International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 2.102

Association of Chest Compression Fraction and Outcome in Patients with Cardiac Arrest - A Prospective Observational Study

Dr. Sneha R[1], Dr. Shameem K U[2], Dr. Sisira Sunil[3], Dr. Hashim Abdul Latheef[4], Dr. Abul Faizy S M[5], Dr. Mufeedha Ali N.P[6]

[1]Department of Emergency Medicine, SUT Hospital, Pattom
Email: *sneharunni94[at]gmail.com*

[2]Department of Emergency Medicine, KIMSHEALTH Trivandrum
Email: *dr.shameemku[at]gmail.com*

[3]Department of Emergency Medicine, Caritas Hospital, Kottayam
Email: *sisirasunil1[at]gmail.com*

[4]Department of Emergency Medicine, KIMSHEALTH Trivandrum
Email: *hashim007[at]gmail.com*

[5]Department of Emergency Medicine, KIMSHEALTH Trivandrum
Email: *dr.abulfaizy[at]gmail.com*

[6]Department of Emergency Medicine, Medical Trust, Kochi
Email: *mufeeda9044[at]gmail.com*

Abstract: ***Cardiopulmonary resuscitation (CPR) guidelines recommend target values for compressions, ventilations, and CPR-free intervals allowed for rhythm analysis and defibrillation. Compression fraction is defined as the proportion of CPR time spent providing chest compressions. Studies evaluated the incremental benefit of higher chest compression fraction on survival to hospital discharge. From the literature available so far, it is almost found that there is a positive association between increased chest compression fraction and ROSC. And there are studies that show negative correlation of chest compression with ROSC. So the present study conducted by us(where the study population is the patients in Emergency Department and the in patients in KimsHealth hospital who were in cardiac arrest) would be helpful to validate the association of CCF in attaining ROSC. In our study, we were trying to find a correlation between chest compression fraction and survival of the patients. Aim: To find the independent association between chest compression fraction during cardiac arrest and the outcome in patients in KIMS HEALTH by evaluating return of spontaneous circulation and percentage of survival of the patients at the time of their hospital discharge by observation and analysis. Primary Objective: To determine the independent association of chest compression fraction and outcome in patients by evaluating the return of spontaneous circulation in them as well as percentage of survival of the patients at the time of their hospital discharge by observation and analysis. Design, Setting and Participants: The study was done on the patients in emergency department and In-patients in KimsHealth who were in cardiac arrest in the year 2020-2022. Study Population: Patients who were in the emergency department and In – patients (who were admitted in the hospital) with cardiac arrest in the age group above 18 yrs in KimsHealth. We excluded all out of hospital cardiac arrest patients, patients with Unwitnessed cardiac arrest and we also excluded patients whose bystanders refused for the participation in the study. Method of Study: For our study, a stopwatch was switched on when the code blue was announced and chest compression is initiated. For each time of interruption of CPR, the stopwatch was paused and was resumed when CPR is started again. As a part of the study, the total time for CPR and time taken for chest compression was noted. Results: In our study, out 0f 96 patients, 56 % (majority) patients were in chest compression category81 - 100 % .50 % of the patient's attained ROSC. Out of the people who attained ROSC, 74 % people were in chest compression fraction category 81% -100 % and only 33.33% of patients were in the category 41-60 %. People who attained ROSC were followed up till they got discharged from the hospital. Among the patients who improved at the time of their discharge, majority (57 %) received CPR with chest compression fraction 81-100 % and 33.3 % people had received chest compression with CCF of 41-60 percentage and the rest received CPR with CCF of around 23.6 %. Conclusion: Thus, this study was really helpful to find the validate the association between chest compression fraction with ROSC and survival to hospital discharge. We conclude that even though the quality of CPR depends on various factors, monitoring and improving chest compression fraction of patients in cardiac arrest in a hospital would bring better clinical outcome in them.***

Keywords: Cardiopulmonary resuscitation (CPR), Chest compression fraction (CCF), Return of spontaneous Circulation (ROSC), out-of-hospital cardiac arrest (OHCA), Defibrillation

1. Introduction

As defined by the American Heart Association and the American College of Cardiology, "(sudden) cardiac arrest is the sudden cessation of cardiac activity so that the victim becomes unresponsive, with no normal breathing and no signs of circulation. If corrective measures are not being taken rapidly, this condition progresses to sudden death[(1)]. Sudden cardiac death is not be used to describe events that are not fatal. People are more likely to survive cardiac arrest when the following sequence of events occurs as rapidly as possible: recognition of early warning signs, activation of

the emergency medical system, basic, defibrillation, intubation, and intravenous medications[4]

Because neurological and psychological recovery from cardiac arrest is tied to the time within which these critical interdependent treatment modalities are delivered, high resuscitation rates leads to a high percentage of patients who recover to their pre- arrest neurologic level. The quality of CPR is an important contributor to successful outcome. One of the most important aspects of quality CPR is thought to be the proportion of time spent performing chest compressions[4,5]. Interruptions in chest compressions are common during treatment of cardiac arrest. Studies demonstrate that interruptions in chest compressions decrease coronary and cerebral blood flow, resulting in worst survival outcome[6-8].

Cardiopulmonary resuscitation (CPR) guidelines recommend target values for compressions, ventilations, and CPR-free intervals allowed for rhythm analysis and defibrillation. In addition to compression depth, blood flow is dependent on compression rate, compression/ decompression ratio, and low intrathoracic pressure in the decompression phase, avoiding - leaning on the chest by the rescuer [8-10].

Interruptions in chest compressions occur for a variety of reasons, including provider fatigue and switching of compressors, performance of ventilations, placement of invasive airways, application of CPR devices, pulse and rhythm determinations, vascular access placement, and patient transfer to the ambulance[11,12].Despite significant resuscitation guideline changes in the last decade, several studies have shown that chest compressions are still frequently interrupted or poorly executed during resuscitations[13]

Compression fraction is defined as the proportion of CPR time spent providing chest compressions. Studies evaluated the incremental benefit of higher chest compression fraction on survival to hospital discharge.

From the literature available so far, it is almost found that there is a positive association between increased chest compression fraction and ROSC. And there are studies that show negative correlation of chest compression with ROSC. So the present study conducted by us (where the study population is the patients in Emergency Department and the in patients in KimsHealth hospital who were in cardiac arrest) would be helpful to validate the association of CCF in attaining ROSC. In our study, we were trying to find a correlation between chest compression fraction and survival of the patients.

2. Literature Survey

Sudden cardiac arrest is a major cause of death in the adult population of developing countries, and only 10%–15% of cardiopulmonary resuscitations (CPRs) being successful. The global annual prevalence of sudden cardiac arrest is estimated at 4-5 million cases worldwide [15]. Cardiopulmonary resuscitation (CPR) remains the single most viable emergency management alternative for patients with cardiac arrest, and its current version was developed approximately fifty years ago [16,17]

Cardiac arrest is usually due to underlying structural cardiac disease. Seventy percent of cardiac arrest cases are thought to be due to ischemic coronary disease, the leading cause of cardiac arrest. Other structural causes include congestive heart failure, left ventricular hypertrophy, congenital coronary artery abnormalities, arrhythmogenic right ventricular dysplasia, hypertrophic obstructive cardiomyopathy, and cardiac tamponade. Nonstructural cardiac causes include Brugada syndrome, Wolf- Parkinson-White syndrome and congenital long QT syndrome. There are many non- cardiac etiologies like intracranial hemorrhage, pulmonary embolism, pneumothorax, primary respiratory arrest, toxic ingestions including drug overdose, electrolyte abnormalities, severe infection (sepsis), hypothermia, or trauma[1,18].

Cardiopulmonary resuscitation is a series of lifesaving actions, to support and maintain breathing and circulation for an infant, child or adult who has had a cardiac or respiratory arrest, thereby improving the chances of survival. Standard CPR includes the manual application of chest compressions and ventilations to patients in cardiac arrest, done in an effort to maintain viability until advanced help arrives. This procedure is a basic component of basic life support (BLS) and advanced cardiac life support (ACLS) [19-21].

Cardiopulmonary resuscitation (CPR) is a well-established treatment for cardiac arrest. Conventional CPR includes both chest compressions and rescue breathing, such as mouth to-mouth breathing. Rescue breathing is delivered between chest compressions using a fixed ratio, such as two breaths to 30 compressions or can be delivered asynchronously without interrupting chest compression. Studies show that applying continuous chest compressions is critical for survival and interrupting them for rescue breathing might increase risk of death. Continuous chest compression CPR may be performed with or without rescue breathing. An asphyxia arrest is caused by lack of oxygen in the blood and occurs in drowning and choking victims and in other circumstances. A non asphyxial arrest is usually a loss of functioning cardiac electrical activity[22-24]. CPR for out-of-hospital cardiac arrest can be performed using continuous chest compression-only, or interrupted chest compression plus artificial ventilation (conventional CPR).

The difference between continuous chest compression CPR and interrupted (conventional) chest compression CPR, is that in continuous chest compression CPR, rescuers do not interrupt compressions to perform artificial ventilation[22,25,26].The cardiac output derived following optimally performed CPR is greater than 30% of the normal cardiac output, and coronary blood flow during CPR is often less than 35% of the normal coronary blood flow[27]. These findings may be the result of the initial delay in CPR, the older age and severe preexisting underlying disease. So it is perhaps necessary to consider more effective methods for CPR[20,28] .

People are more likely to survive cardiac arrest when the following sequence of events occurs as rapidly as possible: recognition of early warning signs, activation of the emergency medical system, basic cardiopulmonary resuscitation (CPR), defibrillation, intubation, and intravenous medications[29,31].

Recognition of cardiac arrest is not always straightforward, especially for laypersons. Any confusion on the part of a rescuer can result in a delay or failure to activate the emergency response system or to start CPR. Precious time is lost if bystanders are too confused to act[29,30]. Therefore, these adult BLS Guidelines focus on recognition of cardiac arrest with an appropriate set of rescuer actions. Once the lay bystander recognizes that the victim is unresponsive, that bystander must immediately activate (or send someone to activate) the emergency response system[39]. Once the healthcare provider recognizes that the victim is unresponsive with no breathing or no normal breathing (ie, only gasping) the healthcare provider will activate the emergency response system. After activation, rescuers should immediately begin CPR[24,31].

Early CPR can improve the likelihood of survival, and yet CPR is often not provided until the arrival of professional emergency responders.[32,33]. High-quality CPR is important not only at the onset but throughout the course of resuscitation. Defibrillation and advanced care should be interfaced in a way that minimizes any interruption in CPR[34-36].

High-quality chest compressions are defined as compressions at a depth of 5 cm to6 cm and a rate of 100 per minute to 120 per minute, allowing full chest recoil between compressions and minimization of interruptions.[35].

Cardiac Arrest Rythms

We have four potential electrocardiographic rhythms. VF, VT, PEA, and asystole. VF is an unsystematic electrical action, whereas a VT produces systematic electrical pulses. Both VF and VT can provide adequate blood flow. PEA is a systematic rhythm typified by a lack of or inadequate mechanical ventricular action to give a noticeable pulse. Asystole is a lack of ventricular action in the presence or absence of atrial activity.

Thus, health institutions must create a strategy to lower the interval between attack and quick defibrillation. Defibrillation results also improve if the intervals between chest compressions are minimal[40-42].

The use of epinephrine is widely accepted in cardiac arrest management; The α- adrenergic effect of epinephrine increases aortic diastolic pressure, therefore increasing the coronary perfusion pressure (CPP) and likelihood of ROSC. It has, however, the potential to increase dysrhythmias, increase myocardial demand, and decrease cerebral microcirculation.[4,36].

Automated External Defibrillators

In out-of-hospital cardiac arrest (OHCA), Automated External Defibrillators (AED) are increasingly used before Emergency Medical Services (EMS) arrive on the scene(44,45). The use of on-site or dispatched AEDs reduces the time from call to the first defibrillation and increases survival in patients with a shockable rhythm. Traditionally, conventional AED voice prompts instruct the rescuer to interrupt chest compressions for heart rhythm analysis every two minutes. This programmed interruption of chest compressions for rhythm analysis and the delivery of the defibrillation shock may take 12–46 s and may account for 20–40%of the time an AED is connected. These interruptions of chest compressions and long pre-shock pauses are an important undesired consequence of the AED algorithm and negatively influence survival: a pre-shock pause of ≥20 s was associated with a significant reduction in survival to hospital discharge[45-47]

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The proportion of time in which chest compressions are performed in each minute of CPR is an important modifiable aspect of quality CPR. Chest compression fraction (CCF) is the cumulative time spent providing chest compressions divided by the total time taken for the entire resuscitation. Maintaining a high chest compression fraction (CCF; percentage of time patients received compressions through constant chest compressions) is considered a key factor in achieving ROSC of OHCA resuscitation. American Heart Association guidelines for cardio pulmonary resuscitation recommend maintaining the CCF above 80% during CPR.[53]

During prehospital resuscitation, rescuers may stop chest compressions for many reasons that are integral to patient care, such as ventilation, assessing heart rhythm and pulse, defibrillation, or tracheal intubation. Among them, the interruption time of chest compressions for ventilation may have a significant impact on CCF[54,55].

3. Material and Methods

The study was done on the patients in emergency department and In-patients in KimsHealth who were in cardiac arrest. Method of measuring the outcome of interest-

Study Population: Patients who were in the emergency department and In- patients with cardiac arrest in the age group above 18 yrs in KimsHealth.

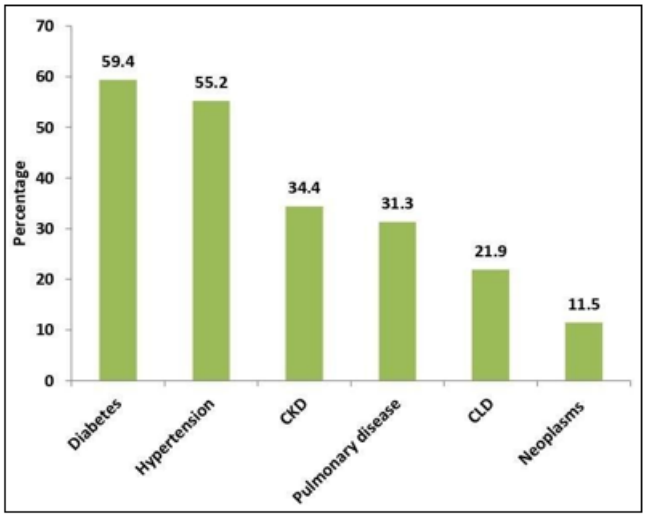
- All patients fulfilling the inclusion criteria and whose informed consent was obtained were enrolled into the study.
- We included both the patients in Emergency Department and the in patients who were in cardiac arrest in KimsHealth for our study. The cardiac arrest should be witnessed by someone and the code blue was announced. CPR was initiated within1 minute of recognition of cardiac arrest.
- CHEST COMPRESSION FRACTION = TIME SPENT FOR CHEST COMPRESSION /TOTAL TIME SPENT FOR CPR
- **Primary outcome**- Return of spontaneous circulation that remained for at least five minutes.
- **Secondary outcome**- Survival of the patients at the time of discharge.
- The percentage of survival of the patient was measured by following up of the patient using Electronic Medical Record data till the patient was

discharged from the hospital.

4. Observation and Results

Out of the 200 patients presented with cardiac arrest in the hospital during the study period, 96 patients were included in the study as per the inclusion criteria.

Distribution of Samples according to Comorbidities



Comorbidities	NO (%)
Diabetes	57(59.4)
Hypertension	53(55.2)
CKD	33(34.4)
Pulmonary disease	30(31.3)
CLD	21(21.9)
Neoplasms	11(11.5)

Distribution of Samples according to Minutes to First Shock

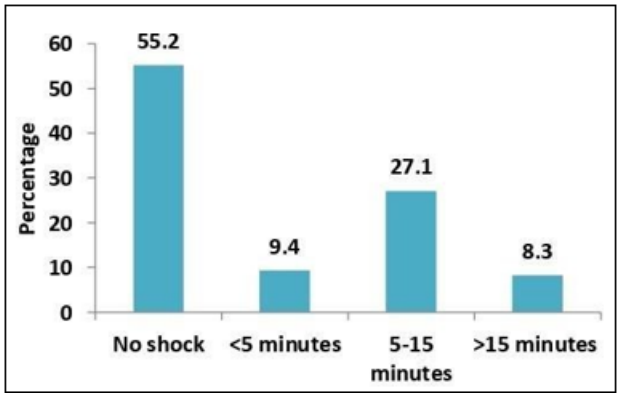


Table 3: Minutes from call to first shock

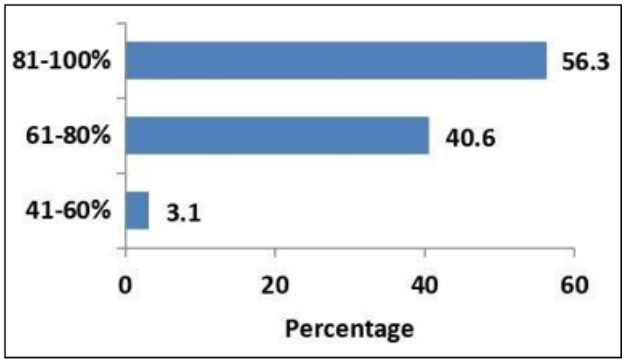
Minutes from call to first shock	No (%)
No shock	53(55.2)
<5 minutes	9(9.4)
5-15 minutes	26(27.1)
>15 minutes	8(8.3)

Distribution of Samples according to Early Epinephrine Administration

Table 4: Early epinephrine administration

Early Epinephrine Administration	No (%)
Yes	96(100)
No	0

Distribution of Samples according to Chest Compression Fraction

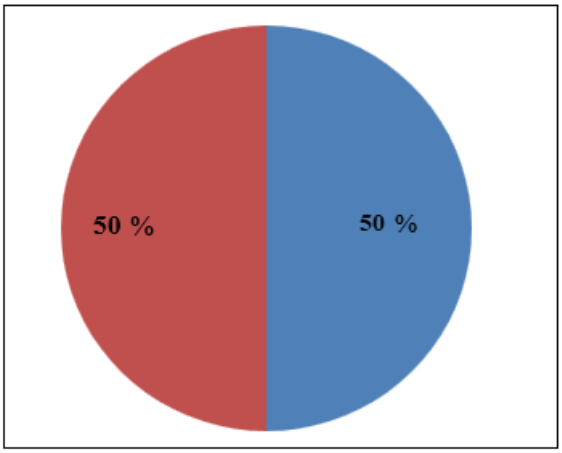


Distribution of Samples according to Chest Compression Rate

Table 5: Chest compression rate

Chest Compression Rate	No (%)
<100	4(4.2)
100-120	27(28.1)
>120	65(67.7)

Distribution of Samples according to Return of Spontaneous Circulation Obtained



Half of the study population attained ROSC, while the other half did not attain ROSc after CPR.

Rosc was found to be more in the category with 81-100 % chest compression fraction and it was found to be statistically significant.

Distribution of Samples according to GCS at the Time of Discharge from the Hospital or after 30 Days

Table 6: GCS

GCS	No (%)
<7	54(56.3)
7-13	28(29.2)
13-15	14(14.6)

GCS was noted, at the time of discharge was noted. The people who got discharged with GCS >13 was found to have received CPR with chest compression fraction >80 % at the time of cardiac arrest. The people who got discharged with GcS in between 7 and 13 was also found to have received CPR with chest compression fraction in more than 80% at the time of their cardiac arrest. The people who got discharged with GCS <7 was found to have received CPR with chest compression fraction <60 % at the time of cardiac arrest. and more than 40 %.

Association of ROSC with rate

Table 24: Association of ROSC with rate)

ROSC obtained			
Rate	Yes	NO	
<100	0	4 (100)	0.022*
100-120	10 (37)	17 (63)	
>120	38 (58.5)	27 (41.5)	

*statistically significant

ROSC was obtained more in patients with chest compression rate >120 per minute compared to patients in the group with chest compression <120/mt.

Association of Chest Compression Fraction with Final Outcome

Variable	Chest compression fraction			P value
	41-60% (N=3)	61-80% (N=39)	81-100% (N=54)	
Final outcome				
Improved	1(33.3)	9(23.1)	29(53.7)	0.012*
Deceased	2(66.7)	30(76.9)	25(46.3)	

Final outcome (Improvement in clinical status) at the time of their discharge was found to more in group 81 - 100 % of chest compression fraction and it was found to be statistically significant.

5. Discussion

Cardiopulmonary resuscitation is a series of lifesaving actions, to support and maintain breathing and circulation for an infant, child or adult who has a cardiac or respiratory arrest, thereby improving the chances of survival. Chest compression fraction is the time spent for chest compression and many studies have shown the favourable aspect of increased chest compression fraction.

In our study, which was conducted in a tertiary care hospita l (KIMSHEALTH), we evaluated the association of chest compression fraction with various factors including ROSC obtained and survival to hospital discharge (clinical outcome).

Out of the 200 patients presented with cardiac arrest in the hospital during the study period, 96 patients were included in the study as per the inclusion criteria.

Variables related to cardiac arrest

In our study, in 47 % cases (47 % had shockable rythm), shock was given during CPR and rest of the patients were having non shockable rhythm. Whereas in the study by Nichol et al[62], 95 % patients were shocked. This is due to the fact that the study dealt patients only in VF, which is similar to the study by Christenson et al[7]. The study by Valliancourt et al[14] which is almost comparable with our study dealt with people in cardiac arrest not in ventricular fibrillation and thus it included non-shockable rythms also.

In our study, majority of patients received shock within 5 and 15 mts (26 patients out of 49 patients, around 53 % patients) and 25 patients received CPR prior to first shock. In the study by Christenson et al[7], the mean time before performing defibrillation was 10.7 minutes and the mean time of cpr prior to first shock was 3.2 minutes. This may be either due to incorporation of less number of patients in our study or may be due to the usage of automatic external defibrillators in the foreign countries by the Emergency medical Services. In our study all the patients received early epinephrine administration, where as in the study by Christenson et al[7], early epinephrine administration was noted only in 74%cases and only in 72 % cases in the study by Valliancourt et al[14]. This is due to the better education and ACLS training of the staff in our institution.

Primary outcome measures

Among the study subjects, majority of the patients (56.3 %) were in the category 81-100 %. This is similar to the study by Christenson et al[7] and Valliancourt et al[14], where highest number of people were in the category of 80 % - 90%.

Among the study subjects in our study, majority, out of 96 patients, 65 of them received CPR more than 120 rate. This is similar to the study by Nichol et al[62], where 70 % patients received CPR at a rate more than 110/mt .

Among the study subjects, majority (56.3 % patients) were in the category 81-100 %. In our study only 50 % cases obtained ROSC, which is almost similar to the study by Kumar et al[17], where ROSC is around 51 %. In the study by Valliancourt et al[14], only 24 % obtained ROSC. This reduced ROSC is due to the fact that the study included more of OHCA patients. OHCA patients would not receive medical care similar to IHCA.

In our study Rosc was found to be more in the category with 81-100 % chest compression fraction and it was found to be statistically significant(p<.001). ROSC was obtained more in patients with chest compression rate >120 per minute compared to patients in the group with chest compression <120/mt. This is similar to the study by Kumar et al and Vaillancourt et al[14].

Secondary outcome measures

In our study, at the end of hospitalization 54% survived and the rest died, which is similar to the study of Valliancourt (50%). Where as in the study by Nichol et al only %

survived and 9% survived in the study of Bobrow et al[11,13]. This may be because the patients received better medical care and follow up following cardiac arrest in tertiary hospitals like that of ours.

In our study Rosc was found to be more in the category with 81-100% chest compression fraction and it was found to be statistically significant (p<.001). ROSC was obtained more in patients with chest compression rate >120 per minute compared to patients in the group with chest compression <120/mt. This is similar to the study by Kumar et al[17] and Vaillancourt et al[14]. Majority of the patients who survived had GCS<7 in our study, while the studies by Mathew et al[16] found that most of the patients who survived has GCS between 7 and 13. This difference may be due to multiple factors like the cause of cardiac arrest, the in-patient care, socio economic condition of the patient.

In our study, significant positive correlation was found between chest compression fraction, ROSC, GCS and survival to hospital discharge. This is similar to the study by Christenson et al[7], Bobrow et al[11,13] and Valliancourt et al[14], where they found significant positive association between chest compression fraction and ROSC or survival to hospital discharge. While the study by Nichol et al[62], found that there was no significant association found between CPR and ROSC.

Also, it was found that final outcome was found more in patients with hypertension compared to other comorbidities. This is similar to the study by Mathew et al[16]. It was also found that people with neoplasms had poor outcome compared to other comorbidities. Not much studies which were taken for review has taken neoplasm as a variant.

6. Conclusion

From the study, we were able to find out the correlation of risk factors with the chest compression fraction. From the study, due to the better ACLS training in the institute, it was found that all patients received early epinephrine administration. This would have contributed d to their better outcome. Also, we could find that majority of people who had attained ROSC had received CPR with chest compression fraction more than 80 %. The study analysed that among the patients who survived, most of them had a GCS <7 at the time of their discharge. While majority of the patients who survived with Gcs>13, had received CPR with chest compression fraction >80 %. Thus, this study was really helpful to find the validate the association between chest compression fraction with ROSC and survival to hospital discharge. We conclude that even though the quality of CPR depends on various factors, monitoring and improving chest compression fraction of patients in cardiac arrest in a hospital would bring better clinical outcome in them.

7. Future Scope

The present study has several limitations. First, because this is an observational study, it can only establish an association between chest compression fraction and survival rather than a causal relationship. Chest compression fraction may be correlated with an unmeasured determinant of survival (eg, rescuer commitment to the resuscitation or expectation of patient survival). Nevertheless, we believe a causal relationship is likely. The present findings are biologically plausible; an increase in the intervention improved the clinical outcome incrementally. Also, this study was done in a single urban tertiary care centre and extrapolating the same data to the general population might not be possible. The sample size in this study was also limited to conclude and generalise the results.

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Author Profile

Dr. Sneha R, MBBS, DNB (EM), completed Post-graduation (DNB) in Emergency Medicine from KIMS HEALTH hospital. Currently working as an Emergency Physician in SUT HOSPITAL, Pattom, Trivandrum **Email:** sneharunni94**[at]**gmail.com

Dr. Shameem K U, MBBS, MD, (EM), DNB (EM), MRCEM (UK), Currently working as consultant and group coordinator, Department of Emergency Medicine, KIMSHEALTH Trivandrum

Dr. Sisira Sunil, MBBS, DNB(EM), Currently working as Registrar in Department of Emergency Medicine, Caritas Hospital, Kottayam

Dr. Hashim Abdul Latheef, MBBS, MEM, MRCEM(UK) Currently working as Specialist in Department of Emergency Medicine, KIMSHEALTH, Trivandrum

Dr. Abul Faizy S M, MBBS, MEM, currently working as Specialist in Department of Emergency Medicine, KIMSHEALTH, Trivandrum

Dr. Mufeedha Ali N.P, MBBS, DNB (EM), Currently working as Registrar in Department of Emergency Medicine, Medical Trust hospital, Kochi.