Use of a Feedback Device in Simulated Cardiopulmonary Arrest can improve cardiopulmonary resuscitation better than training

Rong Zeng
Wuhan University Zhongnan Hospital
Daoquan Liu
Wuhan University Zhongnan Hospital
Haoli Ma
Wuhan University Zhongnan Hospital
Lian Lin
Wuhan University Zhongnan Hospital
Xianlong Zhou
Wuhan University Zhongnan Hospital
Yan Zhao
Wuhan University Zhongnan Hospital
Xiaoqing Jin (redjin@whu.edu.cn)
Wuhan University Zhongnan Hospital

Research article

Keywords: Cardiopulmonary resuscitation, Audiovisual feedback, Training, Simulated cardiopulmonary arrest, Chest compression

Posted Date: May 6th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-450618/v1

Abstract

Background: High-quality cardiopulmonary resuscitation (CPR) is the basis of successful cardiac arrest resuscitation, but the bystanders often perform inadequate compressions.

Objective: To determine whether the use of an audiovisual feedback (AVF) device during cardiopulmonary resuscitation(CPR) training or a simulated cardiopulmonary arrest (CPA) scenario is more conducive to improving the quality of chest compression (CC).

Methods:A total of 160 participants from Wuhan University and senior clinical medicine undergraduates who had not participated in any CPR training before and had no actual CPR experience were recruited.They were randomly divided into the following 4 groups.First,all participants practiced on the Resusci Anne QCPR manikin during CPR training. All participants practiced at least 3 cycles of CC each time (Group C and Group D received the AVF device) until they passed the assessment. Finally, they took part in a 2-minute continuous CC during simulated CPA (Group B and Group D received the AVF device)

Results:CC quality was improved with the AVF device during simulated CPA. With the AVF device compared with no AVF device improved depth compliance during simulated CPA by 22.8% ($P<0.001$) and rate compliance by 11.3% ($P=0.003$). The use of the AVF device during CPR training resulted in a –2.6% ($P = 0.61$) change in appropriate CC depth compliance compared with no AVF device. At the same time, there was a –1.3% ($P = 0.724$) change in compliance with rate guidelines

Conclusion: Use of a feedback device in simulated cardiopulmonary arrest can improve cardiopulmonary resuscitation better than training.

Background

In the vast majority of cases, cardiac arrest occurs suddenly, and a quick and effective treatment is needed[1]. Out-of-hospital cardiac arrest (OHCA) is a health issue all over the world and has received a lot of attention[2]. In Asian countries, OHCA has become an increasingly major cause of death[3]. At the same time, its incidence is 41.8/100 000 among the general population in China[4]. According to statistics, nearly 1 in 1000 people every year will succumb to an OHCA[5]. During the coronavirus disease 2019(COVID-19) pandemic, the number of patients who suffered from OHCA is more than earlier[6]. About 47% of OHCAs are witnessed by bystanders [7].

The 2015 American Heart Association (AHA) guidelines highlighted the first line of the OHCA Chain of Survival as recognition of cardiopulmonary arrest (CPA) by bystanders, and the bystander’s reactions and skills of cardiopulmonary resuscitation (CPR) determine the survival of patients [8]. Although advanced life support (ALS) interventions are commonly believed to increase OHCA survival, high-quality bystander CPR is still a fundamental strategy for an improved survival rate[9, 10]. High-quality CPR is described as follows: rate between 100 and 120 compressions per min (cpm), compression depth between 5 cm and 6 cm, allowing complete chest recoil after each compression, minimized interruptions in chest compressions (CC), and avoiding excessive ventilation [11]. However, even well-trained rescuers cannot guarantee adequate rate and depth of CC in emergencies, let alone the bystanders[12].Nowadays, there are more and more researches on the application of AVF device to CPR, the purpose of which is to improve the quality of CPR.Recent evidence has also shown that use of AVF device during a real cardiac arrest can improve the quality of CPR[13, 14]. But the current dilemma is that feedback devices are not always available at training sites or medical institutions.

The aim of this prospective randomized study is to investigate whether the use of an AVF device in CPR training or in a simulated CPA scenario is more conducive to improving the quality of CC.

Methods

Study setting and population

We obtained approval from the Ethics Committee of Zhongnan Hospital of Wuhan University, Hubei Province, China. We also obtained written informed consent from participants, and we informed all participants that we will evaluate their performance for scientific purposes only. We performed all procedures according to the Declaration of Helsinki. The study was conducted at the Clinical Skill Training Center of the Second Clinical Medical College of Wuhan University over one weekend in September 2020. All participants were fourth-year undergraduate students specializing in Clinical Medicine. A total of 160 participants had not participated in any CPR training before and had no actual CPR experience. Upon inclusion in this study, all students received CPR training on a manikin following a standardized teaching protocol of the medical school, according to the ILCOR guideline for adult basic life support. The height and weight of all participants were recorded.

Study design

The instructor was an AHA BLS instructor, and he provided explanations on the correct method of CPR. Participants were randomly divided into four groups: Group A (without an AVF device during CPR training and simulated CPA); Group B (without an AVF device during CPR training and with an AVF device during simulated CPA); Group C (with an AVF device during CPR training and without an AVF device during simulated CPA); and Group D (with an AVF device during CPR training and during simulated CPA). The study consisted of the following three phases: First, all participants watched a 30-minute video of CPR, and the instructor emphasized all points of CPR. Then, they practiced on the adult Resusci Anne QCPR manikin(Laerdal China Ltd., Hangzhou, China) during CPR training with or without the AVF device (Group C and Group D received the AVF device) until they passed the assessment. Each group was guided by an AHA trainer who had no knowledge of our experimental grouping situation. All participants practiced at least 3 times, 2 minutes each time. Finally, they took part in a 2-minute continuous CC during simulated CPA with or without the AVF device (Group A and Group B received the AVF device). The rate and depth of CCs were recorded. Data of technical performance were recorded by the Laerdal Computerized Skill Reporting System and were analyzed Later,Due to the technical problems of data acquisition, a total of

23 participants were excluded, so we recruited a total of 137 participantsIn the end, groups A, B, C, and D had 36, 32, 38, and 31 students, respectively.

The manikin used in our study was an adult Resusci Anne QCPR(Laerdal China Ltd., Hangzhou, China). We used SimPad PLUS as an AVF equipment in this study. The AVF device is a tablet which can give us timely feedback on depth and rate of CCs, so as to adjust the compression to improve our compression quality. The Laerdal SimPad PLUS can simulate CPR and automatically recorde data. The study protocol is summarized in Figure. 1.

Measurements

We analyzed the depth and rate of CCs, the percentage of CCs with correct depth (5–6 cm), the rate of CCs, and the percentage of CCs with correct rate (100–120 cpm) among the groups according to with or without feedback devices during CPR training or simulated CPA scenario.

Data analysis

All data were analyzed with commercial software (SPSS version 20, SPSS Inc., Chicago, IL). Data are expressed as numbers,percentages and means with their 95% confidence intervals (CI). A two-tailed p value less than 0.05 was considered statistically significant.

Results

Demographic characteristics of the participants

The demographic data of famong the four groups are summarized in Table 1. there were no significant differences in height, or weight between groups ($p > 0.05$, respectively).

Table 1
Characteristics among the four groups.

95%CI	Group A	Group B	Group C	Group D
Height (cm)	164.3 (161.6–167.0)	168.4 (166.0–170.9)	164. 7 (162.2–167.2)	166.8 (164.1–169.4)
Weight (kg)	55.1 (51.7–58.5)	56.4 (51.3–58.5)	55.2 (52.0–58.3)	55.1 (51.8–58.5)

The effect of the AVF device on the quality of CC during training and simulated CPA

The mean percentage of CCs with adequate depth (5–6 cm) in the four groups is shown in Table 2. The percentage of CCs with adequate rate (100–120 cpm) is shown in Table 3. Based on our findings, we can derive the following conclusions. use of a feedback device in simulated CPA can improve CPR better than training

Table 2
Proportion of CCs for CC Depth Between 5 cm and 6 cm

Appropriate CC Depth	Mean (95% CI), %			
	No AVF during simulated CPA	**AVF during simulated**	**benefit**	**Mean Benefit Main Effect**
No AVF during CPR training	A 33.6 (21.7–45.6)	B 56.3 (46.5–66.1)	22.7 (7.7–37.7)	22.8 (13.3–32.3)
AVF during CPR training	C 32.8 (22.8–42.8)	D 55.5 (49–62)	22.7 (11–34.5)	
AVF benefit	−0.8 (−16 to 14.4)	−0.8 (−12.4 to 10.8)	NA	NA
AVF mean benefit main effect	−2.6 (−12.8 to 7.6)		NA	NA
AVF: audiovisual feedback;CPR :cardiopulmonary resuscitation;CPA: simulated cardiopulmonary arrest.				

Table 3
Proportion of CCs for a CC Rate of 100 to 120 per Minute

Appropriate CC Rate	Mean (95% CI), %			
	No AVF during simulated CPA	**AVF during simulated**	**benefit**	**Mean Benefit Main Effect**
No AVF during CPR training	A 68.5 (59.6–77.4)	B 83.1 (78.1–88.1)	14.6 (4.6–24.7)	11.3 (4.1–18.5)
AVF during CPR training	C 71.5 (62.4–80.7)	D 79.4 (73.4–85.3)	7.9 (−2.9 to 18.6)	
AVF benefit	3 (−9.6 to 15.7)	−3.7(−11.3 to 3.8)	NA	NA
AVF mean benefit main effect	−1.3 (−8.7 to 6.1)		NA	NA
AVF: audiovisual feedback;CPR :cardiopulmonary resuscitation;CPA: simulated cardiopulmonary arrest.				

The mean percentage of CCs in each group with depth was 33.6% in Group A (without the AVF device during CPR training and simulated CPA) (Mean CC Depth: 4.7 cm (95% CI 4.4–5.1 cm)) (eTable1 in the Supplement), 56.3% in Group B (without the AVF device during CPR training and with the AVF device during simulated CPA) (Mean CC Depth: 5 cm (95% CI 4.9–5.2 cm), 32.8% in Group C (with the AVF device during CPR training and without the AVF device during simulated CPA) (Mean CC Depth: 4.5 cm (95% CI 4.2–4.8 cm)), and 55.5% in Group D (with the AVF device during CPR training and during simulated CPA) (Table 2) (Mean CC Depth: 5.1 cm (95% CI 5–5.3 cm)). The mean percentage of the appropriate CC rate in each group was 68.5% in Group A (without the AVF device during CPR training and simulated CPA) (Mean CC Rate: 110.3 cpm (95% CI 106.9–113.7 cpm) (eTable2 in the Supplement), 83.1% in the Group B (without the AVF device during CPR training and with the AVF device during simulated CPA) (Mean CC Rate: 111.2 cpm (95% CI 109.7–112.7 cpm)), 71.5% in Group C (with the AVF device during CPR training and without the AVF device during simulated CPA) (Mean CC Rate: 112.4 cpm (95% CI 109.8–115 cpm)), and 79.4% in Group D (with the AVF device during CPR training and simulated CPA) (Table 3) (Mean CC Rate: 112.3 cpm (95% CI 110.4–114.1 cpm)).

With or without the AVF device during CPR training

The use of the AVF device during CPR training resulted in a − 2.6% (95% CI, − 12.9–7.6%; $P = 0.61$) change in appropriate CC depth compliance compared with no AVF device (Table 2). At the same time, there was a − 1.3% (95% CI, − 8.7–6.1%; $P = 0.724$) change in compliance with rate guidelines (Table 3).

With or without the AVF device during simulated CPA

The use of the AVF device during simulated CPA resulted in a 22.8% (95% CI, 13.3–32.3%; $P < 0.001$) absolute increase in CC depth compliance (Table 2) and an 11.3% (95% CI, 4.1–18.5%; $P = 0.003$) absolute increase in CC rate compliance compared with no AVF device (Table 3). Figure 2 shows the main effect of the AVF device during CPR training and simulated CPA on the quality of CCs.

Discussion

This study evaluated the effect whether the use of an AVF device during CPR training or simulated CPA scenario is more conducive to improving the quality of CC. Our results showed that using the AVF device during simulated CPA can improve the quality of CC. Considering that the participant is performing CPR, there is often lack of an AVF device for assessing the depth of CCs; as the time increases, participants have a fatigue effect, which makes it harder to achieve the appropriate CC depth and appropriate CC rate[15]. Wee et al. indicated that the use of feedback devices helps to improve the quality of CPR[16]. This opinion is also shared by the other authors[13, 17, 18]. In spite of this, the use of the feedback device in practical application still raises the following questions: (1) most of the hospitals or training institutions in China do not have the AVF device; especially the outside hospitals, they lack the feedback devices; (2) Under the condition of using the CPR AVF device, whether the survival rate of patients improves needs to be studied [19]. (3) Even if we use the AVF device in CPR training, the actual scene is without the AVF device. Whether the operator will not get accustomed to it and will affect the quality of CC? Therefore, the purpose of our study is to determine whether the use of AVF equipment during CPR training or during simulated CPA scenarios is more conducive to improve the quality of CC.

In this study, our findings expand the observations of the effect of the AVF device on the quality of CC during CPR training and simulated CPA scenario. The findings of our study may have important pragmatic implications for recommending the use of more feedback devices in public places, including hospitals and public places outside the hospitals. During a simulated CPA scenario, the use of an AVF device has significantly improved the percentage of CCs with appropriate depth and rate. Interestingly, the rate of CCs in all groups fulfilled the 2015 AHA Guidelines for recommendations. With respect to the rate of CCs, it is easier to achieve the standard by emphasizing and practicing with the songs of a particular beat. The participant can keep the rates in a relatively stable range by the number of beats[20]. During a simulated CPA scenario, the AVF device improved the CC quality through increasing the proportion of appropriate rate and depth, and the application of the AVF device significantly improved the quality of CC. These results were in line with those of a previous study, which has already shown that the application of the AVF device is effective for refreshing CPR skills in a simulated cardiac arrest scene [15]. In general, compared with the application of the AVF device during CPR training, the use of the AVF device during simulated CPA scenarios is more conducive to improving the quality of CC.

Diverse factors likely influence the effectiveness of the device and the quality of CPR, including rescuers responsiveness to the visual feedback devices, patient age, and duration of training. Our research aimed to evaluate individual models under ideal laboratory conditions. In clinical practice, CPR is performed under more challenging conditions, especially with different patients[12]. Thus, a further study is needed for application of a real-time feedback device in resuscitation from real sudden cardiac arrest[12, 19]. In addition, because we did not conduct follow-up surveys of the participants, we were not able to determine whether their CPR quality differed over training or CC for a long time. Therefore, further investigations about the use of a feedback device for regular assessment are required [21, 22].The main limitation of this study is that it was conducted using manikins. Another limitation of our study is that we did not collect long-time training or chest compression test data of all participants' CPR quality.We do not know if the use of AVF devices will improve their CPR quality over a long time. Therefore, we plan to design a long-term training or CC test to estimate these participants' CPR quality after using the AVF device during CPR training and a simulated CPA scenario.

Conclusions

Compared with the application of the AVF device during CPR training, the use of the AVF device during simulated CPA scenarios is more conducive to improving the quality of CC.

Abbreviations

CPR
Cardiopulmonary resuscitation
AVF
Audiovisual feedback
CPA

Cardiopulmonary arrest
CC
Chest compression
OHCA
Out-of-hospital cardiac arrest
AHA
American Heart Association
ALS
Advanced life support

Declarations

Acknowledgments

The authors would like to thank all the participants who made this study possible，and thank LetPub (www.letpub.com) for its linguistic assistance during the preparation of this manuscript.

Funding

No authors received funding or resources in relation to this article.

Author information

Rong Zeng and Dao-quan Liu are the co-first authors in this study.

Affiliations

Emergency Center, Zhongnan Hospital of Wuhan University, Wuhan, 430071, Hubei Province, China

Rong Zeng, Dao-quan Liu, Hao-li Ma, Lian Lin, Xian-long Zhou, Yan Zhao & Xiao-qing Jin

Hubei Clinical Research Center for Emergency and Resuscitation, Zhongnan Hospital of Wuhan University, Wuhan, 430071, Hubei Province, China

Rong Zeng, Hao-li Ma, Lian Lin, Xian-long Zhou, Yan Zhao & Xiao-qing Jin

Department of Urology, Zhongnan Hospital of Wuhan University, Wuhan, 430071, Hubei Province, China

Dao-quan Liu

Contributions

Rong Zeng and Dao-quan Liu: acquisition of data, analysis and interpretation of data, drafting the article, and final approval; Hao-li Ma, Lian Lin, and Xian-long Zhou: interpretation of data, revising the article, and final approval; Yan Zhao and Xiao-qing Jin: conception and design of the study, critical revision, and final approval. The authors read and approved the final manuscript.

Corresponding author

Correspondence to Yan Zhao and Xiaoqing Jin

Ethics declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Ong MEH, Perkins GD, Cariou A. Out-of-hospital cardiac arrest: prehospital management. Lancet. 2018;391:980–8.
2. Chamberlain RC, Barnetson C, Clegg GR. Halbesma N.Association of measures of socioeconomic position with survival following out-of-hospital cardiac arrest: a systematic review. Resuscitation. 2020.
3. Kitamura T, Iwami T, Kawamura T, Nagao K, Tanaka H. Hiraide A.Nationwide public-access defibrillation in Japan. The New England journal of medicine. 2010;362:994–1004.
4. Zhang S. Sudden cardiac death in China: current status and future perspectives. Europace. 2015;17(Suppl 2):ii14–8.
5. Berdowski J, Berg RA, Tijssen JG, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: Systematic review of 67 prospective studies. Resuscitation. 2010;81:1479–87.
6. Singh S, Fong HK, Mercedes BR, Serwat A, Malik FA, Desai R. COVID-19 and out-of-hospital cardiac arrest: A systematic review and meta-analysis. Resuscitation. 2020;156:164–6.
7. Wnent J, Bohn A, Seewald S, Fischer M, Messelken M, Jantzen T, Gräsner I. Gräsner JT.[Bystander resuscitation: the impact of first aid on survival]. Anasthesiol Intensivmed Notfallmed Schmerzther. 2013;48:562–5.
8. Neumar RW, Shuster M, Callaway CW, Gent LM, Atkins DL, Bhanji F, Brooks SC, de Caen AR, Donnino MW, Ferrer JM, et al. Part 1: Executive Summary: 2015 American Heart Association Guidelines

Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015;132:315-67.

9. Kleinman ME, Brennan EE, Goldberger ZD, Swor RA, Terry M, Bobrow BJ, Gazmuri RJ, Travers AH, Rea T. Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015;132:414-35.
10. Ahmed SM, Garg R, Divatia JV, Rao SC, Mishra BB, Kalandoor MV, Kapoor MC. Singh B.Compression-only life support (COLS) for cardiopulmonary resuscitation by layperson outside the hospital. Indian J Anaesth. 2017; 61:867–73.
11. Perkins GD, Handley AJ, Koster RW, Castrén M, Smyth MA, Olasveengen T, Monsieurs KG, Raffay V, Gräsner JT, Wenzel V, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Sect. 2. Adult basic life support and automated external defibrillation. Resuscitation. 2015;95:81–99.
12. Ruiz de Gauna S, González-Otero DM, Ruiz J, Russell JK. Feedback on the Rate and Depth of Chest Compressions during Cardiopulmonary Resuscitation Using Only Accelerometers. PloS one. 2016;11:e0150139.
13. Kirkbright S, Finn J, Tohira H, Bremner A, Jacobs I, Celenza A.Audiovisual feedback device use by health care professionals during CPR: a systematic review and meta-analysis of randomised and non-randomised trials. Resuscitation. 2014; 85:460–71.
14. Nolan JP.High-quality cardiopulmonary resuscitation. Curr Opin Crit Care. 2014; 20:227–33.
15. Nishiyama C, Iwami T, Kawamura T, Ando M, Yonemoto N, Hiraide A, Nonogi H. Quality of chest compressions during continuous CPR; comparison between chest compression-only CPR and conventional CPR. Resuscitation. 2010;81:1152–5.
16. Zhou XL, Wang J, Jin XQ, Zhao Y, Liu RL, Jiang C. Quality retention of chest compression after repetitive practices with or without feedback devices: A randomized manikin study. The American journal of emergency medicine. 2020;38:73–8.
17. Iskrzycki L, Smereka J, Rodriguez-Nunez A, Barcala Furelos R, Abelarias Gomez C, Kaminska H, Wieczorek W, Szarpak L, Nadolny K, Galazkowski R, et al. The impact of the use of a CPRMeter monitor on quality of chest compressions: a prospective randomised trial, cross-simulation. Kardiol Pol. 2018;76:574–9.
18. Wieczorek W, Smereka J, Ladny JR, Kaminska H, Galazkowski R, Szarpak L. The impact of a CPRezy™ feedback device on the quality of chest compressions performed by nurses. The American journal of emergency medicine. 2018;36:1318–9.
19. Wee JC, Nandakumar M, Chan YH, Yeo RS, Kaur K, Anantharaman V, Yap S, Ong ME.Effect of Using an Audiovisual CPR Feedback Device on Chest Compression Rate and Depth. Ann Acad Med Singap. 2014; 43:33–8.
20. González-Salvado V, Fernández-Méndez F, Barcala-Furelos R, Peña-Gil C, González-Juanatey JR. Rodríguez-Núñez A.Very brief training for laypeople in hands-only cardiopulmonary resuscitation. Effect of real-time feedback. The American journal of emergency medicine. 2016;34:993–8.

21. Baldi E, Cornara S, Contri E, Epis F, Fina D, Zelaschi B, Dossena C, Fichtner F, Tonani M, Di Maggio M et al. Real-time visual feedback during training improves laypersons' CPR quality: a randomized controlled manikin study. Cjem. 2017;19:480–7.
22. Mpotos N, De Wever B, Cleymans N, Raemaekers J, Valcke M, Monsieurs KG. Efficiency of short individualised CPR self-learning sessions with automated assessment and feedback. Resuscitation. 2013;84:1267–73.

Figures

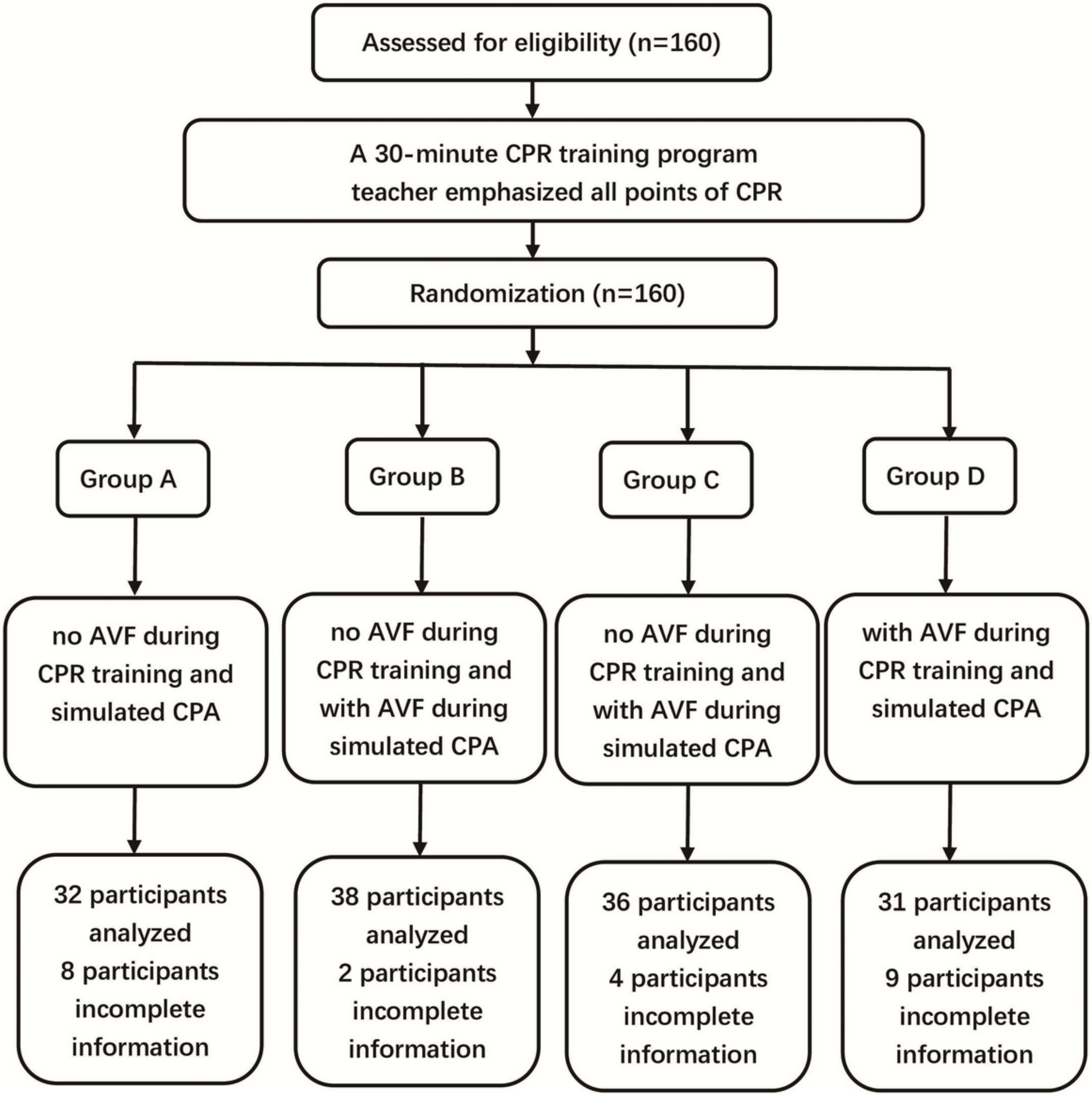

Figure 1

Flow diagram of participant.

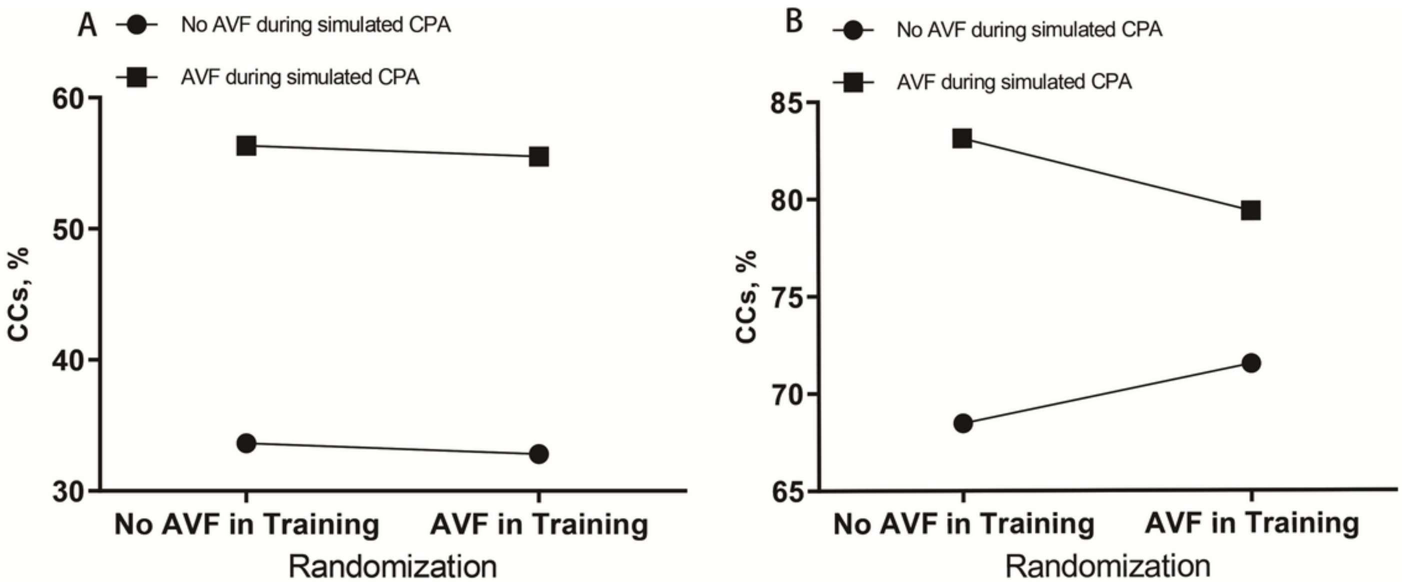

Figure 2

Effects of the AVF device used in training and simulated CPA on CC Quality. (A) The mean proportion of CCs with appropriate depth between 5 and 6 cm. (B) The mean proportion of CCs with a rate of 100–120 per minute. AVF: audiovisual feedback. CPA: simulated cardiopulmonary arrest.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- eTable1.docx
- eTable2.docx