Journal of Cardiovascular Disease Research

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

Original Research Article

Prognosticating return of spontaneous circulationusing ultrasonography in cardiac arrest patients undergoing cardiopulmonary resuscitation

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Abstract

Introduction: There has been limited research assessing the usage of USG, its benefits and harms during cardiopulmonary resuscitation. Various studies showed presence of sonographic cardiac activity at the resuscitation was significantly associated with a successful outcome in patients without cardiac activity at the beginning of resuscitation. This study was planned to assess the prognostic value of using USG in cardiac resuscitation of patients with cardiac arrest and to evaluate the prognostic value of using ultrasound in cardiac resuscitation for patients with cardiac arrest and to determine reversible causes found in patients attaining Return ofSpontaneous circulation (ROSC).

Materials and methods: A hospital based prospective study with 52 patients was conducted on all patients who presented to the emergency department with discernible/no signs of life. The principal investigator will be given hands-on training with cardiac ultrasound in SMF prior to the start of study. During the training, he will be trained to assess cardiac activity so as to be able to differentiate between the presence or absence of cardiac activity. Following were considered as positive outcomes after successful resuscitation were a) successful ROSC and pulse preserved for more than 20 minutes, b) returning of breathing (excluding gasping, coughing and sudden movement), c) evidence of palpable pulse, and d) measureable blood pressure.

Results: Out of 52 patients, 12% cases were in-hospital arrest and 88% cases were out-hospital arrest. 25% had a cardiac arrest witnessed by someone whereas 75% had an unwitnessed cardiac arrest. Out of 52 patients examined, 11 patients had presence of cardiac activity witnessed by the ventricular wall motion using POCUS and 41 patients had no cardiac activity in POCUS. Among 52 patients with cardiac arrest, effective cardiopulmonary resuscitation resulted in return of spontaneous circulation among 8 patients (15%). 44 patients (85%) did not have ROSC after CPR. 6 patients got admitted in the hospital and 2 got discharged / transfer out. In this study, we obtained 75.0% sensitivity, 88.6% specificity, 54.5% PPV, and 95.1% NPV of the POCUS in detection of cardiac activity.

Conclusion: Employing an easy-to-use device as a highly reproducible predictor of survival in cardiac arrest patients would be of high value for the emergency physician deciding whether to continue resuscitative efforts.

Keywords: Ultrasonography; Cardiac arrest; Cardiopulmonary resuscitation

Introduction

Cardiac arrest is the most critical emergency and frequently encountered situation in the Emergency Room (ER) / Intensive Care Unit (ICU). Cardiac arrest is the abrupt loss of heart function in a person who may or may not have underlying heart disease. Clinically, it is defined as the cessation of cardiac mechanical activity, confirmed by the absence of a detectable pulse, unresponsiveness and apnea/gasping respiration. Etiology of cardiac arrest can be broadly classified into traumatic and non-traumatic. Traumatic cardiac arrest is usually due to tension pneumothorax, pericardial tamponade which requires specific management to rescue spontaneous circulation. Non-traumatic cardiac arrest can occur with 3 different cardiac rhythms namely a) shockable rhythms - ventricular fibrillation (VF) & pulseless ventricular tachycardia (pVT), b) asystole, and c) pulseless electrical activity (PEA).

The American and European resuscitation guidelines provides algorithm for managing cardiac arrest whose main objectives are to ensure a constant blood flow to the brain while identifying the causes of the condition, and treating them, if possible.[1-3] Cardiac resuscitation in a broad term means an attempt to restore spontaneous circulation to vital organs. CPR can be classified as basic or advanced. Basic CPR is the attempt to restore effective circulation with external compression of the chest wall, plus expired air inflation of the lungs. This definition excludes the bag-valve mask, invasive techniques of airway maintenance such as intubation of the airway and airway devices that pass the pharynx. Advanced CPR/ACLS refer to the attempt of restoring circulation with basic CPR in addition to advanced airway management and ventilation techniques, defibrillation, endo-tracheal intubation and securing venous cannulation.4

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

The goals of resuscitation are to preserve life, restore health, relieve suffering, limit disability and respect individual's decisions, rights, and privacy. The critical points to be pursued to improve prognosis are the early initiation of resuscitation maneuvers, the quick identification and treatment of underlying causes, and also the reduction of the duration of no-flow intervals. A key skill for the Emergency Physician (EP) is the care of patients with cardiac arrest because they are often chaotic and physicians who attempt resuscitation need prompt diagnostic certainties. The only diagnostic technology recommended by the Advanced Cardiac Life Support (ACLS) protocols during resuscitation is active electrocardiography (ECG)

Echocardiography (2 dimensional-Echo) refers to ultrasonographic evaluation of the heart which provides vital information related to management. This is ideal for use in the emergency department because it is rapid, accurate, and non-invasive allowing repeated examination.[5] Bedside usage of ultrasound by the emergency physician began in the late 1980s for the trauma patient. Usage of USG has now expanded rapidly over the recent years. Currently it is useful for procedures like endo-tracheal intubation, central/femoral vein catheterization and to detect the presence of cardiac activity during CPR.

At present, there is a need to differentiate between various causes of cardiac arrest, which are not a direct result of a primary ventricular arrhythmias like ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT) where the pattern/rhythm of electrical activity is the focus of treatment rather than the cause, but in PEA and asystole are corrected by addressing the underlying cause.[3]

The decision to terminate resuscitation measures in the setting of cardiac arrest is based on several criteria, some of which are very subjective.[6] The introduction of ultrasonography duringcardiac resuscitation can potentially help us in this regard, as it may depict the approximate cause of cardiac arrest in patients with initially absent mechanical activity and guides to decide on the duration of effective CPR in needed cases

Although USG usage in patients undergoing CPR is limited, its presence of cardiac activity in USG has increased correlation with return of spontaneous circulation (ROSC). The most important factor restricting the use of the trans-thoracic USG during CPR is that its interrupts the chest compressions. On the other hand, the use of USG during CPR can help the physician to decide quickly. The future updates for ACLS by AHA (American Heart Association) may recommend the use of USG during CPR, since many studies have shown its efficacy.[7-8] In order to improve survival, echocardiography needs to be successfully integrated with CPR.

There has been limited research assessing the usage of USG, its benefits and harms during cardiopulmonary resuscitation. Bolvardi et al and Tombuk et al, in their studies showed presence of sonographic cardiac activity at the resuscitation was significantly associated with a successful outcome in patients without cardiac activity at the beginning of resuscitation.[7-8] More recent studies by Mandavia et al and Tang et al have confirmed that emergency physicians are able to practice bedside echocardiography with a high degree of overall accuracy.[9-10] Hence this study was planned to assess the prognostic value of using USG in cardiac resuscitation of patients with cardiac arrest. This study is to evaluate the prognostic value of using ultrasound in cardiac resuscitation for patients with cardiac arrest and to determine reversible causes found in patients attaining Return of Spontaneous circulation (ROSC).

Materials and methods

After obtaining institutional ethical clearance with IEC no 21/2018 dated 30.01.2018, a hospital based prospective study was conducted on all patients who presented to the emergency department of Sundaram Medical Foundation with discernible/no signs of life from March 2018 to June 2019. A total of 52 cases with 95% confidence interval were taken for the study according to the study published by Bolvardi et al.[7]

Patients age ≥ 18 years, patients with in-hospital cardiac arrest and out of hospital cardiac arrest were enrolled in the study. Patients age below 18 years, patients who have not got resuscitated as requested by the relatives//guardian, patients with traumatic cardiac arrest, and patients who require prolonged CPR were excluded from the study.

All patients with clinical suspicion of sudden cardiac arrest requiring cardiac resuscitation underwent an initial cardiac ECHO on presentation (single subxiphoid four chamber view). Sequential POCUS examination (if required) was carried out during resuscitation, at the time of carotid pulse checks. Determination of cardiac kinetic activity using a brief B-mode transthoracic echocardiography was done without interrupting CPR. CPR was performed following ACLS protocols guided by AHA 2015. Irrespective of the presence/absence of cardiac activity all patients who presented with discernible/no signs of life were given effective cardiopulmonary resuscitation.

The findings of POCUS were documented. The final outcomes after cardiac resuscitation also noted. The principal investigator will be given hands-on training with cardiac ultrasound in SMF prior to the start of study. During the training, he will be trained to assess cardiac activity so as to be able to differentiate between the presence or absence of cardiac activity. Following were considered as positive outcomes after successful resuscitation were a) successful ROSC and pulse preserved for more than 20 minutes, b) returning of breathing (excluding gasping, coughing and sudden movement), c) evidence of palpable pulse, and d) measureable blood pressure. The flow of the study is depicted in Figure 1.

Data compilation was made in Microsoft Office excel sheets. Data editing and validation was carried out for all records. Categorical variables are summarized using counts (frequency) and percentage. Chi square test will

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

be done to analyze the positive and negative outcomes with the USG findings and the initial rhythm. SPSS (Statistical Package for Social Sciences) version 26.0, Chicago, Illinois, USA was used for statistical analysis. Sensitivity and specificity of point of care ultrasound (POCUS) was estimated. Level of significance (α) was set at 5%. P value was considered. statistically significant if $p \leq 0.05$.

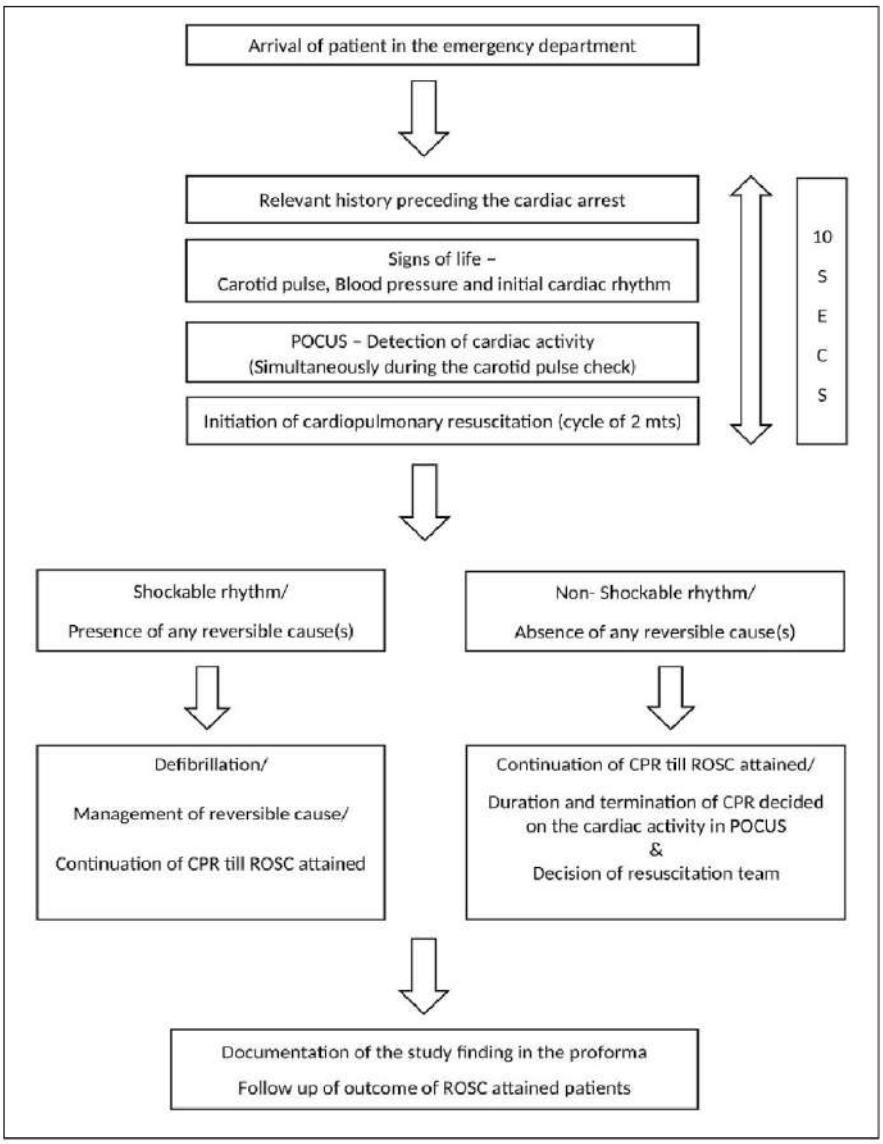

Figure 1: The flow of the study methodology

Results

52 patients were enrolled in the study. Bedside ultrasonography was done within the first 10 seconds of arrival during the initial pulse check. POCUS did not delay with initiation of resuscitation or interfere with resuscitative efforts in any of the patients.

A total of 52 patients took part in this study who came into the emergency department with a history of unresponsiveness. 18 patients were female (35%) and 34 patients were male (65%). Among the 52 individuals, less than 40 years were 8 patients, 16 patients were between 40-60 years of age, 18 patients were between 60-80 years, more than 80 years were 10 patients. The mean and standard deviation were 63 ± 19 years. 12% cases were in-hospital arrest and 88% cases were out-hospital arrest. 25% had a cardiac arrest witnessed by someone whereas 75% had an unwitnessed cardiac arrest. The distribution of various co-morbidities among study participants were mentioned in Figure 2.

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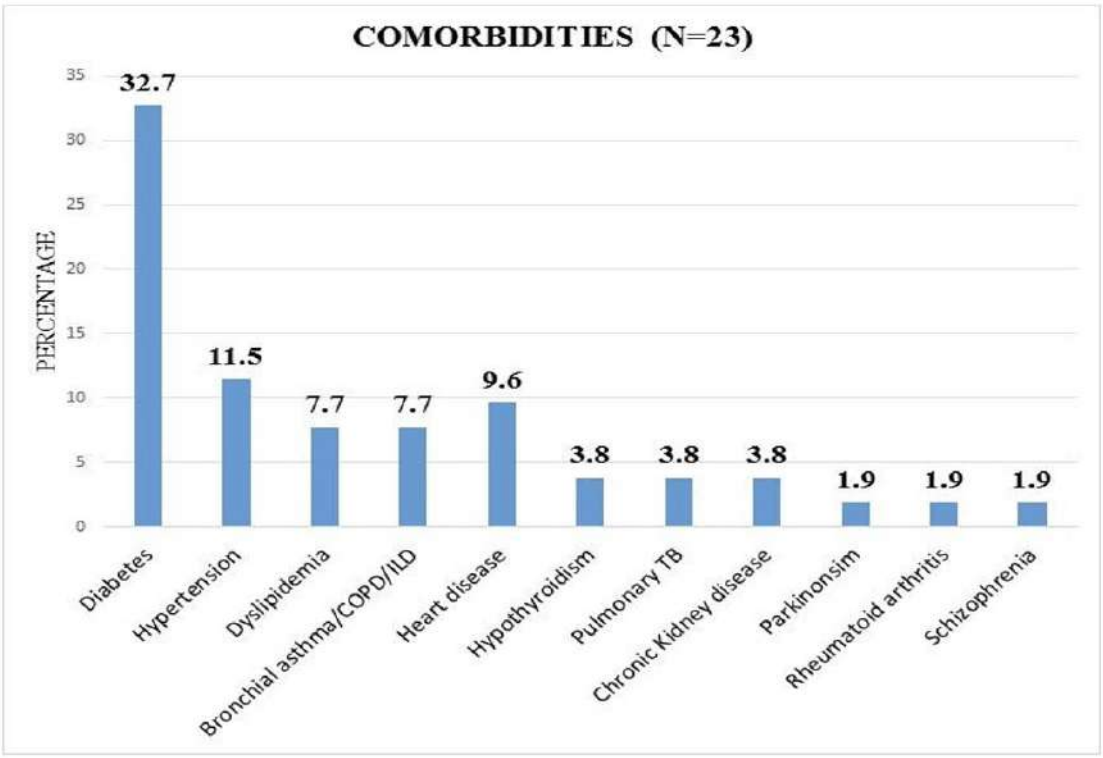

Figure 2: Distribution of co-morbidities among study participants

On examination of initial arrival rhythm of patients who presented with cardiac arrest, 41 patients (79%) had asystole, 4 (8%) patients had ventricular fibrillation /pulseless ventricular tachycardia (VF/pVT) and 7 patients(13%) had pulseless electrical activity (PEA). From a total of 52 cases examined, 11 patients had presence of cardiac activity witnessed by the ventricular wall motion using POCUS and 41 patients had no cardiac activity in POCUS. Among 52 patients with cardiac arrest, effective cardiopulmonary resuscitation resulted in return of spontaneous circulation among 8 patients (15%). 44 patients (85%) did not have ROSC after CPR. 6 patients got admitted in the hospital and 2 got discharged / transfer out. Among the 52 patients with cardiac arrest, reversible cause of the cardiac arrest was analysed. This was broadly classified into H / T groups. In the H Group - Hypoxia was observed in 35 patients (67%), Hydrogen ions 10 (19%), Hyperkalemia 4 (8%), hypokalemia 1(2%), Others 2 (4%) were cardiac tamponade and toxins. The comparison of cardiac activity with ROSC attained is mentioned in Figure 3.

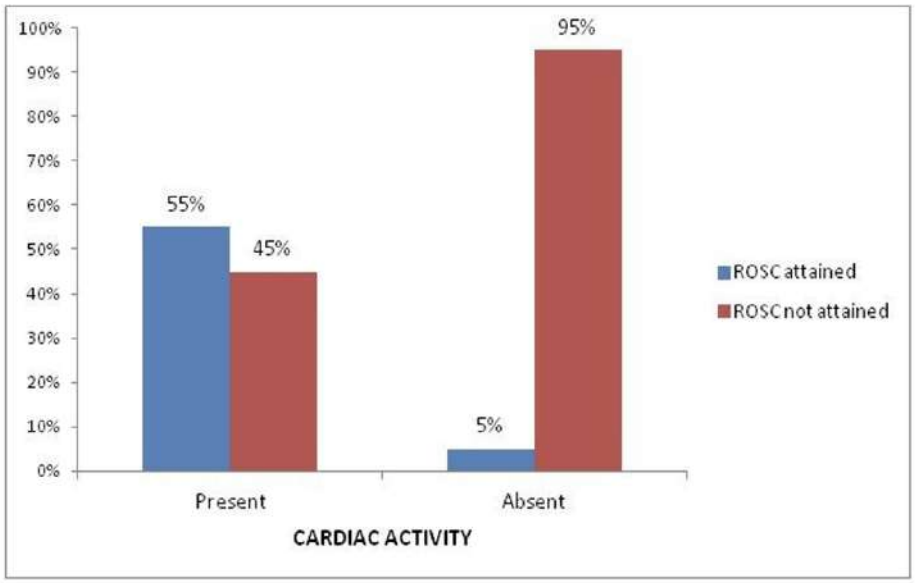

Figure 3: Comparison of cardiac activity with ROSC attained

From a total of 52 cases examined, 11 patients had initial positive cardiac kinetic activity and 41 patients had no cardiac activity. Among the patients who had positive kinetic activity, 6
patients (55%) showed successful response to resuscitation with ROSC. 5 patients (45%) did not have ROSC even

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

with effective resuscitation efforts. On the other hand, among the 41 patients with no heart activity detected on ultrasound only 2 patients had a successful response to resuscitation and whereas in the rest of 39 patients (95%) the efforts for resuscitation was not successful. The difference between successful and unsuccessful response to resuscitation was statistically significant (p=0.0003)

Reversible causes involving hyperkalemia, hypokalemia had 100% successful ROSC after resuscitation. ROSC was achieved among 2 out of 10 (20%) and 5 out of 35 (14.3%) with acidosis and hypoxia, respectively. Other reversible cause involving cardiac tamponade and toxins had equal chances of ROSC after resuscitation. The comparison of initial rhythm with ROSC attained is mentioned in Figure 4

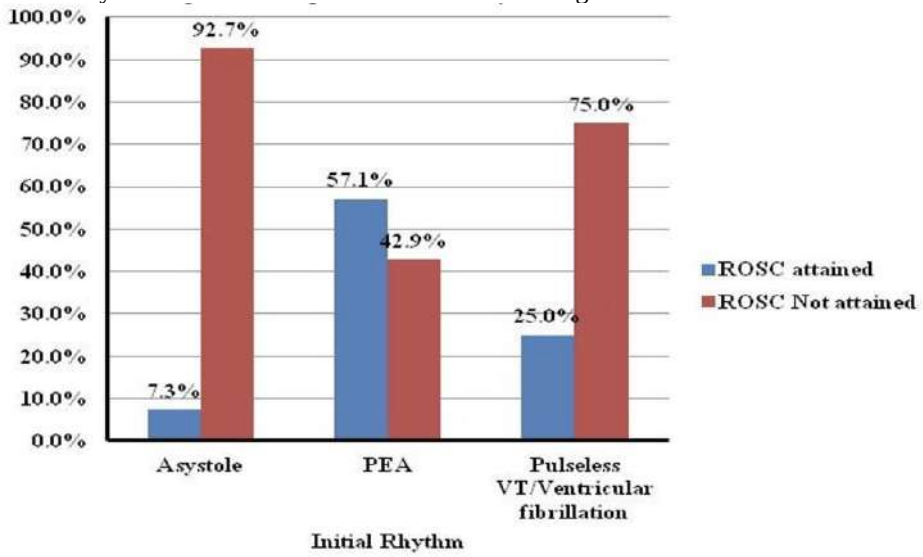

Figure 4: Comparison of Initial rhythm with ROSC attained.

Among 41 patients with asystole, 3 of them (7.3%) had ROSC after resuscitation and 38 had unsuccessful resuscitation (92.7%). 4 patients (57.1%) with PEA as their initial rhythm on arrival has successful ROSC after resuscitation, while 3 patients (42.9%) with PEA did not have successful resuscitation. Only one patient (25%) with shockable rhythms had successful resuscitation with ROSC. Remaining 3 patients (75 %) did not attain ROSC after resuscitation.

Table 1: Clinical and demographic characteristics of the study participants

Characteristics		**Total**	**Successful resuscitation**	**Unsuccessful resuscitation**	**Statistical significance**
Gender	Male	34	5 (14.7%)	29(85.3%)	0.85 (NS)
	Female	18	3 (16.7%)	15(83.3%)	
Age	18-50		0.0%	100.0%	0.26 (NS)
	>50		19.5%	100.0%	
Arrest location	In hospital	6	0.0%	100.0%	0.61 (NS)
	Out of hospital	46	17.4%	82.6%	
Initial rhythm	PEA	7	4(57.1%)	3(42.9%)	**0.002(S)**
	Asystole	41	3(7.3%)	38(92.7%)	
	VF/VT	4	1(25.0%)	3(75.0%)	
Cardiac activity on USG	Present	11	6(55%)	5(45%)	**0.0003(S)**
	Absent	41	2(5%)	39(95%)	
	Hydrogen ions	10	2(20%)	8(80%)	

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

eversiblecause	Hyperkalemia	4	4(100.0%)	0(0.0%)	**0.0005(S)**
	Hypokalemia	1	1(100.0%)	0(0.0)	
	Hypoxia	35	5(14.3%)	30(85.7%)	
	Others	2	1 (50%)	1(50%)	

*S -statistically significant NS- not statistically significant
In this study, we obtained 75.0% sensitivity, 88.6% specificity, 54.5% PPV, and 95.1% NPV of the POCUS in detection of cardiacactivity.

Discussion
Cardiopulmonary arrest (CPA) is the main cause of death in many parts of the world in spite of significant improvement in treatment. (50) The most important intervention that connects the CPA to life is the cardiopulmonary resuscitation (CPR). Resuscitation of a patient in cardiac arrest requires a great deal of time and ED resources. There are a number of widely accepted prognostic parameters that determine the prognosis of cardiac arrest includes downtime, bystander CPR, duration of resuscitative efforts, initial electrical rhythm and age.[11-12] A time–efficient, reliable means of determining those patients who are potentially salvageable from cardiopulmonary resuscitation from non-salvageable patients would be of great clinical use for an emergency physician in these times.

Unfortunately, there is no consensus as to when to decide on termination of CPR and how long to continue resuscitation in cases of PEA. So, there is a significant need for a reproducible and accurate prognostic parameter. Emergency physicians started to use the bedside ultrasound (USG) in trauma care patients in the late 80s and expanded its application rapidly over the two decades.[13-16] USG is now used to detect the presence of cardiac activity during CPR and for invasive procedure intubation, central /femoral vein catheterization, etc.[17-18]

The purpose of focused echocardiography in resuscitation is to evaluate cardiac contractility and increase the success of CPR.[8,19] The primary goal of cardiac ultrasonography in patients with cardiac arrest is to recognize organized contractions of the heart and thus improves resuscitative efforts in these patients. USG on the other hand can be used to detect some reversible causes of cardiac arrest. Although sufficient evidence does not exist to support or refute the routine use of ultrasound to predict the success of resuscitation, it has been proven that focused USG of heart can be used during cardiopulmonary resuscitation.[20]

Several studies including Arntfield et all have investigated the role of ultrasound in the emergency department and have been shown that the use of ultrasound can accelerate detection of causes of cardiac arrest and reduce the time required for treatment.[21] The main advantage of POCUS in cardiopulmonary resuscitation is rapid and real time evaluation of multiple systems that helps to narrow down the differential diagnosis and prompt timely intervention. It also allows rapid evaluation of a patient's response to resuscitative efforts. On the other hand, the disadvantages are the high learning curve for one to be adept in performing sonography and interpreting results. In addition, there is a possibility of interfering with the ACLS process if the sonographers are inadequately trained.

This study was conducted on 52 patients requiring cardiopulmonary resuscitation. The presence of sonographic cardiac activity at the beginning of resuscitation was significantly associated with a successful outcome (6/11 [55%] versus 2/41 [5%]) patients without cardiac activity at the beginning of resuscitation). Our results are consistent with the results of Bolvardi et al.[7] study 41/49 (83.7%) versus 15/110(13.6%) and Tomruk et al.[8] (19/27 [70.45%] versus 55/122 [45.1%]). The aim of our study was to evaluate the ability of heart ultrasonography as a predictor of prognosis in patients with cardiac arrest. This is the only Indian study available on time.

In this study, absence of heart activity on USG at the beginning of cardiopulmonary resuscitation is correlated with failure in resuscitation procedure and therefore shows that the absence of ultrasound represents a poor outcome in resuscitation of patients with cardiac arrest in the emergency department. This result is in accordance with the study of Blaivas *et al* in which, regardless of the initial rhythm of patients, all of them who does not show cardiac movement in the initial USG died. Therefore the positive predictive value in study of Blaivas et al was 100%, but in our study, only 5% of patients without cardiac movement in the initial USG show positive response to CPR, so the positive predictive value was 54.5%.

In the present study, USG showed sensitivity of 75.0%, specificity of 88.6%, positive predictive value of 54.5% and negative predictive value of 95.1% correlates well with Bolvardi et al study with sensitivity of 73.2%, specificity of 92.2% negative predictive value of 84.6% and positive predictive value of 83.7%.[7] Also in comparison with study of Tomruk et al. showed sensitivity of 25%, a specificity of 90%, negative predictive value

ISSN:0975-3583,0976-2833 VOL14,ISSUE05,2023

of 60%, and positive predictive value of 70% has higher specificity and predictive value.[8] Another difference between our study and study by Tomruk et al is inclusion of initial rhythm of patients in our study which is not included in the latter study.[8] Previously suggested parameters for the prediction of ROSC including pre-hospital resuscitation time interval. Out of hospital echocardiography usage were not studied in detail as done in other studies.

In the present study, our secondarily objective was to find any reversible causes. These reversible causes broadly classified into 5H's and 5T's as described in the ACLS guidelines. Most of our patients found to have hypoxia as the reversible cause but even with rapid resuscitative measures only few attained ROSC. In the present study, of the 52 patients underwent CPR, 6 admitted in the hospital, 2 transferred to another hospital for definite care and 44 declared dead despite resuscitative efforts. Only 2 discharged from the hospital including the transferred out patients. In accordance with other studies, the present study supports the prognostic value of ultrasonographic detection of cardiac activity at the beginning of aresuscitation procedure, rather than long-term outcomes.

The limitations of this study are

- The accuracy of information reported by family or ambulance personnel could not be verified, and it is possible that reported times were inaccurate in some cases.
- In addition, the patients did not undergo conventional cardiac echocardiography.
- Patient survival was defined as successful resuscitation rather than long-term outcome.
- Ultrasonography evaluations were made from the subxiphoid cardiac area only, in order to avoid treatment delay, this resulted in minor delays for image acquisition as CPR couldnot be interrupted.

Conclusions

Employing an easy-to-use device as a highly reproducible predictor of survival in cardiac arrest patients would be of high value for the emergency physician deciding whether to continue resuscitative efforts. Our results support the idea of POCUS as an additional criterion in the evaluation of outcome in CPR patients and demonstrate its feasibility in the Emergency room. Because of the severe consequences of the decision to abandon further resuscitation efforts, larger studies with highly significant results are needed to support the routine use of a POCUS examination in the initial phase of CPR as a predictor for outcome.

Acknowledgments: Nil
Conflicts of interests: Ni l
Funding sources: Nil

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