Cardiac Ultrasonography in Predicting Resuscitation Outcomes in Cardiac Arrest Patients in the Emergency Department at Suez Canal University Hospital

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Abstract:

Introduction: ***Cardiopulmonary arrest represents a critical endpoint for numerous medical conditions, characterized by the cessation of effective cardiac activity and the subsequent halt of blood circulation to essential organs. Without immediate intervention, this condition is rapidly fatal. Cardiac ultrasound is independent of the patient's heart rhythm and can provide information about cardiac contractions in patients who do not have a pulse. Aim: to assess how well emergency physicians' use of cardiac ultrasonography can forecast the results of resuscitation for individuals experiencing adult cardiac arrest. Methodology: This was an observational study that was done on 92 patients who were presented with cardiac arrest to the emergency department who fulfilled the inclusion criteria (adults aged 18 years or older, both sexes, and non-traumatic cardiac arrest). Results: US readings about the fate of the patients revealed that 97.3% (n: 72) of patients with a standstill on the 1st US reading died, while 5.56 %(n:1) survived. The rhythm distribution in relation to fate revealed that all patients with asystole rhythm 72 (97.3%) died, while patients with ROSC were 55.56 % (n:10) with fine VF, 38.89% (n: 7) with VF, 5.56% (n: 1) PEA, and no patient with pulseless VT was presented. Conclusion: Cardiac ultrasound in resuscitation had 97.30 percent specificity and sensitivity, with a 98.6% negative predictive value and an 89.47% positive predictive value.***

Keywords: Cardiac arrest, Emergency, Resuscitation, and Ultrasound.

Introduction:

Many diseases culminate in cardiopulmonary arrest. The heart stops pumping, and the blood supply to the body's essential organs stops during cardiac arrest. The person will pass away in a matter of minutes if no medical intervention is received [(1)]. As a result, it is imperative that cardiopulmonary resuscitation (CPR) procedures be carefully followed in these situations [(2)]. The American Heart Association estimates that 400,000 non-traumatic out-of-hospital cardiac arrests occur in the US each year, underscoring the importance of quick emergency response systems [(3)].

About 90% of people who experience this type of cardiac arrest will die, according to the Sudden Cardiac Arrest Foundation [(4)]. Early cardiac arrest detection and CPR have saved the lives of hundreds of thousands of people worldwide over the past 50 years, highlighting the significance of research on this particular topic [(2)]. Cardiopulmonary arrest is usually managed using established protocols like Advanced Cardiovascular Life Support (ACLS) and Basic Life Support (BLS), which prioritize early recognition,

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high-quality CPR, and identification of reversible causes [5]. For this reason, diagnostic and prognostic measures should always be taken into account, as they give the team more control over a patient's revival [7].

A heart ultrasound, for instance, is a crucial diagnostic technique that is being utilized more and more in emergencies. It can be a useful diagnostic tool in cardiac arrest, particularly when determining whether or not cardiac motions are present [8]. Regardless of the underlying heart rhythm, point-of-care cardiac ultrasonography provides crucial prognostic insight by allowing real-time measurement of myocardial activity in patients who are not breathing. [9]. In patients without a pulse, early detection of cardiac contractions may offer insights into the prognosis of resuscitation [10]. There is still little agreement on the predicted accuracy of cardiac ultrasonography, even though several studies have examined its prognostic role during resuscitation. [10].

In addition to diagnosing and evaluating the reversible causes of cardiac arrest (cardiac tamponade, mass lesions as tumor shrinkage or clots, evaluation of ventricular volume and left ventricular regional wall motion of the heart, etc.), cardiac ultrasound is effective in making treatment decisions [11]. It is required that cardiac ultrasonography be performed on all patients experiencing cardiac arrest. Although it is a practice changer, this diagnostic technique is not emphasized in the present version of ACLS [12].

The purpose of this study was to assess how well emergency physicians' use of cardiac ultrasonography could forecast the success of resuscitation efforts for adult patients experiencing cardiac arrest.

Methodology:

Ninety-two patients with cardiac arrest who were brought to the emergency department and met the inclusion and exclusion criteria were chosen based on non-probability convenience sampling, after calculating the sample size by a statistician. The study was prospective, and the Confidentiality of patient data was maintained with no delay or harm to the patient's resuscitation. The agreement of the patient's family was obtained without obligation by the researcher.

Inclusion criteria: 1. Adult > or 18 years; 2. Both sexes; 3. Nontraumatic cardiac arrest was the subject of this observational study, which investigated the predictive power of cardiac ultrasonography performed by emergency physicians in the emergency department of Suez Canal University Hospital.

The positive outcomes will be considered as any successful resumption of blood flow for more than 20 minutes, return of breathing (excluding gasping, coughing, or sudden movements), evidence of a palpable pulse, and measurable blood pressure.

Exclusion Criteria

1- Pediatric cardiac ultrasonography requires a qualified diagnostic medical sonographer to perform imaging tests on children because the process may interfere with resuscitation.

2. The same patient is experiencing repeated cardiac arrest.

3. Cardiac arrest due to trauma.

Results:

The gender distribution among the study population reveals that 54% were females, while 46% were males. The mean age of the study population was around 61.8 years, 61.77 years in dead patients, and 61.94 years in survivors, with a p-value of 0.929, which wasn't statistically significant. The total number of dead patients was 74 (54.05%) females and 45.95% males, while the surviving patients were 18. (55.56%) females and 44.44% males, with a p-value of 0.909, which wasn't statistically significant as shown in table 1

Table 1: Demographics of the patients

		All patient	Death	ROSC	p-value
Age- mean ± SD		61.8 ± 6.48	61.77 ± 6.63	61.94 ± 5.99	0.929
Gender	Male	42 (45.65%)	34 (45.95%)	8 (44.44%)	0.909
	Female	50 (54.35%)	40 (54.05%)	10 (55.56%)	
	Total	92	74 (100%)	18 (100%)	

As shown in figure 1 Chronic disease distribution among the study population and revealed that hypertension and diabetes were the most common chronic illnesses, with 58.7% and 53.26% respectively. Chronic cardiac disease was presented by 43.48% while chronic chest disease and chronic renal disease were the least common chronic illnesses presented by 6.52% and 5.43% respectively.

Figure 2 shows the distribution of pre-arrest complaints among the study population, and it was found that chest pain was the most common pre-arrest complaint, at 55.43%, followed by dyspnea at 42.39%, while DLOC was the least common pre-arrest complaint, at 6.52%.

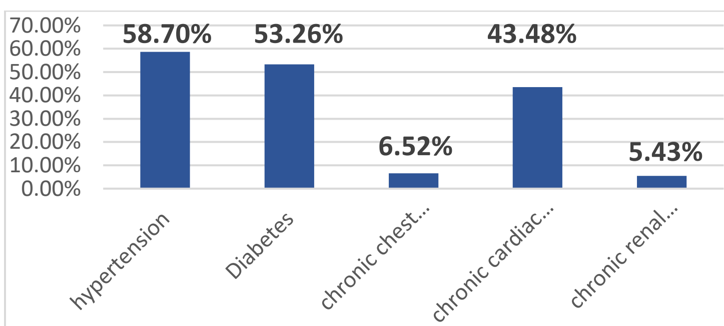

Figure 1: Chronic disease distribution among the study population

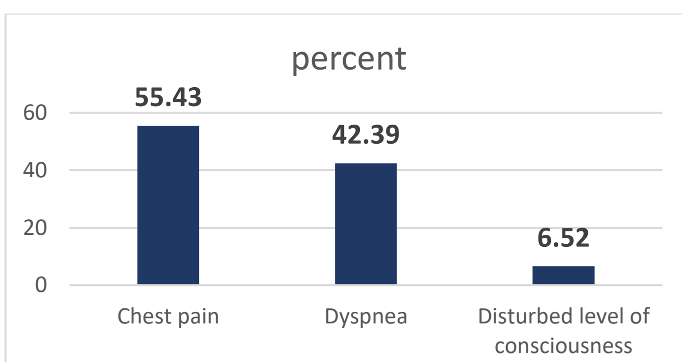

Figure 2: Pre-arrest complaint distribution among the study population

Table 2 shows the mean of arrival time at the hospital which was 21.78 minutes.

Figure 3 shows the Ultrasound readings among the study population: revealed that in the US first read 79.35% was standstill, while 20.65 % was with valvular wall motion, and none of the patients presented with ventricular wall motion in the 1st US read. While the US final read revealed that 80.43% was a standstill, 19.57% was with ventricular wall motion (ROSC), and no valvular wall motion was detected in the final US read.

Table 2: Arrival time at hospital mean and standard deviation	
Variable	Mean ± SD
Time of arrival (minutes)	21.78 ± 6.27

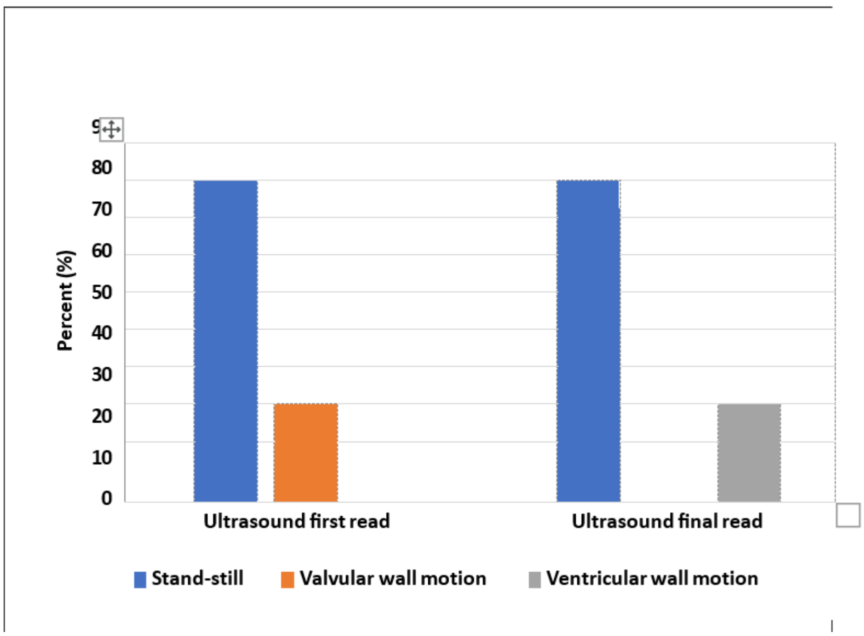

Figure 3: Ultrasound readings among the study population

Figure 4 shows the Rhythm distribution detected by the monitor among the study population and revealed that the majority of the rhythm was asystole by 78.26%, then fine VF by 13.04%, then VF by 7.61% and the least presentation was PEA by 1.09%.

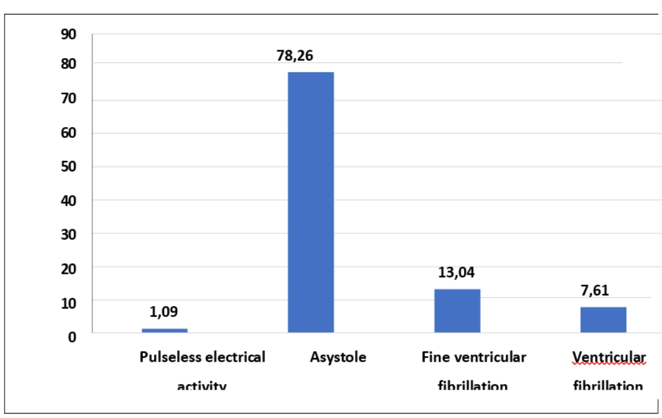

Figure 4: Rhythm distribution detected by the monitor among the study population.

Table 3 shows Chronic disease distribution among study groups according to fate and shows that all patients with chronic chest disease survived, while 77.78% of chronic cardiac disease survived with p-value ≤0.00l, which is statistically significant.

Table 4 shows the Time of arrival means and standard deviations among study groups according to fate, which was 24.14±3.92 min. among dead patients and was 12.11 ± 4.65 minutes among survived patients, with a p-value **<0.001,** which is statistically significant.

Table 3: Chronic disease distribution among study groups (fate)

Fate		Death	ROSC	p-value
Variables	Attributes	n (%)	n (%)	
Hypertension	No	32 (43.24)	6 (33.33)	0.444
	Yes	42 (56.76)	12 (66.67)	
	Total	74 (100)	18 (100)	
Diabetes mellitus	No	36 (48.65)	7 (38.89)	0.457
	Yes	38 (51.35)	11 (61.11)	
	Total	74 (100)	18 (100)	
Chronic chest disease	No	74 (100)	12 (66.67)	**<0.001**
	Yes	0 (0)	6 (33.33)	
	Total	74 (100)	18 (100)	
Chronic cardiac disease	No	48 (64.86)	4 (22.22)	**0.001**
	Yes	26 (35.14)	14 (77.78)	
	Total	74 (100)	18 (100)	
Chronic renal disease	No	69 (93.24)	18 (100)	0.257
	Yes	5 (6.76)	0 (0)	
	Total	74 (100)	18 (100)	

Table 4: Time of arrival means and standard deviations among the study groups (fate)

	Death	ROSC	p-value
Variable	Mean ± SD	Mean ± SD	
Time of arrival (minutes)	24.14 ± 3.92	12.11 ± 4.65	**<0.001**
Mann-Whitney U test			

Table 5 shows US readings in relation to the fate of the patients and it revealed that 97.3% of patients with stand still on 1st US reading died while 5.56% survived, and shows that 94.44 % of patients with valvular wall motion survived and shows that all patients with ventricular wall motion on the final US read survived (18 patients) with statically significant p-value

Table 6 shows the rhythm distribution in relation to fate, revealing that all patients with asystole rhythm died, while patients with ROSC were 55.56% with fine VF,38.89% with VF, and 5.56% PEA, with a statistically significant p- p-value.

Table 7 shows the relation between the means and SD of time of arrival and the rhythm, and revealed that the least means of time of arrival were 11.75 and 12 min, found with fine VF and VF, respectively, while the PEA and asystole were with means of 15 and 24.5 min, respectively, with a p-value <0,001, which is statistically significant.

Table 5: Ultrasound readings distribution among study groups (fate)				
Fate		Death	ROSC	p- value
Variables	Attributes	n (%)	n (%)	
Ultrasound first read	Stand-still	72 (97.3)	1 (5.56)	**<0.001**
	Valvular otion wall	2 (2.7)	17 (94.44)	
	Ventricular Motion wall	0 (0)	0 (0)	
	Total	74 (100)	18 (100)	
Ultrasound final read	Stand-still	74 (100)	0 (0)	**<0.001**
	Valvular Motion wall	0 (0)	0 (0)	
	Ventricular Motion wall	0 (0)	18 (100)	
	Total	74 (100)	18 (100)	

Table 6: Rhythm distribution among study groups (fate)				
Fate		Death	ROSC	p- value
Variables	Attributes	n (%)	n (%)	
Rhythm	PEA	0 (0)	1 (5.56)	**<0.001**
	Asystole	72 (97.3)	0 (0)	
	Fine VF	2 (2.7)	10 (55.56)	
	VF	0 (0)	7 (38.89)	
	Total	74 (100)	18 (100)	

Table 7: Time of arrival mean and standard deviations among the study groups (rhythm)					
Rhythm	PEA	Asystole	Fine VF	VF	p-value
Variables	Mean ±SD	Mean ±SD	Mean ± SD	Mean ±SD	
Time of arrival (minutes)	15	24.5±3.27	11.75±4.52	12 ± 4.9	**<0.001**
Kruskal-Wallis test					

Table 8 shows US readings in relation to rhythm and revealed that stand still was found in asystole and PEA, while valvular wall motion was found in fine VF and VF.

Table 9 shows that logistic regression and univariate analysis showed that there were 4 factors that significantly affected the fates of subjects. Reduction in time of arrival was in favor of a favorable outcome for the study subjects. On the other hand, the presence of chronic cardiac disease, negative ultrasound first reading, and absent rhythm (asystole) were not at all in favor of the outcomes of subjects.

The table contains four separate simple binary logistic regression models. The trial of the construction of a multiple binary logistic regression failed to produce any model with more than one significant factor

Table 8: Ultrasound readings distribution among study groups (rhythm)						
Rhythm		PEA	Asystole	Fine VF	VF	p- value
Variables	Attributes	n (%)	n (%)	n (%)	n (%)	
Ultrasound first read	Stand-still	1 (100)	72 (100)	0 (0)	0 (0)	**<0.001**
	Valvular wall motion	0 (0)	0 (0)	12 (100)	7 (100)	
	Ventricular wall motion	0 (0)	0 (0)	0 (0)	0 (0)	
	Total	1 (100)	72 (100)	12 (100)	7 (100)	
Ultrasound final read	Stand-still	0 (0)	72 (100)	2 (16.67)	0 (0)	**<0.001**
	Valvular wall motion	0 (0)	0 (0)	0 (0)	0 (0)	
	Ventricular wall motion	1 (100)	0 (0)	10 (83.33)	7 (100)	
	Total	1 (100)	72 (100)	12 (100)	7 (100)	

Table 9: Simple logistic regression models for fate					
Model №	Variable	B	p-value	OR	95% CI OR
1	Chronic cardiac disease	1.866	**0.002**	6.462	1.928 - 21.655
2	Time of arrival	-0.551	**<0.001**	0.576	0.443 - 0.749
3	Ultrasound first reading	6.417	**<0.001**	612.000	52.394 - 7148.663
4	Rhythm	4.684	**<0.001**	108.212	16.385 - 714.665
OR = odds ratio. CI = confidence interval					

Table 10 shows the significant results of cross-tabulations of the study variables, where all possible combinations of pairs of variables were done. It implies that changes in variable 1 lead to significant changes in variable 2, consequently. e.g., a change in chronic chest disease results in a significant change in the first read of the ultrasound.

Table 10: Cross-tabulation results		
Variable 1	Variable 2	p-value
Chronic chest disease	Ultrasound first read	***<0.001***
	Ultrasound final read	***<0.001***
	Fate	***<0.001***
Chronic cardiac disease	Ultrasound first read	***0.001***
	Ultrasound final read	***0.001***
	Fate	***0.001***
Ultrasound first read	Ultrasound final read	***<0.001***
	Fate	***<0.001***
Ultrasound final read	Fate	***<0.001***

The tables 11 and 12 show the diagnostic accuracy of ultrasound first reading as a predictor for fate, as it was sensitive by 94.44% and specific by 97.3%. Cardiac ultrasound in cardiac arrest has a +ve predictive value of 89.47 and % -ve predictive value of 98.63%.

Table 11: 2 x 2 table for diagnostic accuracy calculation				
-	-	Return of spontaneous circulation		Total
-	Attributes	Yes	No	
U/S first read	Yes	17 (85%)	2 (2.70%)	19 (20.65%)
	No	1 (15%)	72 (97.30%)	73 (79.35%)
Total		18 (100%)	74 (100%)	92 (100%)

Table 12: Diagnostic accuracy of the first ultrasound read regarding fate	
Parameters	Details
Sensitivity (%)	94.44
Specificity (%)	97.30
Positive predictive value (%)	89.47
Negative predictive value (%)	98.63
Likelihood ratio positive	34.94
Likelihood ratio negative	0.057
Accuracy (%)	96.74

Discussion

This was an Observational study, where 92 cardiac arrest patients who presented to the Department of Emergency Medicine in the period from March 2018 to August 2019 and met the inclusion criteria were resuscitated successfully by the attending emergency physicians who implemented the CPR algorithm, and the hearts of all 92 study patients were visualized by the cardiac US performed by the researcher.

Our study shows gender distribution among the study population and revealed that 54% were females while 46% were males. That wasn't matching another study that showed that gender distribution among the study population was 28.6% females and 71.4% [13]

Our study shows that the mean age of the study population was 61.8 years, 61.77 years in dead patients, and 61.94 years in survivors. That didn't match another study that revealed that the mean age for the study population was 70.3, for the survivors was 66.3 years, and for the non-survivors was 70.9 years [13].

Our study shows that hypertension and diabetes were the most common chronic illnesses, at 58.7% and 53.26% respectively. Chronic cardiac disease was presented by 43.48% while chronic chest disease and chronic renal disease were the least chronic illnesses presented by 6.52% and 5.43% respectively, In contrast, another study found that 24 patients (38 percent) had respiratory symptoms, 7 patients (11 percent) had metabolic symptoms, 6 patients (9 percent) had cardiac symptoms, 4 patients (6 percent) had neurologic symptoms, 17 patients (27 percent) had numerous symptoms, and 6 patients (9 percent) had undefined symptoms. The majority of patients with multiple abnormalities had metabolic (44 percent) and respiratory (39 percent) conditions [14].

There was another study showing similar results and the same concept, as it revealed that hypertension was present in 46.26%, DM was present in 24.19%, while known cardiac diseases were present in 35.88% [15]

Another study showed a similar result, as it revealed that the preceding cardiac arrest illnesses were cardiac in 50.5%. While 49.46% were non-cardiac, the most common cause was chronic chest disease. [16]

Our study shows that the Pre-arrest complaints among the study population found that chest pain was the most common pre-arrest complaint at 55.43%, dyspnea at 42.39% and DLOC was the least common pre-arrest complaint at 6.52%. That was matching another study that was done on total population of 839 of cardiac arrested patients and showed that chest pain was presented in 46.3% (n: 199), dyspnea presented in 18.1 %(n: 78), syncope and DLOCwas presented in 5.6% (n: 22) and other symptoms were presented in 29.5% (n: 127) [15]

Our study shows that the Time of arrival means and standard deviations among study groups according to fate were 12.11 ± 4.65 min. among survived patients, which was close to the results of another study that showed that the Mean ± SD of survived patients was 15 ± 12 min.[17]

Our study shows that US readings in relation with fate of the patients and it revealed that 97.3% (n: 72) of patients with standstill on 1st US reading died while 5.56 %(n:1) survived, and shows that 94.44 %(n:17) of patients with valvular wall motion survived will 2.7% (n:2). This was consistent with another study that found that four out of ten (40%) patients with cardiac activity on the initial US survived to hospital admission, but just one (3.1%) of the 32 patients with cardiac standstill on the initial US did so [13].

Our study shows the rhythm distribution with fate revealed that all patients with asystole rhythm 72 (97.3%) died, while patients with ROSC were 55.56 % (n: 10) with fine VF, 38.89% (n: 7) with VF, and 5.56% (n: 1) PEA, and no patient with pulseless VT was presented. That did not match another study that revealed that 17.18% of surviving patients had asystole, while 34.97% of them were PEA, 35.58% were VF, and 12.26% were pulseless VT. [17].

This change may be due to the large sample size of that study (n: 468), while our study had 92 patients only; the mean age of the studied population was around 52 years, while it was in our study around 62 years.

Our study showed US readings regarding rhythm and revealed that standstill was observed in asystole and PEA, while valvular wall motion was observed in fine VF and VF. Another study found that eight patients (6 percent) of the 140 patients whose ECG showed asystole exhibited cardiac activity on POCUS, which was inconsistent with this finding. Fourteen patients (30 percent) of the 46 PEA patients had POCUS-confirmed heart activity. [18]

This discrepancy may be due to technical differences, variations in technician expertise, and a large study population.

Our study shows that cardiac ultrasound in resuscitation revealed a sensitivity of 94.44%, Specificity of 97.30 %, Positive predictive value was 89.47% and Negative predictive value was 98.63%. In contrast to the study of (20), which had a sensitivity of 25%, specificity of 90%, negative predictive value of 60%, and positive predictive value of 70%. The study of (19) had a sensitivity of 73.2%, specificity of 92.2%, negative predictive value of 84.6%, and positive predictive value of 83.7%. A bigger sample size that includes both traumatic and non-traumatic cardiac arrest, as well as inside and outside hospital cardiac arrest, could be the cause of this discrepancy.

Limitations

-the relatively small sample size and the limited type of study population.

-For technical reasons, it was not possible to videotape the ultrasound scan for documentation and review by another interpreter.

-While not focusing on the method itself, our study aims to evaluate whether an emergency physician can predict the outcome of a CPR patient with ultrasound.

- Another drawback was the brief survival period of patients undergoing cardiopulmonary resuscitation (20 minutes post-resuscitation was deemed successful); also, this study did not examine long-term consequences following resuscitation.

Conclusion

We concluded the following from our study:

Four factors significantly affected the fates of subjects. A reduction in time of arrival was in favor of a favorable outcome for study subjects. On the other hand, the presence of chronic cardiac disease, negative ultrasound first reading, and absent rhythm (asystole) were not at all in favor of the outcomes of subjects.

There was a significant relation between the time of arrival and the rhythm detected with the monitor. Fine VF and VF were found with the shortest time of arrival, while PEA and asystole were found with longer time of arrival.

US readings about rhythm revealed that standstill was found in asystole and PEA, while valvular wall motion was found in fine VF and VF.

Cardiac ultrasound in resuscitation had 94.44 % Sensitivity and 97.30 % Specificity. With a Positive predictive value of 89.47% and a Negative predictive value of 98.6%.

Recommendations:

Early Arrival and Intervention

Efforts should be directed toward minimizing the time from cardiac arrest onset to hospital arrival, as shorter arrival times were associated with more favorable rhythms (fine VF and VF) and better outcomes.

Risk Stratification

Patients with chronic cardiac disease and those presenting with asystole or negative initial ultrasound findings should be recognized early as high-risk groups. Tailored resuscitation protocols and closer monitoring are recommended for these patients.

Integration of Point-of-Care Ultrasound (POCUS)

Cardiac ultrasound should be incorporated as a standard adjunct in resuscitation protocols. Its high sensitivity (94.44%) and specificity (97.30%) support its reliability in differentiating between true cardiac standstill and potentially salvageable rhythms.

Clinical Decision-Making Support

Ultrasound findings of cardiac standstill in asystole and PEA may help guide clinicians in determining the futility of ongoing resuscitation, while detection of valvular or wall motion in fine VF or VF can prompt more aggressive resuscitative measures.

Training and Implementation

Regular training of emergency and critical care teams on the use of POCUS in cardiac arrest scenarios is recommended to enhance diagnostic accuracy and improve patient outcomes.

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