	**< 0.001**
	CC3	6.94	0.42, 13.46	**0.031**	0.64	0.17, 1.11	**0.003**	-41.90	-54.48, -29.32	**< 0.001**
	CC4	5.81	-0.60, 12.21	0.096	0.73	0.23, 1.22	**0.001**	-34.90	-49.53, -20.26	**< 0.001**
CC2	CC3	0.80	-1.88, 3.49	> 0.950	-0.07	-0.25, 0.10	> 0.950	25.48	14.75, 36.20	**< 0.001**
	CC4	-0.33	-3.26, 2.61	> 0.950	0.02	-0.20, 0.23	> 0.950	32.48	18.10, 46.86	**< 0.001**
CC3	CC4	-1.13	-4.38, 2.12	> 0.950	0.09	-0.13, 0.31	> 0.950	7.01	-7.30, 21.31	> 0.950

CC1: Baseline chest compression without audiovisual feedback; CC2: Chest compression with audiovisual feedback; CC3: Chest compression without audiovisual feedback 30 minutes after CC2; CC4: Chest compression without feedback 5-7 days after.
Values in bold indicate statistical significance.

Discussion

Our study shows that the use of AV feedback during CPR contributes to improving and maintaining the quality of CC, which is a crucial component of resuscitation. However, the quality of CC without AV feedback among anaesthetic trainees did not achieve the desired percentage of compressions in target and the quality that had earlier improved significantly with the feedback. This finding is in line with results from previous studies involving healthcare professionals working in critical areas.[11-12] Pritchard *et al.* found that AV feedback significantly improved the recommended CC depth and rate performed by healthcare professionals in the emergency department by 38% and 35%, respectively.[11] Similar significant improvement was found by Chelladurai *et al.*, where the CC depth and rate improved from 38.6% to 85% and 39.3% to 86.4%, respectively.[12] There were 5 (10%) participants who were not able to synchronise with the AV feedback device. The specific reasons were not documented but a few participants expressed performance anxiety. Perhaps if given additional attempts, they would have been calmer and able to keep up with the prompts.

Most of the trainees were unable to answer correctly regarding the 3 parameters of high-quality CC, despite all having attended a BLS course and 49 of 50 having attended an ALS course prior to this study. However, most of them had attended the courses more than 2 years prior to the study. Nevertheless, no association was found between BLS knowledge and the skill of CC performance in this study. A study by Lee *et al.* showed that hands-on practice during the resuscitation course improves CC quality.[13] Apart from the resuscitation guidelines being revised and updated every 5 years, most bodies, like AHA and the Malaysian MoH recommends healthcare providers to undergo these life support courses every 2 years to maintain their skill and knowledge.[2,5] This is because the need for CC is not a daily event and thus requires regular training. Apart from attending courses, flexible access to simulation laboratories with self-instructional video for life support courses where healthcare workers can practice at their own pace may play a role in future training.[14] Nevertheless, in this study we assumed no association between the duration of previous BLS and ALS training to the skill of performing CC as all participants were actively practising anaesthesia.

At baseline, even though the mean CC rate was within the recommended range of 100–120 per min, the mean CC depth was more than 6 cm, which may lead to rib fractures and other complications, as shown in previous studies.[15,16] A device which is able to quantify effective and safe depth of the CC would help to prevent such injuries.

We found that although the mean CC rate and depth were within range for the latter 2 intervals, compressions in target of 70% was not achieved. This could be due to the varying rate and depth over the strenuous 2-minute compression cycle, whereby some rescuers were overdoing the initial compression leading to exhaustion prior to the end of the cycle. Prompt device would guide the rescuers to deliver CC appropriately at a constant pace without going too fast, with less chances of exhaustion. A previous study has shown that perceived exertion with CC was less with AV feedback than without it.[17]

In our study, subsequent compressions in target decreased over time without AV feedback. Nevertheless, the quality of these CCs were significantly better compared to the baseline. Without frequent assessment, the knowledge and skills of BLS and ALS can decrease within a few months.[5] A study by Zhou *et al.* showed that CC quality declined over the long term despite training with AV feedback devices, which is similar to our findings.[18]

Hence, as per recommendations for adult BLS and ALS by 2020 AHA Guidelines, the use of real-time AV feedback during CPR in ICU may prove to be beneficial, along with guidance from arterial blood pressure and end-tidal carbon dioxide during resuscitation to improve CPR quality, as they are readily available in ICU settings.[19] This study supports these recommendations, as most participants achieved the compressions in target with the prompt device.

This study has several limitations. Firstly, a period of familiarisation with the AV feedback device was not allocated. A few participants expressed performance anxiety and therefore were not able to synchronise with the device as quickly as others, leading them to be excluded from the subsequent sessions. A simulated manikin trial does not entirely reflect real-life situations, as manikins are standard in size compared to the wide variability of real patients' bodies.

Conclusion

AV feedback device usage significantly improves CC performance, but the improved skill was not retained fully when CC was performed without the device afterwards. Therefore, real-time AV feedback may ensure better CC, a component of cardiopulmonary resuscitation.

Declarations

Ethics approval and informed consent

This prospective, observational simulation study was approved by the institution's research and ethics board. Written informed consent was obtained from the participants prior to enrolment into the study.

Competing interests

Dr. Muhammad Maaya served as Section Editors in Malaysian Journal of Anaesthesiology. He has not been involved in any part of the publication process prior to manuscript acceptance; peer review for this journal is double blind. The remaining authors have no competing interests to declare.

Funding

Funding for this study was provided by Universiti Kebangsaan Malaysia (FF-2020-079).

Acknowledgements
We would like to express our gratitude to Mrs Qurratu Aini binti Musthafa for her guidance in the segment of statistical analysis.

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