Original Article

Evaluation of the quality of cardiopulmonary resuscitation provided by the emergency response team at a tertiary care hospital

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ABSTRACT

Background and Aims: Chest compression fraction is the proportion of time spent on chest compression during cardiopulmonary resuscitation (CPR). The aims of this study were to know the quality of CPR provided during in-hospital cardiac arrest (IHCA) by analysing the chest compression fraction and to see the correlation of chest compression fraction with return of spontaneous circulation (ROSC) in the hospital setting. **Methods:** This prospective observational study was conducted in patients aged >18 years who developed IHCA. An observer would assess the quality of CPR provided by noting the time spent on chest compression. The chest compression fraction was calculated and correlated in patients with ROSC and without ROSC. Patients who survived were followed until discharge, and their neurological score was determined using the cerebral performance category (CPC). **Results:** We included 126 patients in the study; the mean chest compression fraction achieved was 78% (standard deviation [SD] ± 5). A total of 73 (58%) patients achieved ROSC and among them, 11 patients (9%) survived to hospital discharge. We found that the patients with ROSC had a significantly higher chest compression fraction of 80% (SD ± 5), as compared to 75% (SD ± 5), in whom ROSC could not be achieved. A multivariate logistic regression test showed higher odds (1.125) of ROSC in patients with high chest compression fraction. The mean CPC among the survivors was 1.4 (SD ± 0.5). **Conclusion:** Our study shows that health-care providers in our hospital provide high-quality CPR, and chest compression fraction is independently associated with ROSC in IHCA.

Key words: Cardiopulmonary resuscitation, heart arrest, resuscitation, return of spontaneous circulation

INTRODUCTION

High-quality cardiopulmonary resuscitation (CPR) determines the outcome of in-hospital cardiac arrest (IHCA) patients. American Heart Association (AHA) 2020 CPR guidelines have defined objective parameters to maintain the CPR quality. They include providing chest compressions at a rate of 100–120 compressions per minute, providing chest compressions with adequate depth of at least 5 cm, minimising interruptions in the chest compressions, averting leaning on the chest between compressions and avoiding excessive ventilation.[1] Minimising interruptions in the chest compression leads to more time spent on chest compression, which transcends to higher the chances of return of spontaneous circulation (ROSC).

Chest compression fraction is the proportion of time spent on chest compression during CPR. A high chest

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compression fraction indicates minimal interruptions, which is a measurable quality indicator of the CPR provided. Various studies have shown that a chest compression fraction of 60%–80% is associated with a greater incidence of ROSC and survival.[2,3] AHA 2020 guidelines also recommend targeting chest compression fraction >60% in all patients and >80% as frequently as possible.[1]

We conducted this study to know the quality of CPR provided at our institute by measuring the chest compression fraction, as previous evidence suggests chest compressions during CPR are inadequate during IHCA.[4] Also, most of the studies done to measure the CPR quality are done in out-of-hospital cardiac arrest (OHCA), and data for in-hospital arrest are very limited.[2,3] Our objective was to measure the quality of CPR provided in IHCA by analysing the chest compression fraction. We also wanted to see the correlation of chest compression fraction with ROSC in our hospital setting.

METHODS

This prospective observational study was conducted at a tertiary care teaching college hospital after obtaining Institutional Ethics Committee (IEC) clearance. The study was registered with the Clinical Trial Registry of India (CTRI/2019/12/022202) and was conducted from December 2019 to April 2021. All patients with age >18 years who developed IHCA and in whom code blue was announced for resuscitation were included in the study. Patients with a history of trauma and do-not-resuscitate orders were excluded from the study. Waiver of the written informed consent was approved by the IEC. All the resuscitation team members and observers were trained with the latest AHA basic life support (BLS) and advanced cardiac life support (ACLS) measures.

Code blue was announced by calling a dedicated number in the hospital. The code blue team comprises a consultant intensivist, a resident doctor, a respiratory therapist, and an intensive care unit (ICU) nurse in our unit. One additional consultant would go along with the code blue team as an observer for the study. The observer is a consultant intensivist trained in the latest AHA BLS and ACLS. The observer noted the time of initiation of CPR and recorded the total duration of CPR using a stopwatch and the time spent on chest compression using another stopwatch. The proforma captured the time duration, and other relevant clinical data were recorded from the case file. Chest compression fraction was calculated after the CPR outcome using the time noted in the proforma. It was calculated as the ratio of time spent for chest compression to the total time of CPR. The data entry was done into the excel sheet. The code blue team was unaware of the study being conducted to minimise the bias.

The comorbidities, diagnosis, acute physiology and chronic health evaluation II (APACHE II), and sequential organ failure assessment (SOFA) score recordings were made from the case sheets and laboratory values.

Post ROSC patients were shifted to ICU for further management. In the ICU, AHA post-cardiac arrest care algorithm was followed, and in patients with poor neurological status, target temperature management was done with a target of 36°C.[1] The patients who achieved ROSC and survived were followed until discharge, and the neurological score at discharge was determined using the cerebral performance category (CPC). CPC is the most commonly used neurological outcome measure in post-cardiac arrest patients.[5,6] At our hospital, we observe Utstein style for reporting cardiac arrest and the same was followed for the study.[6] These are the guidelines for uniform reporting of adult resuscitation by the International Liaison Committee on Resuscitation. We have a cut-off value of 30 minutes to stop CPR in our hospital. In a few instances, a shorter or longer CPR duration was allowed at the discretion of the code blue team.

Considering the recommendation of chest compression fraction >80% by the AHA guidelines, we expected the resuscitations with the above-recommended chest compression fraction to be achievable in 80% of patients with 10% relative precision and 0.05 alpha error, the sample size required for our study was calculated to be 100.

Summary statistics were done by proportions for categorical/binary variables and mean and standard deviation (SD) for continuous variables. Inferential statistics were done by both univariate and multivariate analysis. Univariate analysis was done using the Chi-square test and independent *t* test. Multivariate analysis was done by binary logistic regression enter method. The statistical methods were done using Statistical Package for the Social Sciences (SPSS) version 21.0 for Windows. A value

of $P < 0.05$ was considered statistically significant. All continuous variables presented in the decimal values were rounded to the nearest whole number for simplification.

RESULTS

We included 126 patients during our study period, and the mean chest compression fraction achieved was 78% (SD ± 5). A total of 73 (58%) patients achieved ROSC, and amongst them, 11 patients (9%) survived to hospital discharge [Figure 1]. The demographic data and Utstein variables were compared between ROSC and non-ROSC patients. No significant difference was observed in age, gender, Charlson comorbidity index score, initial rhythm, APACHE II, and SOFA score between the patients who achieved ROSC and those who did not achieve ROSC. The cause of arrest, location of arrest, and the time taken for initiation of CPR were also similar between the two groups. However, we found that the patients who achieved ROSC had a significantly higher chest compression fraction of 80%(SD ± 5) as compared to 75% (SD ± 5) in whom ROSC could not be achieved [Table 1, Figure 1]. The mean chest compression fraction of patients who had a cardiac arrest in the ward was 78% (SD ± 4), and it was 78% (SD ± 5) for patients in the ICU, which is not significant. The mean time taken to achieve ROSC was 11 min 57 s (SD ± 05:49), and for patients who did not achieve ROSC, the mean CPR duration was 26 min 04 s (SD ± 06:36) [Table 1].

The chest compression fraction achieved was separated into three categories, and ROSC achieved in each group was compared [Table 2]. In the patient group in whom chest compression fraction >80%

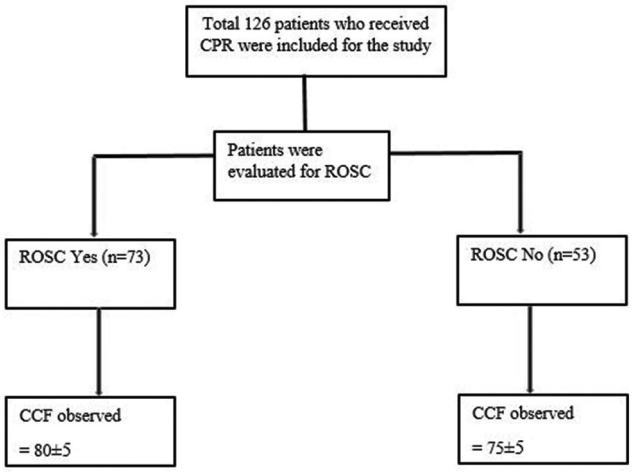

Figure 1: Consolidated Standards of Reporting Trials (CONSORT) flow diagram. CCF- Chest compression fraction, CPR- Cardio Pulmonary Resuscitation, ROSC- Return of spontaneous circulation

Table 1: The general characteristics of the patients and their correlation to ROSC

	Total *n*=126	ROSC Yes *n*	ROSC No *n*=53	*P**
Age [Years (SD)]	57 (16)	58 (15)	59 (18)	0.8
Male [*n* (%)]	81 (64)	44 (60)	37 (70)	0.3
Charlson Co-morbidity Index Score [mean (SD)]	4 (2)	4 (2)	4 (2)	0.9
Arrest rhythm [*n* (%)]				
Asystole	84 (67)	47 (65)	37 (70)	0.7
PEA	22 (17)	12 (16)	10 (19)	
VF/VT	20 (16)	14 (19)	6 (11)	
Cause of arrest :				
Cardiac *n* (%)	36 (29)	21 (29)	15 (28)	0.4
Non-cardiac *n* (%)	90 (71)	52 (71)	38 (72)	
Time for initiation of CPR by primary responder in seconds [mean (SD)]	9 (2)	8 (2)	9 (2)	0.2
Time taken for code team to reach the arrest location in min [mean (SD)]	01:53 (0:30)	01:55 (0:32)	01:50 (0:24)	0.3
Witnessed arrest				0.3
Yes *n* (%)	117 (93)	68 (93)	49 (92)	
No *n* (%)	9 (7)	5 (7)	4 (8)	
APACHE II [mean (SD)]	22 (6)	21 (6)	23 (5)	0.1
SOFA [mean (SD)]	9 (3)	9 (3)	10 (3)	0.1
Location of the arrest				
Ward *n* (%)	77 (61)	45 (62)	32 (60)	0.8
ICU *n* (%)	49 (39)	28 (38)	21 (40)	
Average chest compression fraction % (SD)	78 (5)	80 (5)	75 (5)	0.02
Average CPR time in min [mean (SD)]	17:53 (09:18)	11:57 (05:49)	26:04 (06:36)	<0.001
Survived (*n*)	11	11	0	<0.001

Data expressed as mean±SD (standard deviation) and numbers (percentage in brackets) * Chi-square test and independent *t*-test were used. SD- Standard deviation, PEA-Pulseless electrical activity, VF-Ventricular fibrillation, VT-Ventricular tachycardia, APACHE II- Acute physiology and chronic health evaluation II, SOFA- sequential organ failure assessment, ICU-Intensive care unit, CPR-Cardiopulmonary resuscitation, ROSC-Return of spontaneous circulation

was achieved, a majority (86%) had achieved ROSC, compared to patients with chest compression fraction of 60-80% in whom around 40% achieved ROSC [Table 2, Figure 2].

A multivariate logistic regression test using age, sex, time for initiation of CPR, APACHE II, SOFA, Charlson comorbidity index score, chest compression fraction, initial rhythm, and arrest location was done in ROSC achieved patients. All the clinically significant parameters irrespective of their *P* value in the univariate analysis were included. The test showed superior odds (1.125) of ROSC in patients with high chest compression fraction (95% confidence interval) [Table 3]. The Hosmer and Lemeshow test showed a *P* value of 0.3, which indicated that the multivariate logistic regression model is a good fit (the *P* value > 0.05 in the Hosmer and Lemeshow test indicates a good fit and that it is significant).

Table 2: ROSC pattern according to the chest compression fraction

	ROSC	
	Yes *n* (%)	No *n* (%)
Chest Compression Fraction		
>80%	42 (86)	7 (14)
60%-80%	29 (40)	44 (60)
<60%	2 (50)	2 (50)
Total	73 (58)	53 (42)

Data expressed as number (percentage in brackets) The Chi-square test showed high chest compression fraction was significantly associated with ROSC (*P*<0.001). ROSC- return of spontaneous circulation

Table 3: Multivariate logistic regression test showing factors associated with ROSC

	P	OR	95% C. I. for OR	
			Lower	Upper
Age (Years)	0.85	0.99	0.96	1.03
Sex	0.29	0.63	0.27	1.49
Time for initiation of CPR	0.24	0.87	0.69	1.09
APACHE II	0.73	0.98	0.88	1.08
SOFA	0.92	0.99	0.81	1.20
Charlson Comorbidity Index Score	0.87	1.01	0.81	1.27
CCF	0.01	1.12	1.02	1.24
Initial rhythm	0.88			
PEA	0.97	0.98	0.35	2.75
VT	0.45	2.02	0.32	12.69
VF	0.70	1.31	0.32	5.34
Location of arrest	0.79	1.10	0.50	2.45
Constant	0.09	0.001		

Multivariate logistic regression test shows only Chest compression fraction (CCF) is significantly associated with return of spontaneous circulation (ROSC), *P*=0.01. CI- Confidence interval, OR- Odds ratio, APACHE II- Acute physiology and chronic health evaluation II, SOFA- sequential organ failure assessment, CCF- Chest compression fraction, PEA-Pulseless electrical activity, VF-Ventricular fibrillation, VT- Ventricular tachycardia, CPR- Cardiopulmonary resuscitation, ROSC- return of spontaneous circulation

Among all the patients who received CPR, 11 (9%) patients survived to hospital discharge. Ventricular fibrillation (VF)/Ventricular tachycardia (VT) was the commonest initial rhythm amongst the survivors, whereas asystole was the commonest initial rhythm amongst non-survivors. Cardiac cause of arrest was significantly more amongst the survivors than the non-survivors. The time taken by the primary responder to initiate CPR, APACHE II score, and the SOFA score was significantly less amongst the survivors than the non-survivors. The survivors had a significantly higher chest compression fraction of 81% (SD ± 2) as compared to 78% (SD ± 5) in the nonsurvivors [Table 4]. Further, at discharge, seven patients had CPC 1 and, four had CPC 2 and, the mean CPC amongst the survivors was 1.4 (SD ± 0.5).

DISCUSSION

Our study describes the quality of CPR provided for IHCA at a tertiary care hospital by measuring chest compression fraction. In our study, the average chest compression fraction achieved was 78% (SD ± 5), which is in proximity to the AHA 2020 guidelines.[1] Garg *et al*.[7] recommended similar goals to be achieved while providing CPR for IHCA in the Indian context. The data for chest compression fraction are most commonly available for OHCA, and the average chest compression fraction achieved in an observational study by Idris *et al*.[8] was 70%. The chest compression fraction data for IHCA is limited, and an observational study by Kilgannon *et al*.,[9] mentioned the chest compression fraction of 91% was achieved in their study. Chest compression fraction was high in this study as most patients were intubated before CPR,

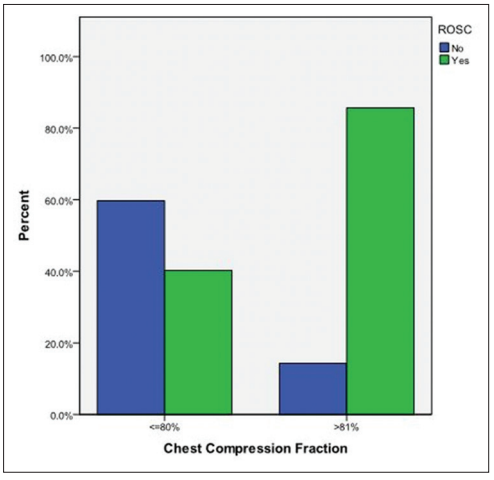

Figure 2: Correlation of ROSC with chest compression fraction. ROSC- Return of spontaneous circulation

Table 4: The characteristics of the patients who survived at hospital discharge

	Total *n*=126	Survival Yes *n*=11	Survival No *n*=115	*P**
Age [Years (SD)]	59 (16)	58 (19)	59 (16)	0.9
Male [*n* (%)]	81 (64)	7 (64)	74 (64)	0.9
Charlson Co-morbidity Index Score [mean (SD)]	4 (2)	4 (2)	4 (2)	0.9
Arrest rhythm [*n* (%)]				
Asystole	84 (67)	4 (36)	80 (70)	0.04
PEA	22 (17)	2 (18)	20 (17)	
VF/VT	20 (16)	5 (46)	15 (13)	
Cause of arrest :				
Cardiac *n* (%)	36 (29)	5 (45)	31 (27)	0.03
Non-cardiac *n* (%)	90 (71)	6 (55)	84 (73)	
Time for initiation of CPR by primary responder in sec [mean (SD)]	9 (2)	8 (1)	9 (2)	0.04
Time taken for code team to reach the arrest location in Min [mean (SD)]	01:53 (0:30)	01:40 (0:18)	01:54 (00:29)	0.1
Witnessed arrest				0.7
Yes *n* (%)	117 (93)	10 (91)	107 (93)	
No *n* (%)	9 (7)	1 (9)	8 (7)	
APACHE II [mean (SD)]	22 (6)	16 (7)	22 (6)	0.03
Average chest compression fraction % (SD)	78 (5)	81 (2)	78 (5)	0.02
Average CPR Time in Min [mean (SD)]	17:53 (09:18)	07:43 (01:32)	18:52 (09:09)	0.001
Survived	11	11	0	0.001
CPC score (mean)	-	1.4 (0.5)	-	NA

Data expressed as mean±SD (standard deviation) or number (percentage in brackets) * Chi-square test and independent *t*-test were used SD- Standard deviation, PEA-Pulseless electrical activity, VF-Ventricular fibrillation, VT-Ventricular tachycardia, APACHE II- Acute physiology and chronic health evaluation II, SOFA- sequential organ failure assessment, CPC- Cerebral Performance Category, CPR-Cardiopulmonary resuscitation

thus allowing more time for chest compression. Most patients were intubated during the CPR in our study, and a chest compression fraction of 78% (SD ± 5) was achieved.

Four patients in our study had a chest compression fraction of <60% due to difficulty in intubation during CPR. We tried to use a laryngeal mask airway for ventilating three patients. Inadequate ventilation causing multiple attempts for intubation would have caused interruptions in CPR and a low chest compression fraction.

ROSC sustained for more than 20 min was considered successful and was achieved in 58% of the patients in our study, which is higher than other IHCA studies in which ROSC of 53% was achieved.[9,10] A higher ROSC rate of 62% was reported by a prospective study in the Indian population.[11] We also looked into factors associated with ROSC. We found that chest compression fraction was significantly higher in the patients who achieved ROSC, which is in concordance with other observational studies by Christenson *et al*.[2] and Vaillancourt *et al*.[3] Chest compression fraction as an independent predictor of ROSC and survival was contradicted by an observational OHCA study conducted by Cheskes *et al*.[12] They concluded that a higher chest compression fraction value was paradoxically associated with lower odds of ROSC and survival when compared to other predictors of CPR quality. They speculated that the paradoxical results were due to two reasons. Firstly, in OHCA, providers perform multiple tasks during shorter resuscitation periods leading to lower chest compression fraction. Secondly, providers might get fatigued by targeting a higher chest compression fraction, and in the process, compromising chest compression depth, which can lead to poor quality of CPR and lower ROSC.

Along with chest compression fraction, adequate chest compression rate and depth are equally important factors associated with successful ROSC.[13,14] These parameters simultaneously could not be measured in our study, as our automated external defibrillator (AED) did not have that capacity. Physiological monitoring of CPR quality, targeting end-tidal carbon dioxide concentration >10 mm Hg and arterial diastolic pressure >20 mm Hg, is also recommended to improve CPR quality, which could not be done in our study.[15]

The initial quality of CPR provided by the ward team also affects the outcome. We could retrieve the time taken to initiate CPR in the ward from the patient records, which is comparable in both groups. The initial CPR duration in the ward, as reflected in the time taken by the code blue team to reach the arrest site, is also comparable in both groups.

We had a total of 11 patients (9%) who survived to hospital discharge. Patients who survived had a significant difference in the time taken by the primary responder to initiate CPR, initial rhythm, chest compression fraction, APACHE II, and SOFA score compared to non-survivors. Since the overall population of survivors were less, we did not do a multivariate logistic regression test in this population, and it was also not included in the study objective. CPC is the most commonly used neurological outcome measure in post-cardiac arrest patients and, CPC 1 or 2 is considered good neurological function at discharge to live an independent life.[5,6] All the patients who survived had CPC ≤ 2, suggesting a good neurological outcome. We need a higher sample size to extrapolate survival findings to the general population.

The survival rate in our study is low compared to data available for the western population (20%), which can be due to multiple reasons. Our teaching hospital predominantly receives referral cases, and the mean SOFA score of non-survivors is 10, which has a mortality prediction of around 50%. In the study conducted in the Indian population, Joshi M mentioned a survival rate of 10.4%.[11] The incidence of cardiac aetiology as the cause of arrest was higher in their study than in our study, and cardiac aetiology had higher survivors. Hence survival rate might be influenced by many factors, and we need more studies on CPR in our country to know the survival pattern in Indian settings.

Our study depicts that the CPR quality in our institute, as measured by chest compression fraction is at par with the recommended guidelines. Training health care workers at a dedicated training centre at our institute helped provide high-quality CPR. Pareek *et al*.[16] also reported that training healthcare workers with resuscitation helped in better CPR outcomes in IHCA. Still, the data regarding the quality of CPR provided is lacking in the Indian population, and our study provides more information in this regard. Our study also addresses a few of the concerns made by Pahade *et al*.[17] and Kapoor *et al*.[18] regarding the lack of CPR data for the Indian population. Our study should also encourage researchers to undertake more studies in CPR and provide data to the Indian resuscitation council (IRC) to formulate guidelines.

Our study has many limitations. First, it was a single-centre observational study. Secondly, we could not record the chest compression depth and rate along with chest compression fraction, as we lacked AED/defibrillator to record these data. However, all the CPR providers in the study were trained with the latest AHA BLS and ACLS guidelines, and we expected them to provide a decent rate and depth of chest compressions. Thirdly, we calculated the chest compression fraction manually by recording the time duration using a stopwatch. The presence of an observer for recording the CPR data could cause the code blue team to be more alert, but usually, a consultant intensivist forms a part of the code blue team in our hospital, and we tried to reduce this effect by keeping the code blue blinded about the study.

CONCLUSION

Our study demonstrates that health care providers in our hospital provide high-quality CPR. Chest compression fraction is independently associated with ROSC in IHCA. Larger multicentre studies are required to emphasise these findings in ROSC and survival patients.

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Conflicts of interest
There are no conflicts of interest.

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