Title: The Effect of Chest compression feedback (CCF) in cardiopulmonary resuscitation procedures by using a Cardiopulmonary resuscitation (CPR) meter on Return of Spontaneous Circulation (ROSC)

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Abstract

Background: Management of patients who require cardiopulmonary resuscitation is one of the most critical tasks that nurses perform in the intensive care units (ICUs). Improving the quality of CPR can be very important in improving cardiopulmonary outcomes and survival. However, often the depth, release, and rate of chest compressions are controlled subjectively by the nurse. This study aimed to investigate the effect of chest compression feedback (CCF) by nurses using a Cardiopulmonary Resuscitation (CPR) meter on the Return of Spontaneous Circulation (ROSC) in patients undergoing CPR admitted to the intensive care units.

Methods: This single-blinded, two-arm parallel randomized clinical trial was conducted on 70 patients undergoing cardiopulmonary resuscitation who were admitted to the intensive care unit of the Iraqi-Korean Specialized Intensive Care Hospital in Baghdad, Iraq. The patients were randomly allocated to the experimental and control groups (35 subjects per group). Feedback was given to the nurses in the experimental group by a CPR meter as soon as CPR began. Patients in the control group received routine CPR. To assess the key indicators of ROSC, including blood pressure, pulse, and End-Tidal Carbon Dioxide (ETCO2), we recorded ROSC rates at 5, 10, 15, 20, and 30 minutes following CPR. The measurements and data collection were conducted according to the Utstein Style Guidelines. Subsequently, data on sustained ROSC, blood pressure, pulse, and ETCO2 were analyzed to ensure accuracy and comparability based on these guidelines. Statistical analysis was performed using SPSS software (V.24). Independent t-test, Chi-square test, and repeated measures ANOVA were employed to analyze the data. The significance level was set at $p < 0.05$.

Results: The percentages of spontaneous blood flow return after 30 minutes of resuscitation were 17.55% and 14.35% in the experimental and control groups, respectively. Within-group comparison showed a significant difference in the blood pressure, pulse, and ETCO2 of both groups in the time interval of five minutes to 30 minutes after the start of CPR. Between-group comparison showed significant differences in the patients' blood pressure and pulse in all time intervals, except for the first five minutes. The ETCO2 difference was only significant after 10 and 30 minutes of CPR.

Conclusion: Providing feedback to nurses by CPR meters provides an effective method to increase the quality of CPR and return of spontaneous circulation of patients.

Keywords: Cardiopulmonary resuscitation Feedback, Return of Spontaneous Circulation, CPR meter, Intensive care unit, Randomized clinical trial

Highlights

- The percentage of return of spontaneous circulation (ROSC) after 30 minutes of resuscitation was higher in the intervention group (17.55%) compared to the control group (14.35%).
- Using a CPR meter provided a significant improvement in systolic blood pressure and pulse rate from 10 minutes after the start of CPR.
- Use of a CPR meter significantly improved ETCO2 levels at 10 and 30 minutes after the start of CPR.
- Providing feedback to nurses by CPR meters provide an effective method to increase the quality of CPR and return of spontaneous circulation of patients.

Plain Language Summary

Cardiopulmonary resuscitation (CPR) is a vital medical procedure used to help restore cardiac function. Our study aimed to investigate whether providing continuous feedback on chest compressions to nurses, using a CPR meter, could improve the quality of resuscitation and a better return of spontaneous circulation (ROSC) in patients admitted to the ICU. Our findings show that using a CPR meter, improves the quality of chest compressions, and provides a higher rate of ROSC. Using this application could be an effective way to improve outcomes for patients undergoing CPR.

Introduction

Cardiac arrest (CA) is a medical emergency that can lead to death if not treated immediately. Cardiopulmonary resuscitation (CPR) is a lifesaving measure that improves survival rates after cardiac arrest (Vural et al., 2017). Patients admitted to the intensive care units (ICU) are at risk of CA due to critical clinical conditions (Katircioglu et al., 2023). The incidence of ICU-CPR is approximately 40 in 1,000 admissions overall and approximately 10 in 1,000 admissions after the day of ICU admission (Zajic et al., 2022).

Patient monitoring and invasive and semi-invasive treatments are performed in the ICU (Marshall et al., 2017) . Due to the breadth of services they provide, ICU can be likened to a small hospital within a large hospital that provides life-saving care to patients in critical conditions. This life-saving care occurs as a result of the interaction among health care providers, patients, and medical equipment (Vaillancourt et al., 2011). The ICU is known as the performance control bottleneck in the hospital, and compliance with standards in this unit is of utmost importance. ICU nurses perform many important tasks, one of the most important of which is the management of patients with CA (Seethala et al., 2010).

CA is defined as the cessation of the heart's pumping function, resulting in cessation of cardiac output. Following CA, the patient loses consciousness after 15 seconds and breathing stops after 30-60 seconds, decreased level of consciousness, and loss of pulse and blood pressure occur immediately after cardiac arrest (Morley, 2007).

CPR is one of the most important in-hospital interventions to save the lives of patients who have suffered cardiopulmonary arrest (Elshal et al., 2021). It is a set of measures that, following cardiopulmonary arrest, attempts to artificially restore blood circulation and respiration until the patient's spontaneous blood flow returns. This set of measures is known as basic and advanced cardiac life support (Kim et al., 2020).

In the United States, approximately 2.2 million people require CPR annually, of which approximately 350,000 undergo CPR, many of whom die and many others suffer irreversible damage (Anderson et al., 2014). The survival and discharge rate after cardiopulmonary arrest in the United States has been reported to be 16.5% (Go et al., 2013).

The quality of CPR plays a critical role in improving CPR outcomes and patient survival. Chest compressions are the most important factor in improving the quality of CPR. Chest compressions need to be performed at the correct depth (5–6 cm) and rate (100–120 per minute) (Singh et al., 2022). Therefore, numerous efforts have been made to ensure the effectiveness of chest compressions (Xu et al., 2021). Chest compressions are the most important element of CPR. Coronary and cerebral blood pressure and ROSC are maximized when quality chest compressions are performed (Savastano et al., 2021) . All efforts to provide quality CPR should take precedence over any advanced procedures such as endotracheal intubation or vascular access (Peberdy et al., 2009). The quality of chest compressions is the most important intervention that affects outcome. During CA, the quality of chest compressions can be assessed using a variety of methods that are commonly available in hospitals (Morley, 2007). For example, a CPR meter can be placed between the rescuer's hand and the patient's chest to check the rescuer's chest compression performance for correct depth and rate, increasing the number of correct chest compressions (Kim et al., 2020). The CPR meter as a compact, hand-held device developed by Laerdal Medical, have been designed to provide real-time feedback on the quality of chest compressions during cardiopulmonary resuscitation (CPR). The device measures key parameters including a compression rate between 100–120 compressions per minute (±3/min), a compression depth of at least 50 mm (±10%), and chest recoil with a release force of less than 2.5 kg. Its dimensions are approximately 154 × 64 × 28 mm, allowing easy placement on the patient's chest during CPR efforts (Buléon et al., 2016).

Some studies have explored the impact of CPR feedback devices on resuscitation outcomes. A recent systematic review and meta-analysis of randomized controlled trials conducted by Lin et al. (2025) found that the use of CPR feedback devices in resuscitation training significantly improved the depth and rate of chest compressions (Lin et al., 2025). Furthermore, a study by Buléon et al. (2013) using a CPR meter in a simulation setting showed a significant improvement in chest compression quality, suggesting its potential to enhance rescuer performance (Buléon et al., 2013).

While the use of CPR feedback devices has been widely studied, with some research suggesting a positive impact on resuscitation quality and ROSC, other systematic reviews have reported conflicting results or a lack of significant effect on patient outcomes. For instance, in a systematic review and meta-analysis by Wang et al. (2020) the pooled results did not confirm the positive effects of the CPR feedback device, meaning that despite improvements in chest compression quality, there was no conclusive evidence of a positive effect of feedback devices on patient survival and neurological outcomes (Wang et al., 2020). This inconsistency in the literature highlights the ongoing need for further research, especially considering the variability in healthcare systems and patient populations across different regions.

Therefore, this study aimed to determine the effect of real-time CPR feedback using a CPR meter on ROSC in critically ill patients admitted to the ICU.

Materials and Methods

Design, setting, and sample

This single-blinded, two-arm parallel randomized clinical trial was conducted from January 2023 to October 2024 at the Iraqi-Korean Critical Care Specialty Hospital in Baghdad, Iraq.

Participants were patients requiring CPR admitted to the ICU. Inclusion criteria included patients between 18 and 80 years of age, with cardiac arrest of non-traumatic origin. Patients who died or whose resuscitation was terminated by the resuscitation team were excluded from the study.

Based on the results of Krikscionaitiene et al. (2013), and given a type I error probability of 0.05 and a power of 0.80, the sample size was determined to be 35 patients in each group. To eliminate the effect of the resuscitator role, an attempt was made to include nurses in a fixed ICU where they do not usually move to other wards in the study. Also, given that this was done in different shifts and the patients who entered the groups were randomly assigned, this effect was partially eliminated. The recruitment process is shown in Figure 1.

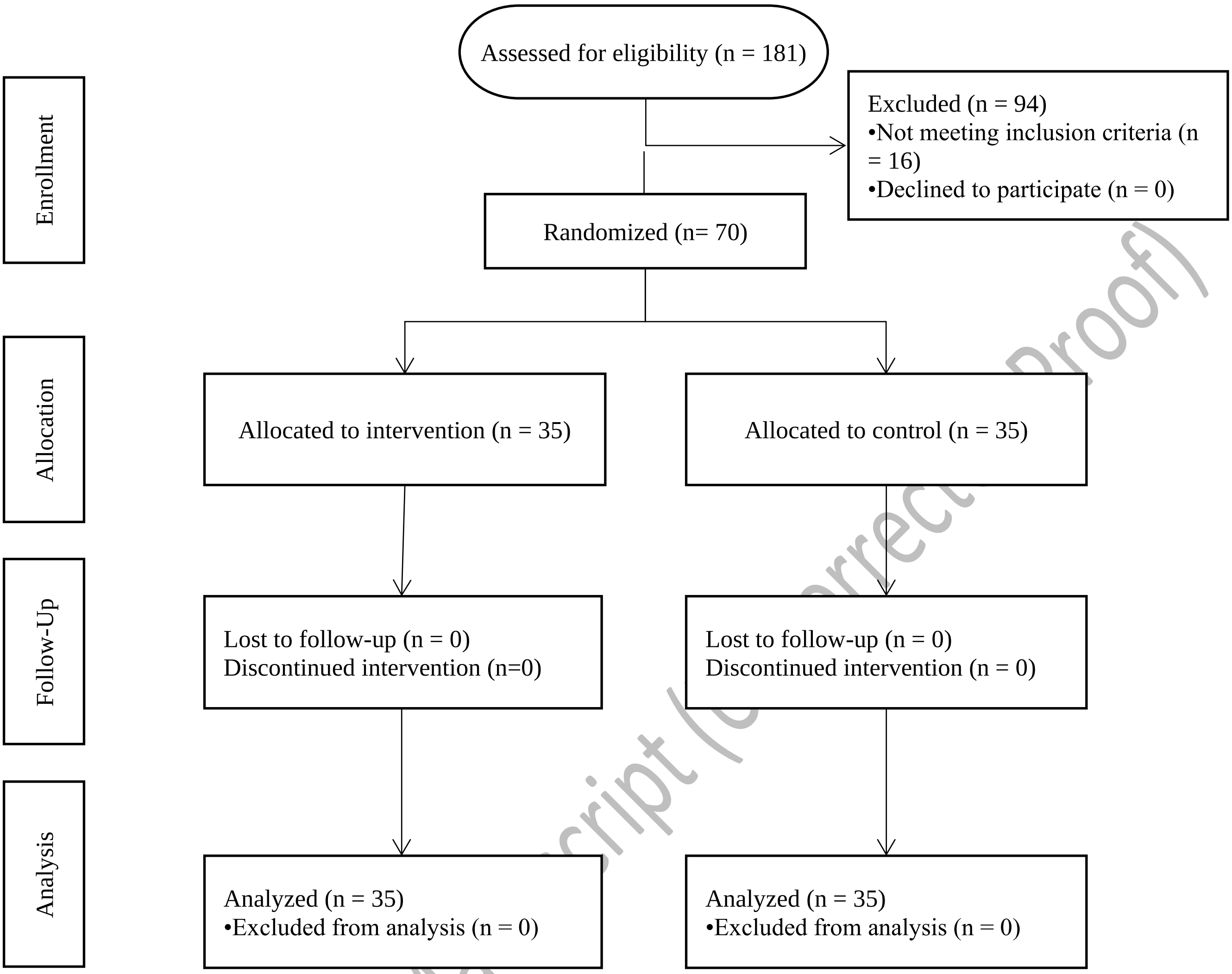

Figure. 1. CONSORT diagram of the study process

Patients were initially recruited from the ICU, based on the inclusion criteria. To ensure a robust randomization process and minimize selection bias, a block randomization design with variable block sizes (e.g. 4 and 6) was employed to randomly assign patients to either the intervention or control groups using the website https://www.sealedenvelope.com/simple-randomiser/v1/lists. This method helps to maintain a balanced number of participants in each group throughout the study. Selection bias may be reduced by using random block sizes and keeping the investigator blind to the size of each block (Efird, 2011).

Intervention

The study objectives were first explained to the participants' families and an informed consent was received by each of them. Then a checklist of demographic information of eligible patients admitted to the ICU was completed. The experimental group underwent CPR using the relevant device, and the control group received routine care without the use of the feedback device.

ROSC components were measured and evaluated in these patients five times during CPR (5, 10, 15, 20, and 30 minutes after the start of CPR). ROSC refers to the rate of pulse, blood pressure, and ETCO2 (At the beginning of cardiac resuscitation, a capnograph was connected to the patient's endotracheal tube by the nurse, and the assigned nurse recorded the patient’s ETCO2 levels).

Data Collection

The primary data collection tools used in this study included a CPR meter for the intervention group and a researcher-developed Utstein guideline checklist for recording ROSC key components (blood pressure, pulse, and ETCO2) in both groups. The Utstein Style Guidelines, developed by ILCOR, standardize reporting of cardiac arrest and CPR outcomes (Nolan et al., 2019).

To ensure the validity of the checklist, its content was reviewed and approved by a panel of experts in nursing and emergency medicine at Shahed University, Tehran province, Iran. The panel evaluated the checklist's items for relevance, clarity, and comprehensiveness. Additionally, the first author trained the assigned nurses to use the checklist and CPR meter to standardize data collection procedures. The inter-rater reliability of the checklist was also assessed among the researchers, yielding a high degree of agreement (Kappa coefficient 0.6-0.8).

Data Analysis

Having collected the data, SPSS-PC software V.24 was used for the statistical analyses. The Kolmogorov-Smirnov test was used to examine the normal distribution of quantitative variables. An independent t-test was used to compare quantitative variables (e.g., Age, CPR time) between the two groups, and a Chi-square test was used to compare qualitative variables (e.g., Gender, underlying disease, heart rhythm when CPR is started, work shift) between the two groups. To compare the percentage of ROSC between the two groups, the Chi-square test was also performed. Additionally, a repeated measures ANOVA was used to examine the mean changes in ROSC components, including systolic blood pressure, pulse rate, and ETCO2, across the intervention period (at 5, 10, 15, 20, and 30 minutes after the start of CPR). At this stage, the analyst was blinded to the data belonging to the intervention and control groups.

Results

Comparison of demographic and clinical characteristics of the experimental and control groups are summarized in Table 1. The mean age of the patients in the intervention and control groups was 59.35±6.14 and 58.10±6.09 years, respectively. Statistical analysis revealed no significant difference between the two groups regarding demographic and clinical characteristics ($p>0.05$). The results of this study showed that the percentage of patients achieving sustained ROSC after 30 minutes of resuscitation was higher in the intervention group (17.55%) compared to the control group (14.35%), indicating that a better outcome was achieved in the intervention group.

Table 1- Personal characteristics of the intervention and control groups

Groups Variables		Groups: Intervention	Control	Statistical test and P value
Age **Mean ± SD**		59.35±6.14	58.10±6.09	t = 1.319, p = .19
CPR time **Mean ± SD**		28.24±3.15	28.94±3.21	t = 1.302, df = 118, p = 0.195
Gender **N (%)**	Male	19 (54.3)	18 (51.4)	x2 =0.057, df = 1, p = 0.811
	Female	16 (45.7)	17 (48.6)	
***Medical conditions** **N (%)**	Cardiac	14 (40)	13 (37.1)	x2 = 3.713, df = 1, p = 0.085
	Non-cardiac	21 (60)	22 (62.9)	
Heart rhythm when CPR is started **N (%)**	PEA	7 (20)	6 (17.1)	x2 =0.576, df = 3, p = 0.90
	VF	13 (37.1)	13 (37.1)	
	Pulseless VT	7 (20)	7 (20)	
	Asystole	8 (22.9)	9 (25.7)	
Shift **N (%)**	Morning	9 (25.7)	9 (25.7)	x2 =1.222, df = 1, p = 0.350
	Evening	10 (28.6)	11 (31.4)	
	Night	16 (45.7)	15 (42.9)	

*** Any condition other than the present illness**

PEA: Pulseless Electrical Activity, VF: Ventricular Fibrillation, Pulseless VT: Pulseless Ventricular Tachycardia

Within group comparison showed a significant difference in the blood pressure, pulse, and ETCO2 of both groups in the time interval of five minutes to 30 minutes after the start of CPR. Between group comparison showed that systolic blood pressure was not significantly different between the intervention and control groups at minute five (P = 0.09); however, a significant difference was observed at minutes ten (P = 0.032), fifteen (P = 0.017), twenty (P = 0.005), and thirty (P = 0.001). Pulse was not significantly different at minute five (P=0.12), but a significant difference was found between the groups at minutes ten (P=0.035), fifteen (P=0.042), twenty (P=0.012), and thirty (P=0.001). ETCO2 was not significantly different between the groups at minutes five (P=0.68), fifteen (P=0.95), and twenty (P=0.88). However, a significant difference was noted at minutes ten (P=0.047) and thirty (P=0.001) (table 2).

Table2. Within- and between-group comparisons of mean and standard deviation of ROSC at five, 10, 15, 20, and 30 minutes after the start of resuscitation

Indicator	**Group**	**five**	**10min**	**15min**	**20min**	**30min**	**P value***
Systolic Blood Pressure	Intervention	7.05±0.6	7.35±0.98	8.75±1.15	9.25±1.27	9.85±01.35	0.032
	Control	6.85±0.55	6.87±0.56	7.25±0.88	7.85±0.93	8.25±1.08	0.04
P value**		0.09	0.032	0.017	0.005	0.001	
pulse	Intervention	47±6	53±6.9	58.7±7.2	68.54±8.45	74±8.75	0.001
	Control	48±5.85	46±5.44	54±6.5	56±6.8	58±35	0.002
P value**		0.12	0.035	0.042	0.012	0.001	
ETCO۲	Intervention	10.2 ±1.25	14.25±3.2	17.55±4.75	27.85±4.85	38±6.35	0.023
	Control	10.55±1.45	12.75±3.65	17.25±4.83	26.85±4.55	35±5.85	0.0023
P value**		0.68	0.047	0.95	0.88	0.001	

- **The unit of measurement for blood pressure and ETCO2 variables is mmHg.**
- **Numbers of this table are for patients in whom these variables were measurable. If they were zero and not measurable, they were not calculated.**

*ANOVA for Repeated measures, ** Independent T-Test

Discussion

This study aimed to evaluate the effect of cardiopulmonary resuscitation feedback to nurses using a CPR meter on ROSC in patients undergoing cardiopulmonary resuscitation admitted to the intensive care unit. According to the findings of the present study, 30 minutes after the start of CPR, ROSC in patients undergoing cardiopulmonary resuscitation in the intervention group was better than in the control group, as shown by better systolic blood pressure and ETCO2.

Effective chest compression remains the cornerstone of successful CPR and is vital for survival and good neurological recovery (Kovacs et al., 2015). As such, the quality of chest compression remains a focal point of international guidelines (Ayala et al., 2014).

Both compression rate and depth are critically important; compression rates below 75 or above 125 compressions per minute are associated with a decreased likelihood of ROSC, which indicates a poorer outcome. Moreover, the use of proper compression force and depth is essential to minimize CPR-associated injuries (Kovacs et al., 2015).

Several CPR adjunct devices have been developed to improve the consistency and quality of chest compressions (Miller et al., 2014). As an example and consistent with the results of the present study, another study showed that the use of the Cardio First Angel™ CPR feedback device has improved the adherence to published CPR guidelines and CPR quality, and was associated with increased rates of ROSC (Vahedian-Azimi et al., 2016).

A study by Lampe et al. (2020) at Northwell Health established a time-dependent function correlating carotid blood flow during CPR with the response to varying chest compressions. The aim of this study was to optimize CPR parameters in real time and thus maximize carotid blood flow, by predicting the carotid blood flow generated by subsequent chest compressions (Lampe et al., 2020).

Currently, patient outcomes after cardiac arrest remain poor. This study found that the average ROSC has increased, consistent with previous studies reporting rates between 13% and 72%. Breuer-Kaiser et al. (2024) showed that although the use of CPR feedback devices is not routine, their use is associated with improved ROSC rates. However, no significant effect was found on ROSC at hospital admission, highlighting the need for further research (Breuer-Kaiser et al., 2024).

One of the main limitations of this study is the relatively small sample size and its conduction within a single clinical setting, which may limit the generalizability of the findings. In the intervention group, adherence to cardiac resuscitation guidelines significantly increased with the use of the CPR meter, which likely reflects the positive impact of this device. However, the possible role of other unmeasured factors in this improvement cannot be entirely ruled out. Future studies should aim to control for these variables and further clarify the precise effect of the device.

Conclusions

The findings of this study highlight the potential benefits of incorporating CPR feedback devices into clinical practice to enhance the quality of resuscitation efforts. By improving adherence to CPR guidelines and supporting timely physiological assessments, these devices can contribute to better patient management during cardiac arrest. Future research should focus on larger, multicenter trials to confirm these benefits and to evaluate long-term patient outcomes, thereby guiding evidence-based implementation of CPR feedback technology.

Ethical Considerations

Compliance with ethical guidelines

This research was approved by the Ethics Committee of Baghdad University (approval code: Ref18843, 14.01.2024). The patients'families were informed about the study's aim, the voluntary nature of patient participation, and the right to withdraw from the study at any time. Informed consent was obtained from the legal guardian of each patient before data collection. All steps of this study involving human participants were conducted in accordance with the ethical principles of the Declaration of Helsinki.

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Authors' contributions: BA and **AK**: conceptualization, methodology, validation, writing—original draft, investigation, visualization, and supervision. **AJK**: conceptualization, methodology, validation, writing—original draft, investigation, visualization, and supervision. **MA**: writing—original draft, review & editing, investigation, visualization, and validation. **HD**: conceptualization and writing—original draft. **RN**: review & editing, validation, and resources. **ZH**: conceptualization, validation, and investigation. All the authors have read and approved the final manuscript for publication and agreed to be accountable for all aspects of the work.

Conflict of interest: The authors declared no conflict of interest

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