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Original Article

Relationship between cardiac ultrasound findings during cardiopulmonary resuscitation with the outcome of patients

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Abstract

Objective: Cardiopulmonary arrest is a devastating outcome of some clinical situations and requires strict implementation of cardiopulmonary resuscitation (CPR) protocols. Since ultrasound is one of the recommended tools to determine the presence of cardiac movements and may be a predictor of the outcome, this study examined the relationship between echocardiographic findings during CPR with patients' outcomes.

Methods: This cross-sectional prospective observational study was conducted on patients with cardio-respiratory arrest in the emergency department of Shariaty hospital during 2019. sampling method was random. Echocardiography was done at the patient's bedside during the CPR process in accordance with the last advanced cardiac life support (ACLS) guidelines, on two points, after the end of the second and 10th minutes from the start of CPR. The echocardiography findings (cardiac movement vs standstill) were recorded, and patient outcomes were followed. Thirty-two patients enrolled in this study with a mean age of 56.9 ± 15.3 years. Chi-square and Mann-Whitney U tests were used to calculate the association between heart contractions during resuscitation and the outcomes via SPSS V.22. Fisher's exact test and Kruskal-Wallis test were used to evaluate the relationship between heart rhythm in the second and tenth minutes with the outcomes of CPR.

Results: The presence of cardiac movement in the 10th minute of CPR, in contrast to the findings of the second minute, had a significant correlation with the success rate of CPR and outcomes ($P < 0.05$). Moreover, patients with ventricular tachycardia (VT)/ventricular fibrillation (VF) cardiac rhythm had a better resuscitation rate, 24-hour survival rate, and better outcome than patients with other cardiac rhythms and asystole ($P < 0.05$).

Conclusion: Echocardiographic findings in the 10th minute of the CPR process can be used as a prognostic factor for cardiac arrest.

Keywords: Cardiac arrest, Cardiopulmonary resuscitation, 2D Echocardiography

Introduction

Despite significant advances in global health, cardiopulmonary arrest is a devastating outcome of most clinical disorders and a leading cause of death with a massive burden of morbidity and mortality worldwide (1,2). Although this condition is often followed by strict implementation of cardiopulmonary resuscitation (CPR) protocols, and in more than 50 years of using this strategy, millions of people have come back to their lives, in many cases, life-saving efforts have failed (3,4).

Moreover, it has been supposed that cardiac contractions, even those non-detectable pulses, may offer a chance of patient's recovery and treatment and has predictive value (5). Therefore, the evaluation of prognostic and diagnostic factors and required devices and methods had always been the focus of the resuscitation team to increase CPR effectiveness and patients' survival rate in cardiac arrest.

In this regard, it has been more than 60 years since the introduction of echocardiography, and thereafter this technology has been mainly used by cardiologists to help assess the anatomy and physiology of heart abnormalities (6). In addition, the use of echocardiography to assess very ill patients has expanded, especially for patients after heart surgery (7). Also, in recent years, it has been mainly used for diagnosis and monitoring in the intensive care unit (8).

On the other hand, ultrasonography was introduced as one of the vital and helpful tools to determine the presence of cardiac movements and its changes in the resuscitation process and the diagnosis of the reversible

cause of cardiopulmonary arrest for affected patients in emergency departments (9,10). However, its effectiveness and the rate of application of its findings and obtained data are not completed and fully understood. Since there are a few researches on ultrasonography findings at different times of CPR implementation and their association with subsequent patients' clinical status and outcomes, the predictive value of ultrasound information is still controversial, and scientists do not get a consensus on a general application in emergency clinical situations.

Hence, to fill this gap of knowledge, in this study, we investigate the relationship between echocardiographic findings during CPR in patients with cardiopulmonary arrest and patients' outcomes.

Methods

This observational cross-sectional study was conducted on 32 patients who suffered from cardiopulmonary arrest and underwent CPR in a busy emergency department of Shariati hospital with an annual visit rate of 40000/ year during 2019. This study protocol was approved by ethics committee of Tehran University of Medical Sciences (IR.IUMS.REC.1401.6). Non-probability and continuous sampling were performed using available samples. Patient information was collected based on the patient's file, their history and through questions from companions and then recorded in certain forms. This form included information about age, sex, location of cardiac arrest, time of cardiac arrest, duration of CPR, underlying cause, CPR outcome, and final outcome of patients.

Inclusion criteria encompassed all patients over 18 years of age who suffered from cardiac and respiratory arrest in the emergency department and underwent CPR for the first time in the last 24 hours. Exclusion criteria consisted of patients under 18 years of age, patients whose echocardiographic examination was not possible in less than 10 seconds in either case, witness arrest patients with ventricular fibrillation or tachycardia returning immediately with shock, and dissatisfaction of the patient companions or lack of companions to obtain consent.

The studied patients underwent bedside echocardiography twice during CPR by the attending emergency medicine physician well trained in this field without interrupting the resuscitation process according to the last ACLS guidelines (11). The procedure was performed after the second (end of first two minutes of procedure) and tenth (after doing 5 cycles of 2-minute resuscitations) minutes while performing a routine rhythm check, and the findings were recorded. Ultrasonographic examination was performed with a 3-7 MHz convex transducer probe (Esaote, MyLab Alpha) in subxiphoid view.

In order to avoid disrupting the resuscitation process, the emergency echocardiographer was not a part of the resuscitation team in any of the cases and examined the patients only in cases where the head of the resuscitation team checked the resuscitation process for carotid flow pulse. To prepare for a proper ultrasound examination, the head of the resuscitation team warns him 20 seconds before stopping the resuscitation to prepare the probe, place it in the appropriate place, and immediately after stopping the resuscitation process for a pulse check, perform the necessary investigations and immediately announce the results of these examinations to the head of the resuscitation team. Accordingly, if necessary, the obtained results can be used in the management of the patient in the resuscitation process. It should be noted that none of the episodes of the ultrasound examination lasted more than 10 seconds.

Echocardiographic findings recorded in this process include the absence of any cardiac movements (standstill), presence of any minor cardiac movements (atrial, ventricular or valvular), presence of significant cardiac movements, evidence of pericardial effusion and right ventricular dilatation (probably as a result of thromboembolic events). The following findings were measured along by the patient outcome: 24-hour survival and discharge rate from the emergency department. The final outcome of CPR in these patients which included death or return of spontaneous circulation (ROSC) was also recorded. ROSC in this study meant the presence of a palpable pulse and measurable blood pressure for at least 10 seconds.

The obtained data were analyzed by using SPSS software version 22 (SPSS Inc., Chicago, IL, USA). Descriptive analysis was used to present demographic data, comorbidities, final diagnosis and general results related to resuscitation. Pearson correlation test was used to calculate the relationship between cardiac ultrasound findings during resuscitation with patients' clinical outcomes and the relationship between changes in the rate of cardiac contractions in the second to tenth minutes with CPR outcomes. Chi-square and Mann-Whitney U tests were used to calculate the association between heart contractions during resuscitation and the outcomes. Fisher's exact test and Kruskal-Wallis test were used to evaluate the relationship between heart rhythm in the second and tenth minutes with the outcomes of CPR.

Results

The present study was carried out on 32 patients with a mean age of 56.9 ± 15.3 years, ranged from 25 to 69 years. The study included 19 (59.4%) men and 13 (40.6%) women. All patients were cases of cardiac arrest in the hospital. The cause of cardiac arrest in only two patients (6.3%) was trauma and the other patients had non-traumatic causes.

Electrocardiographic data recorded in patients during resuscitation showed that in the second minute of resuscitation, the most common heart rhythms were

pulseless electrical activity (PEA) (65.6%), ventricular tachycardia (VT) or ventricular fibrillation (VF) (18.8%) and asystole (15.6%), respectively. While in the tenth minute of resuscitation, the most prevalent rhythms were related to PEA (40.6%) and in the later stages, pulsatile rhythm (31.3%), asystole (25%) and VT/VF (3.1%).

In the second minute of resuscitation, in most patients, slight cardiac contractions were seen (77.6%), and in others (23.4%), cardiac standstill was observed. On the other hand, ultrasound data related to the tenth minute showed that in most patients, there was cardiac immobility (standstill) (37.5%), while 34.4% had significant cardiac contractions and 28.1% had slight cardiac contractions. Other ultrasound findings, including pulmonary embolism (PE), right ventricular dysfunction (RVD), and right ventricular collapse (RVC), were reviewed and presented in Table 1.

The patients studied in this research were resuscitated 1 to 3 times (average 1.2 times) in 24 hours, and the duration of initial resuscitation was 8 to 45 minutes (31.9 ± 17 minutes). Primary resuscitation was successful in 12 (37.5%) of patients. One day after resuscitation, 7 patients (21.9%) survived and unfortunately, 25 patients (78.1%) died. The hospitalization outcomes showed that 6 (18.8%) were finally discharged, and 26 (81.3%) died. Also, patients' outcome one week after initial resuscitation showed that 27 (84.4%) died and only 5 (15.6%) survived after one week (one of the patients who was discharged alive died within a week after the initial resuscitation) (Table 2).

The cardiac movements observed in cardiac ultrasound in the second minute of resuscitation were not significantly correlated with the initial and 24-hour, 7-day resuscitation outcome of patients or their hospitalization outcome, the duration of resuscitation, and the number of resuscitation operations in the first 24 hours ($P > 0.05$).

The presence of cardiac movements in ultrasound resuscitation time in the tenth minute significantly improved the initial outcome of 24-hour and 7-day resuscitation of patients and their hospitalization outcomes ($P < 0.05$). Moreover, a significant relationship was observed with the duration and the number of CPR in the first 24 hours. The resuscitation time decreased with increasing heart rate ($P < 0.001$, correlation coefficient = 0.581), but the number of CPR increased in 24 hours ($P = 0.020$, correlation coefficient = 0.410) (Table 3).

The presence of contraction in the second minute was not effective in the initial success of resuscitation and its duration. Also, there was no significant relationship between contraction variable and survival rate during the first 24 hours after resuscitation and patients discharged from the hospital and survived within a week ($P > 0.05$).

In contrast, the presence of contraction in the tenth minute was effective in the initial and 24-hour success of resuscitation and its duration. However, there was no significant relationship between this variable and patients discharged from the hospital and their survival ($P > 0.05$).

Comparing the mean number of resuscitations in the first 24 hours between patients with and without cardiac contraction in the second and tenth minutes of resuscitation showed that the number of resuscitations did not differ significantly based on the presence or absence of contraction.

The results of data analysis showed that the heart rhythm based on electrocardiography performed in the second and tenth minutes of resuscitation had a significant relationship with the initial resuscitation, the clinical outcome of the first 24 hours of patients, hospitalization and clinical outcomes after one week. Thus, patients who had VT/VF cardiac resuscitation had a better resuscitation rate, 24-hour survival rate, and better outcome than patients with other cardiac rhythms and asystole ($P < 0.05$).

There was a significant difference between the rhythms found during resuscitation in terms of resuscitation duration ($P = 0.018$). Further comparison of the two types of Asystole, PEA and VT/ VF rhythms, showed that there

Table 1. Ultrasound findings in resuscitated patients

Complication	PE		RVD		RVC	
	The 2nd min	The 10th min	The 2nd min	The 10th min	The 2nd min	The 10th min
Detection	4 (12.5%)	4 (12.5%)	3 (9.4%)	3 (9.4%)	1 (3.1%)	1 (3.1%)

PE, pulmonary embolism; RVD, right ventricular dysfunction; RVC, right ventricular collapse.

Table 2. Relationship between cardiac ultrasound findings during resuscitation and clinical outcomes of patients

ultrasound time during CPR		10th minute CPR	Resuscitation result	Number of repetitions in 24 h	Clinical results in 24 h	Final clinical outcomes	Clinical results of the first week
The 2nd min	Pearson correlation coefficient	0.111	0.028	-0.0148	0.170	0.155	0.138
	P value	0.545	0.880	0.314	0.352	0.398	0.450
The 10th min	Pearson correlation coefficient		0.862	0.410	0.640	0.488	0.520
	P value*		<0.001	0.020	<0.001	0.005	0.002

*Calculated by Pearson correlation coefficient.

Table 3. Relationship between changes in the rate of cardiac contractions in the second to tenth minute of resuscitation with its results

Changes in heart contraction	Resuscitation result	Resuscitation time	Number of repetitions in 24 h	Clinical results of patients in 24 h	Final clinical outcomes of patients	Clinical results of the first week
Pearson correlation coefficient	0.851	-0.838	0.471	0.581	0.430	0.473
P value	<0.001	<0.001	0.007	<0.001	0.014	0.006

*Calculated by Pearson correlation coefficient.

was a significant difference only between VT/VF and PEA rhythms so that the recovery time in patients with PEA rhythm in the second minute was significantly more than patients with VT/VF rhythm ($P=0.005$).

There was a significant difference between the rhythms found at the tenth minute in terms of recovery time ($P<0.001$). Further comparison of the two types of normal rhythms, Asystole, PEA and VT/VF, showed that there was a significant difference between the pulsating rhythm and the two rhythms of PEA and Asystole. Therefore, the recovery time in patients with pulsatile rhythm per minute in the tenth minute was significantly lower than patients with PEA and Asystole rhythms ($P<0.001$).

Discussion

In the present study, we found that ultrasonographic findings, especially the findings of the end of the tenth minute of resuscitation, can be a critical prognostic factor in the success of resuscitation and better outcomes. This achievement is consistent with the results of previous studies conducted by Bolvardi et al and Tomruk et al showing that the use of cardiac ultrasound during CPR is useful to predict resuscitation success (12,13). However, in their research, the ultrasonographic findings at the beginning of the CPR process significantly predicted rehabilitation success. In contrast, in the present study, the ultrasonographic examination was performed two times and ten minutes after the start of CPR, and only the findings of the 10-minute resuscitation were associated with successful CPR. Furthermore, Kedan et al, in their study, also concluded that the assessment of cardiac movements on transaortic echocardiogram has a helpful effect on predicting CPR outcomes and point of care ultrasound could be applied in CPR time (14). Additionally, beyond the prognosis usage, some reports, such as the study undertaken by Arntfield and Millington, confirmed that ultrasound is a valuable method in diagnosing the reason for cardiac arrest and decreasing the treatment period (15).

However, it is supposed that the main reason for our observations could be the low sample size; because, in the ultrasonographic examinations of patients in the second minute, there were only 3 patients who did not have any movements (standstill) in the ultrasonographic examination of their hearts. Meanwhile, the resuscitation success of one of these patients led to a success rate of 33%. In contrast, the other patients (29 patients) who had minor cardiac movements eventually had a success rate of 37% resuscitation, which in terms of the percentage was similar to the standstill group, but had asymmetry with them in number. Therefore, it seems that the main reason for the lack of difference in the success of rehabilitation in these two groups is the small sample size of patients.

Our findings also revealed that by increasing cardiac movements on ultrasound at the time of resuscitation in the tenth minute, the success rate of initial resuscitation and 24-hour survival of patients was improved, and finally, the overall mortality of patients was reduced. Of course, the intensity of this correlation was different, and the increase in cardiac movements in the tenth minute of resuscitation had a strong correlation with the initial resuscitation outcomes. Whereas it demonstrated a moderate correlation with the 24-hour survival of patients, the outcome, one-week survival, and the number of repetitions repeated in 24 hours.

On the other hand, stronger association with initial resuscitation success and less association with the final outcome in patients seems to be justifiable by this issue that the final outcome of patients is affected by many factors, including the type and severity of the underlying disease, as well as comorbidity and other factors. Therefore, it is perfectly acceptable to correlate less with the patient's heart movements during CPR than for success in a resuscitation episode. However, the patient's cardiac movements during the CPR process, as well as the increase in the patient's heart rate from the second to the tenth minute of resuscitation can be associated with 24-hour survival. In this regard, Gaspari et al demonstrated that although bedside ultrasound could be a valuable method to manage patients with different conditions, they observed that drug consumption and type of cardiac movements can interfere and alter patients' outcomes predicted by ultrasound (16).

In addition, the increase in heart rate in the tenth minute of resuscitation accompanied by a moderate correlation with the number of resuscitations performed in the next 24 hours was related to the higher rate of cardiac movements in the tenth minute of resuscitation. This led to the greater success rate of resuscitation and patient survival. So, naturally, the possibility of cardiac arrest and resuscitation will increase within 24 hours after the initial resuscitation. Thus, the connection of these two variables with each other seems to be rational.

This study also demonstrated that patients who had VT/VF cardiac resuscitation had a better resuscitation rate, 24-hour survival rate, and better outcomes than patients

with other cardiac rhythms and asystole. Nevertheless, this issue has been investigated in many studies with different results. For example, based on our observations, Cebicci et al presented that the rate of resuscitation success and 24-hour survival of patients with asystole heart rhythm was significantly lower than that of patients with VT/VF and PEA heart rhythms (17). Bolvardi et al similarly showed that the success rate of resuscitation in patients with VT/VF rhythm was higher than patients with PEA rhythm and patients with Asystole rhythm had the lowest success rate of resuscitation (12). But in contrast, Tomruk et al claimed that there was no difference in the success rate of resuscitation based on primary heart rhythm in patients (13).

Another interesting finding of this study, which could not be accurately evaluated due to the small sample size, was that 5 patients underwent CPR and ultrasonographic examination due to myocardial infarction in the present study. Finally, the resuscitation process was successful for all of them, and they were discharged alive.

These results were consistent with the results of Merchant et al (18), indicating that reversible cardiac arrest risk factors, such as thrombosis (coronary occlusion), should be considered during the resuscitation process. This issue could also be a basis for future studies with larger sample sizes in which the success rate of CPR and long-term prognosis in patients with myocardial infarction be compared with other patients. This study also showed that the mean duration of CPR in patients with a VT/VF rhythm in the second minute of the CPR process was shorter than in patients with a PEA heart rhythm. That is why VT/VF are shocking heart rhythms, which increase the likelihood of recurrent rhythm and resuscitation in these patients.

Considering all the above, this study was performed to evaluate the ultrasonographic features of patients during CPR at intervals where the resuscitation process was interrupted to check the carotid pulse for a maximum of 10 seconds. Although it is challenging to obtain ultrasonographic information in 10 seconds, it cannot be extended beyond 10 seconds to prevent disruption of the resuscitation process, and it may not be possible to record ultrasonographic findings in a group of patients. To tackle this problem, people who had enough experience in echocardiography participated, but they had no experience in resuscitation of patients. Also, the head of the resuscitation team was announced 30 seconds before the interruption; the probe was prepared and placed in the subxiphoid area to make the maximum use of time. If the necessary information could not be obtained despite all these measures, the patient would be excluded from the study. Another limitation was the study population, which goes back to the limited number of patients with cardiac and respiratory arrest; nevertheless, it was tried to select the sample size based on standard studies and further multicenter studies with a larger sample size are suggested.

Finally, it is important to mention that this study investigated the relationship between heart rhythm and ultrasonographic findings with 24-hour survival and the final outcome of patients. This issue has been less addressed so far, and previous studies have often emphasized the association of ultrasonographic findings with early resuscitation success rate.

Conclusion

The present study demonstrated that ultrasonographic findings during CPR can serve as a prognostic factor in predicting the success rate of CPR and patient survival and outcome. Among them, findings in the tenth minute of the CPR process were more predictive. It was also revealed that patients with cardiac arrest who had a VT/VF heart rhythm in the second or tenth minute of the CPR process had a higher resuscitation success rate, 24-hour survival, and higher hospital discharge.

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Competing Interests

None.

Ethical Approval

All the procedures performed in this study were based on ethical standards of the local ethics committee of Tehran University of Medical Sciences (IR.IUMS.REC.1401.6), as well as 1964 Helsinki declaration. Written informed consent was obtained from all patients and normal subjects.

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