Biolife
AN INTERNATIONAL QUARTERLY JOURNAL OF BIOLOGY & LIFE SCIENCES
4(3):446-454
ISSN (online): 2320-4257
www.biolifejournals.com
BIOLIFE RESEARCH ARTICLE

Role of Cardiac Sonography and Capnometry in Predicting Cardiopulmonary Resuscitation Outcomes

El Sayed A.A[1], Aglan A.A[2], Tammam H.M.H[3], Alterkawi H.A[4*]

[1,4] *Department of Critical Care Medicine, Faculty of Medicine, Alexandria University, Egypt*

Email: terkawi1987@hotmail.com

ABSTRACT

While capnography is used routinely as a non-invasive monitoring tool, cardiac sonography is also increasingly used in intensive care settings. Both of them have been proposed to assist in decision-making in management of cardiopulmonary arrest (CPA). In this study, we tested the performance feasibility and the role of cardiac sonography & capnometry as predictors of successful resuscitation of CPA patients. Focused cardiac sonography was performed for 100 ICU patients with CPA during the 10 seconds of pulse evaluation period. Simultaneously measurements of PetCO2 were recorded. All survivors of the initial resuscitation were followed up for 1 week and the Glascow Outcome Score was calculated. The mean number of US scans was 10.46 for each patient. The overall success rate for obtaining adequate views was 97%.The rate of discordance between manual pulse detection and US scans was 4.2%. Sonographically detected cardiac activity was noted in 54% of cardiac arrest subjects, and it was associated with increased survival 79.6% as opposed to 8.7% in those without sonographically identified cardiac activity on all scans ($p < 0.001$). It also predicted return of spontaneous circulation (ROSC) with 4.41 Positive LR, and 0.854 AUC. Our US Scan results diagnosed six potentially reversible causes, and led to four additional interventions, three of which led to a change in outcome. Using an average PetCO2 cut-off value of 10 mmHg for survival yielded 7.57 +LR; and AUC of 1. Kinetic cardiac activity and both average PetCO2 ≥10 mmHg and uptrend $PetCO_2$ were significantly associated with ROSC; however, the latter is still a better predictor. Implementing both tools have additive predictive effects for ROSC. Echocardiography during CPR is feasible, more reliable than manual pulse check and can contribute to diagnosing potentially treatable cardiac arrest etiologies.

Keywords: Cardiopulmonary arrest CPA; Cardiopulmonary Resuscitation CPR; Cardiac Ultrasound; capnometry; Return Of Spontaneous Circulation ROSC

INTRODUCTION

There are precise guidelines on how to apply advanced life support, but only hazy recommendations exist for the critical decision on when to stop resuscitative efforts (Deakin et al., 2010; Lippert et al., 2010). Time of resuscitative effort is sometimes used to measure progress and thus cease efforts when the patient doesn't appear to be responding to treatment. Physician survey data and clinical practice guidelines suggest that factors influencing the decision to stop resuscitative efforts include: duration of resuscitative effort > 30 minutes without a sustained perfusing rhythm, initial electrocardiographic rhythm of asystole, prolonged interval between estimated time of arrest and initiation of resuscitation, patient age and severity of comorbid disease, absent brainstem reflexes, and normothermia (Bailey et al., 2000; Horsted et al., 2004).

However, these parameters are not fully reliable (Lippert et al., 2010), so it would be of considerable clinical use to have a reproducible and accurate prognostic parameter, and time-efficient, reliable means of determining those patients who are potentially salvageable from CPR from those who are not.

Also, critically ill patient often have variant conditions [such as severe hypovolemia, poor vascular tone due to sepsis or intoxication, or high dose vasopressors which contribute to the challenge and difficulty of accurately

How to Site This Article:
El Sayed A.A, Aglan A.A, Tammam H.M.H, Alterkawi H.A. (2016 Role of Cardiac Sonography and Capnometry in Predicting Cardiopulmonary Resuscitation Outcomes. *Biolife*, 4(3), pp 446-454.
doi: 10.5281/zenodo.7319151

Received: 4 July 2016; Accepted; 21 August 2016; Available online : 2 September 2016

depending on pulse assessment for reliable determination of return of spontaneous circulation (ROSC). As bedside ultrasonography has become a vital diagnostic tool in ICUs, It is now possible to use real time cardiac imaging during cardiac arrest. Previous authors have noted bed-side ultrasound even to be useful in differentiating fine ventricular fibrilla-tion from asystole thus altering their treatment (Corbett and O"Callaghan, 1997).

Furthermore, addressing an underlying correctable cause of cardiac arrest (e.g. tamponade, massive pulmonary embolism, tension pneumothorax, hypovolemia) may warrant to change the focus of treatment. The importance of identifying a reversible underlying cause in these forms of cardiac arrest is of such importance that almost half of the ACLS for experienced practitioners manual is dedicated to this topic and its practical application (Cummins, 2002). Research has suggested that cardiac sonography may be beneficial in identifying patients with potentially treatable conditions of pulseless electrical activity and therefore better prognosis when central pulses are not palpable (Varriale and Maldonado, 1997; Ayama and Langsam, 1999; and Cummins, 2014).

Since end-tidal carbon dioxide (ET-CO_2) levels are dependent on the cardiac output generated by cardiopulmonary resuscitation (CPR) in cardiac arrest victims, capnomerty represent another potential predictor of survival or death after cardiac arrest (Cummins, 2014) Both cardiac sonography and capnometry or are well suited to bedside ICU practice because both tests are rapidly performed, noninvasive and easily available.

The objective of this study is to determine the feasibility of performing cardiac sonography during resuscitation, and to evaluate the utility of cardiac sonography & capnometry, both separately and together as a predictor of successful resuscitation of pulseless patients

MATERIAL AND METHODS

Study design:

This was a prospective clinical observational study of cardiac arrest patients undergoing either cardiac ultrasonography alone or in conjunction with capnometer. Survival was defined as Return of Spontaneous Circulation (ROSC) for being the immediate goal of CPR. Those who survived the initial resuscitation were followed up for 1 week and the Glascow Outcome Score was calculated for better perception of how satisfactory the outcomes were.

Approval of the Medical Ethics Committee of Alexandria faculty of Medicine and an informed consent from the patient's next of kin was taken before conducting the study.

Study setting and population:

This study was conducted at Alexandria Main University Hospital. One hundred pulseless ICU patients - calculated according to sample size - were enrolled in a prospective and convenience fashion over a period of nine months starting from April/2015. The minimal required experience for performing ultrasonography on study participants was a 14 hours critical care US workshop during which cardiac sonography using the subxiphoid view was taught and practiced on a series of different human and mannequin simulator models.Participating critical care senior residents performed and interpretted the cardiac sonography studies during the pulse check pause of the ACLS algorithm.

Methods:

Focused cardiac sonography was performed primairly by subxiphoid view, the apical view would be used as an adjunct in obese subjects with inadequate visualization of the heart. The available ultrasound machine in Alexandria Main University Hospital critical care units two devices: 1) SHENZHEN Mindray Biomedical Elcetronics Co, Ltd model DP 3300 of 3.5-5 MHz & model EMD 2100 50 class 1 of 2.5 MHz. 2) Echographe ultrasons class 1, KONTRON MEDICAL, Type SIGMA 330 master, France, with 2-5 MHz curvilinear transducer. The capnometer monitor available at the university hospital is a main- stream capnometer with infrared analysis of ETCO2 that provides only quantitative capnogramic measurements. Patient data including cardiac rhythm of arrest, presence or lack of palpable pulse, sonographic findings, and impression of the clinical utility of cardiac sonography and capnometry results were recorded. The delay & duration of resuscitation as well as the primary diagnosis were recorded. Cardiac sonography was performed in less than 10 seconds to avoid interference with ACLS mandated interventions. Cardiac sonography was carried out during the pulse evaluation or during cardiac rhythm change. The number of scans were determined by the progress of resuscitation. Capnometry was performed upon beginning of resuscitation if the subject was already intubated or immediately after intubation in the ICU. Capnometry levels were noted simultaneous to cardiac sonography exams, only peak ETCO2 levels were reported.

Statistical analysis:

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0 (Kirkpatrick and Feeney, 2013). Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level. The used tests were: 1 - Chi-square test for categorical variables, to compare between different groups. 2 - Fisher's exact correction for chi-square when more than 20% of the cells have expected count less than 5. 3 - Student t-test for normally quantitative variables, to compare between two studied groups. 4 - Z for Mann Whitney test for abnormally quantitative variables, to compare between two studied groups.

RESULTS AND DISCUSSION

We enrolled 100 patients from April, 2015 to December, 2015. Cardiac sonography was successfully implemented in the CPR algorithm and visualized the heart in all 100 study patients. All study patients were either already intubated before, or immediately after the cardiac arrest, and PetCO2 was measured for all subjects. Demographically, the cohort consisted of 56% males and 44% females, with no significance difference in gender distribution between survivors and nonsurvivors [χ^2=3.491, ^{FE}P=0.113]. Mean patient age was 61.61 years. Mean age for the survivors was 57.41, that for nonsurvivors was 64.13 years [t=0.327, P =0.745].

The most prevalent leading causes of cardiac arrsest were the non-cardiac causes 81%, followed by coronary artery Dz 13 %, then non-ischemic heart dz 6% arrest. Only in the last category was there no significant differences with respect to survival vs death.

The non-shockable rhythms were more prevalent [asystole 38% and PEA 23%] than shockable rhythms [PVT 16% and VF 23%]. Of the total nonsurvivors 62.3 % had asystole, while it was present only in 10.6% of the survivors. PEA and VF constituted similar percentages among both survivors [34%] and nonsurvivors [13.2 %]. The least prevalent rhythm of arrest was PVT, being present in only 11.3 % in nonsurvivors and 21.3 % in survivors.

The mean of CPR duration for all subjects was: (21.04 ± 10.85). The total number of US scans was (1046) scans. Subjects underwent a mean of (10.46 ± 5.41) US scans during CPR. The heart was visualized successfully, with adequate views by US within the 10 S pulse check interruptions, by a mean of (10.18 ± 5.27) for total subjects. Subsequently, the US scans failed with a mean of (0.28 ± 0.57) overall. The values of the means for those four parameters were significantly higher in non-survivors compared to survivors (p<0.001).

Discrepancy between manual pulse assessment and US finding [i.e., the rescuer feels pulse by palpation but the sonographer sees cardiac standstill by US] was observed in each patient with a mean of (0.44) overall. Of the total 1046 US scans, discrepancy was found 44 times (4.21%).

Sonographic detection of cardiac activity on the first scan (25/100) was associated more often with survival (22/25 or 88%) than death (3/25 or 12%; χ^2(p) = 22.494 (<0.001). Of patients in whom cardiac activity was present on all scans throughout CPR (10/100), all of them survived (10/10 or 100%; χ^2(^{FE}p) = 12.35 (<0.001). Among patients who had cardiac acitivity on any scans [i.e., cardiac activity present on at least one sonographic evaluation] (54/100), the survivors (43/54 or 79.6%) were significantly more than nonsurvivors (11/54 or 20.4%; χ^2= 50.175; p<0.001). Those who lacked cardiac activity on at least one scan [regardless of whether it was present on other scans or not at all] were (90/100) among whom survivors were (37/90 or 41.1%), while nonsurvivors were (53/90 or 58.9%; χ^2(^{FE}p) = 12.530 (<0.001). In those who lacked cardiac activity on all scans (46/100), death rate was significantly increased (42/46 or 91.3%) compared to survival (4/46 or 8.7%; χ^2(^{FE}p) = 50.175(<0.001) [table 1]. With respect to the subgroup analysis of the main type of cardiac activity identified by US, those who had wall motion were (42/100), among whom rate of survival was significantly elevated (36 or 85.7%, 76.6% of all survivors), compared to death rate (6 or 14.3%, 11.3% of all nonsurvivors, χ^2(^{FE}p) = 43.570(<0.001). On the other hand, Patients who had valvular motion as the maintype of cardiac activity were (12/100), with survivors being (7 or 58.3%, making 14.9% of all survivors) and nonsurvivors being (5 or 41.7%, making 9.4% of all nonsurvivors, χ^2(^{FE}p) = 0.703 (0.402), which is not statistically significant.

Table-1. Comparison between the survivors and nonsurvivors according to presence of cardiac activity during CPR

	Survived (n = 47)		Died (n = 53)		Total (n = 100)	
	No.	%	No.	%	No.	%
Presence of cardiac activity on any scan	43	79.6	11	20.4	54	100.0
□^{2}(p)	50.175*(<0.001)					
Presence Cardiac activity on all scans	10	100.0	0	0.0	10	100.0
□^{2}(^{FE}p)	12.35* (<0.001*)					
Presence of cardiac activity at first scan	22	88.0	3	12.0	25	100.0
□^{2}(p)	22.494* (<0.001*)					
Lack of cardiac activity on at least one scan	37	41.1	53	58.9	90	100.0
□^{2}(^{FE}p)	12.530* (<0.001*)					
Lack of cardiac activities on all scans	4	8.7	42	91.3	46	46.0
□^{2}(^{FE}p)	50.175*(<0.001*)					

χ^2: Chi square test
FE: Fisher Exact for Chi square test
*: Statistically significant at p ≤ 0.05

Six patiens (6%) were found by US to have potentially treatable conditions. Among survivors one had tension pneumothorax, while two had hypovolemia. Among nonsurvivors two had massive pulmonary embolism, while one had tamponade. The cardiac rhythm of arrest was PEA in all of them, except one with massive pulmonary embolism had PVT.

The mean and median initial Pet CO2 in mmhg for all subjects were 10.73 and 11, respectively. They were significantly different between survivors [12.6 as a mean, 12 as a median], and nonsurvivors [9.08 as a mean, 9 as a median], with t(p) = 7.423 (<0.001). On the other hand the mean and median average Pet CO_2 in mmHg for all subjects were 12.23 and 10, respectively. They were significantly elevated in survivors [17.08 as a mean, 16.8 as a median] compared with nonsurvivors [7.92 as a mean, 8 as a median], with t(p) = 31.647 (<0.001) [table-2].

Survival was significantly increased with uptrend PetCO2 levels [□^{2}**(p) =** 77.364* (<0.001*)], whereas both stationary and downtrend PetCO2 levels were associated with increased death rate [□^{2}**(p)=** 22.031 (<0.001), 28.004(<0.001), respectively]. Interestingly, 3 patients with stationary trend survived, and 3 patients with uptrend died, but no patient with downtrend survived.

Table-2. Comparison between the survivors and nonsurvivors according to Pet CO_2

Pet $CO_{2\ in\ mmhg}$	Survived (n = 47)	Died (n = 53)	Total (n = 100)
Initial			
Min – Max.	10.0 – 16.0	3.0 – 13.0	3.0 – 16.0
Mean ± SD.	12.60 ± 2.12	9.08 ± 2.56	10.73 ± 2.94
Median	12.0	9.0	11.0
t(p)	7.423* (<0.001*)		
Maximum			
Min – Max.	19.0 – 36.0	10.0 – 16.0	10.0 – 36.0
Mean ± SD.	26.49 ± 4.38	12.83 ± 1.42	19.25 ± 7.54
Median	26.0	13.0	15.0
t(p)	20.451* (<0.001*)		
Minimum			
Min – Max.	10.0 – 16.0	2.0 – 7.0	2.0 – 16.0
Mean ± SD.	11.66 ± 1.46	4.42 ± 1.29	7.82 ± 3.88
Median	11.0	5.0	6.0
t(p)	26.286* (<0.001*)		
Final			
Min – Max.	19.0 – 36.0	4.0 – 8.0	4.0 – 36.0
Mean ± SD.	26.49 ± 4.38	5.96 ± 1.04	15.61 ± 10.75
Median	26.0	6.0	8.0
t(p)	31.372* (<0.001*)		
Average			
Min – Max.	15.0 – 21.0	5.0 – 11.0	5.0 – 21.0
Mean ± SD.	17.08 ± 1.48	7.92 ± 1.42	12.23 ± 4.81
Median	16.80	8.0	10.0
t(p)	31.647* (<0.001*)		

t: Student t-test
*: Statistically significant at p ≤ 0.05

Table-3. Agreement (sensitivity, specificity and accuracy) for different parameters to predict survivals

	Cut off	AUC	p	Sensitivity	Specificity	PPV	NPV	Accuracy	+LR	-LR
Initial Pet CO_2	≥11	0.859*	<0.001*	80.85	71.70	71.70	80.85	76.0	3.51	0.49
Average Pet CO_2	≥15	1.000*	<0.001*	100.0	100.0	100.0	100.0	100.0	-	0.0
	≥10			100.0	86.79	87.04	100.0	93.0	7.57	0.0
Uptrend $Petco_2$levels	-	0.940*	<0.001*	93.62	94.34	93.62	94.34	94.0	16.54	0.068

Table-3 and **figure-1** shows simultaneously plotted Receiver Operating Characteristic [ROC] curves and calculated statistical measures of performance for three different parameters [initial, average, uptrend] of PetCO2 in predicting survival. The AUC in descending order was as follows; (1) for average $PetCO_2$, (0.940) for uptrend $PetCO_2$, and (0.859) for initial PetCO2. As concerns the other measure of diagnostic accuracy [sensitivity, specificity, PPV, NPP, Accuracy, Positive & Negative Likelihood ratios] average PetCO2 had the best values, while initial PetCO2 with cut off ≥11 had the lowest ones.

Table-4 & figure-2 shows that AUC in descending order was as follows; (0.854) for presence of cardiac activity on any scan, (0.706) for presence of cardiac activity on first scan, and (0.606) for cardiac activity on all scans. Although presence of cardiac activity on any scan had the best values in sensitivity; NPV; accuracy; and Negative likelihood ratio, the presence of cardiac activity on all scans was better in terms of specificity and PPV. Presence of cardiac activity on first scan only outweighed them in the value of Positive likelihood ratio. It should be noted that switching the average $PetCO_2$ cut off from ≥15 to ≥10 affected only the specificity, PPV, Accuracy and + LR.

Figure-1. ROC curve for different parameters to predict survivals

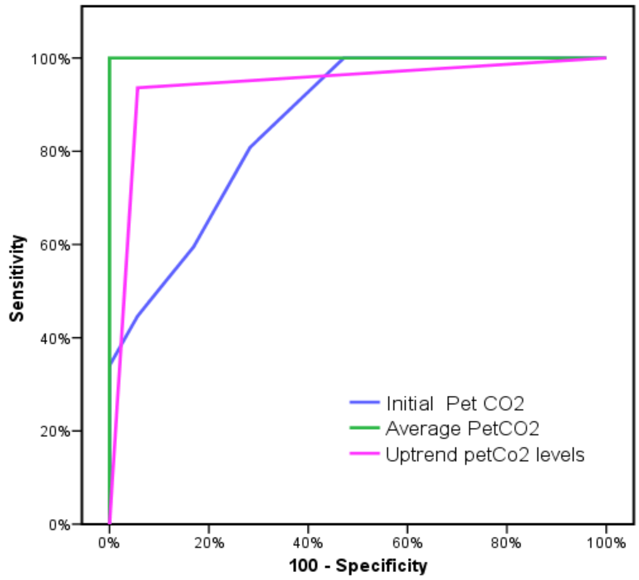


Figure-2. ROC curve for different parameters to predict survivals

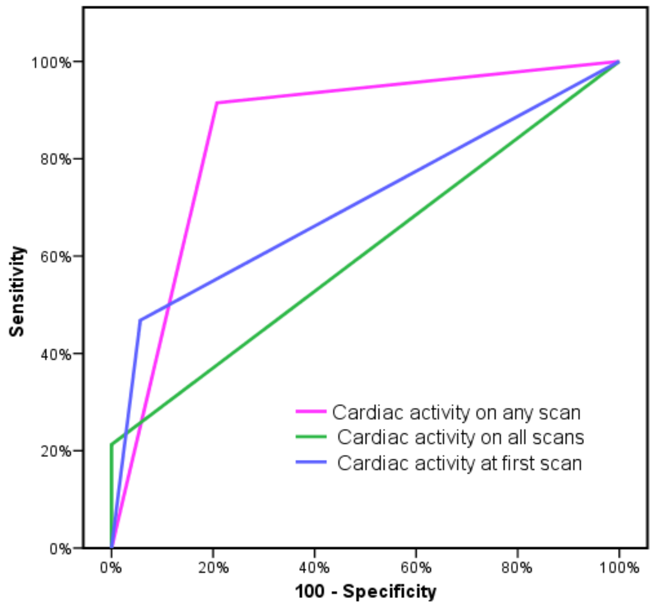
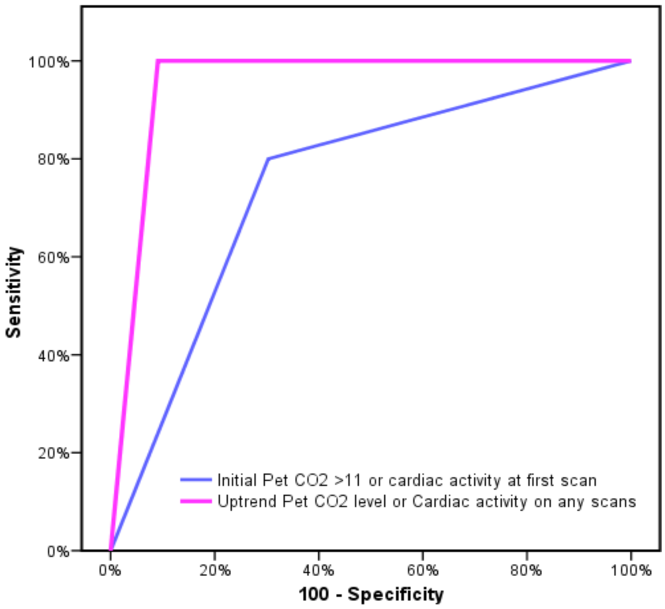


Table-5 and figure-3 documents the summary statistics for the previously demonstrated four different parameters when studied in combination rather than on separated basis.

Each cardiac rhythm of arrest had different rate of association with sonographically detected cardiac kinetic activity [Table 6]. In this current study subgroup analysis showed that both shockable & nonshockable rhythms cardiac arrest had increased survival in those with sonographically detected cardiac activity [□^{2}(^{FE}p) = 14.182 (<0.001) & 30.709 (<0.001), respectively]. Likewise, it was demonstrated that identified cardiac activity was associated with increased survival in both asystole and PEA patients, with □^{2}(^{FE}p) being [14.963(0.005), 5.033 (0.045)], respectively.

Figure-3. ROC curve for combination of co-parameters to predict survivals



The mean Glasgow Outcome Score GOS after 1 weak for patients who had survived was 3.91, median was 4, and the range was (1–5). The mean GOS was significantly higher (4.75) in the four patients who proceeded to ROSC despite having absent cardiac activity on US compared to the rest of survivors (3.84) who had cardiac activity [t(p) = 2.824 (0.022)]. By studying the Correlation strength between Glasgow outcome score after 1 weak and average Pet CO_2 in the 47 survivors the spearman coefficient r_s was -0.095 (p = 0.0526) which is considered a very weak correlation.

DISCUSSION

An increasing body of evidence suggests that capnography and cardiac sonography present an effective tool to help in management of Cardiac arrest patients (Idris et al., 1994; Levine et al., 1997; Ettin and Cook, 1999). However, until recently there was a shortage of literature citing the use of ultrasound by emergency physicians in these arrest states. In addition, most of the evidence of TTE during CPA comes from out-of-hospital CPA, and its results have been extrapolated to in hospital CPA conditions. One study by Flato et al., (2015) have evaluated the use of TTE during CPR in ICU patients but it included only patients with non-shockable rhythm cardiac arrest. This current study was conducted to determine whether cardiac sonography and capnography in cardiac arrest patients undergoing CPR are predictive of survival, and also to evaluate the feasibility of applying that in ICU, the incidence of potentially treatable conditions detected, and the influence on patient management.

Table-4. Agreement (sensitivity, specificity and accuracy) for different parameters to predict survivals

	Cut off	AUC	p	Sensitivity	Specificity	PPV	NPV	Accuracy	+LR	-LR
Presence of cardiac activity at first scan	-	0.706*	<0.001*	46.81	94.34	88.0	66.67	72.0	8.27	0.56
Presence Cardiac activity on any scans	-	0.854*	<0.001*	91.49	79.25	79.63	91.30	85.0	4.41	0.11
Presence Cardiac activity on all scans	-	0.606	0.067	21.28	100.0	100.0	58.89	63.0	1.00	0.79

Table-5. Agreement (sensitivity, specificity and accuracy) for combination of different coparameters to predict survivals

	AUC	p	Sensitivity	Specificity	PPV	NPV	Accuracy	+LR	-LR
Initial Pet CO_2 >11 or cardiac activity at first scan	0.748	0.077	91.49	67.92	71.67	90.0	79.0	2.85	0.13
Uptrend Pet CO_2 level or Cardiac activity on any scans	0.955*	0.001*	100.0	73.58	77.05	100.0	86.0	3.79	0.0

Table-6. Relation between Cardiac rhythm of arrest, Presence of cardiac activity on any scan and capnometry with survival

	Presence of cardiac activity on any scan				Absence e of cardiac activity on any scan				Average petco2
	Asystole	PEA	PVT	VF	Asystole	PEA	PVT	VF	
Survived	3	14	10	16	2	2	0	0	17.08
Died	1	3	3	4	32	4	3	3	7.92

In regard to the survival and the rhythm of arrest in the study subjects, of whom 47% had ROSC, the non-shockable rhythm was more prevalent, but with lower rate of survival. These results appear to be very close to those of a study by Nadkarni et al., (2006). In our study all 100 patients had witnessed and monitored cardiac arrest, with the delay in initiation of CPR being <1 min. Overall, the mean (± SD) duration of CPR was 21.04 (±10.85) min, but it was significantly decreased in survivors [10.72 (±6.8)] min compared to nonsurvivors [30.19 (±1.37) min, p<0.001]. Those results are supported by those of Nadkarni et al., (2006). Consequently, it was found that the means of number total US scans, successful scans, and failed scans were significantly elevated in nonsurvivors compared to survivors. This is likely explained by the longer time of CPR in nonsurvivors compared to survivors.

It`s worth noting that of the 1046 manual pulse checks occurring concomitantly with echo checks the discrepancy rate scan [i.e., alleged felt pulse but cardiac standstill sonographically] was 4.2% (44/1046). In a study by Blaivas et al., (2008) [n = 226] the discordance rate was 11%.

In current study overall, sonographically detected cardiac activity was noted in 54% of cardiac arrest subjects. The lack of cardiac activity on all scans proved to be very good predictor of failure to proceed to ROSC with AUC of (0.854) and was also associated with strongly moderate increase in likelihood of death though not conclusive (+ LR =9.31). On the other hand, sonographic identification of cardiac activity on any time during CPR was associated with increased survival 79.6% as opposed to 8.7% in those without sonographically identified cardiac activity on all scans ($p < 0.001$). The presence of sonographically identified cardiac activity at any time during the resuscitation predicted ROSC with 91.49 % sensitivity, 79.25 % specificity, 4.41 Positive LR, 0.11 Negative LR, and 0.854 AUC. In a meta-analysis by Blyth et al., (2012), in which cardiac kinetic activity was noted in 33.5% and absent in 66.5% of patients, the random-effects pooled results for sensitivity and specificity of echo as a predictor of ROSC were 91.6% and 80.0%, respectively. According to their summary estimates, the Positive LR was 4.26 and Negative LR was 0.18. The pooled area under the curve was 0.93. This is strongly consistent with our results and support the hypothesis that the demonstration of cardiac standstill is associated with an unsuccessful resuscitation (fairly effective although not definitive predictor of death), whereas the detection of cardiac kinetic activity is associated with an improved likelihood of survival (although weak predictor of ROSC).

By studying the association between survival and two different types and strengths of cardiac kinetic activity, it was found that survival was significantly increased with wall motion 85.7% ($p < 0.001$), as opposed to only 58.7% with valve motion ($p < 0.402$). By wall motion we meant intrinsic movement of the myocardium coordinated with cardiac valve movement, whereas by valve motion we meant cardiac valve movement with or without negligible unorganized atrial or ventricular motion. In the meta-analysis by Blyth et al., (2012), they invoked the variability between trial as to what constitutes cardiac activity, and that limited research has been conducted in this area. The authors raised a point that level of cardiac activity may independently be a predictor of viable myocardium or the likelihood of ROSC.

The current study data suggests that a potentially treatable cause can be sought whilst providing appropriate CPR. Our Scan results diagnosed six potentially reversible causes, and led to four additional interventions, three of which led to a change in outcome. Both Breitkreutz et al., (2010) and Hayhurst et al.' (2011) reported further interventions being undertaken as a result of US findings, however, that was not translated into significant survival benefit.

Higher ETCO2 values have been associated with ROSC in previous studies (Sanders et al., 1989; Callaham and Barton, 1990; Kern et al., 1992; Asplin and white, 1995; Cantineau et al., 1996). Our capnometry results add to this evidence base by demonstrating that higher ETCO2 values are associated with better prognosis. We found that the means of initial, final, maximum, minimum, and average PetCO2 values were all higher in patients who were resuscitated than in those who were not ($p < 0.001$ in all those five parameters). Likewise, survival was significantly increased with uptrend PetCO2 levels ($p<0.001$), whereas both stationary and downdtrend PetCO2 levels were associated with increased death rate ($p<0.001$).

With reference to the AUC for the created ROC curves, which is a global measure of diagnostic accuracy, the average of PetCO2 value and uptrend PetCO2 were excellent predictors (AUC = 1.0 and 0.94, respectively), both initial PetCO2 and presence of cardiac activity on any scan were very good predictors (AUC = 0.859 and 0.854, respectively), but the presence of cardiac activity on first scan turned out to be only fairly good predictor (AUC = 0.706).

In Salen et al., (2001) both the sonographic demonstration of cardiac activity and median PetCO2 higher than 16 mmhg were significantly associated with survival. Of the two correlation coefficients, φ of 0.35 for cardiac sonography and point-biserial coefficient of 0.53 for capnography, elevated PetCO2 levels were more strongly associated with survival than the presence of sonographically detected cardiac activity. The multivariate logistic regression model combining cardiac sonography and capnography showed that only capnography was found to be a significant predictor and that cardiac sonography did not enhance the predictive accuracy of the model. Howevere, the current study demonstrated some advantages to the use of two combinations of different co-parameters in comparison to their utility on separated basis. The combination of initial PetCO2 & cardiac activity on first scan only improved the sensitivity, NPV, accuracy and –LR. Likewise the combination of uptrend PetCO2 levels & cardiac activity on any scans only added to the AUC, sensitivity, NPV, and –LR.

By studying the correlation between the average $PetCO_2$ and the Glascow outcome score GOS, the result was insignificant (p=0.526). However, calculating the correlation between presence of cardiac activity and GOS showed increased score in those with absent cardiac activity compared to those with sonographically detected cardiac activity ($p < 0.022$). This might be partly explained by the fact that the four patients who survived despite having no detected cardiac activity had ROSC after a short duration of CPR (4 – 8 min).

CONCLUSION

- Cardiac US during CPR is feasible, more reliable than manual pulse check and can contribute to diagnosing potentially correctable etiologies of cardiac arrest, without hampering CPR efforts.
- Sonographic observation of cardiac activity and both average $PetCO_2$ levels higher than 10 mmhg and uptrend PetCO2 were significantly associated with ROSC; however, the latter two are still better predictors.
- Implementing both cardiacsonography and capnometry during resuscitation had additive predictive effects for ROSC.
- Both shockable & nonshockable rhythms cardiac arrest yielded increased survival when associated with sonographically identified cardiac activity.
- Survival was more significant with wall motion than with valve motion cardiac activity.
- The cardiac standstill harbors a significantly lower but not nill likelihood that a patient will experience ROSC.
- It appears that at present, we lack data to conclude

whether echo in life support or capnography would reliably predict neurological outcome in cardiac arrest patients.

Recommendation

- Training on cardiac sonography during CPR is justifiable for all medical professionals who deal with critical patients.
- Ultrasound finding might not be an adequate reason, by itself, to end resuscitative efforts.

Study limitations

- This was a convenience rather than a consecutive sample, and the sample size was relatively modest.
- This was a single center study.
- For technical reasons, the ultrasound scans were not videotaped for documentation and review by another interpreter.
- The study was not blinded in that the sonographers were aware of the progress and results of the resuscitative efforts.
- We followed up patients who had ROSC for only one week, a time at which patient may be discharged or transferred from the ICU.

Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1]. Asplin, BR. And White, RD. (1995). Prognostic value of end-tidal carbon dioxide pressures during out-of-hospital cardiac arrest. Ann Emerg Med; 25:756-61.

[2]. Ayama, SC. and Langsam, A. (1999). Ultrasound detection of ventricular fibrillation disguised as asystole. Ann Emerg Med; 33:344-6

[3]. Bailey, ED., Wydro, GC. and Cone, DC. (2000). Termination of resuscitation in the pre-hospital setting for adult patients suffering nontraumatic cardiac arrest. National Association of EMS Physicians Standards and Clinical Practice Committee. Prehospital Emerg Care; 4:190.

[4]. Blaivas, M. (2008). Discordance Between Pulse Detection and Emergent Echocardiography Findings in Adult Cardiopulmonary Arrest Patients. J Annemergmed; 06:301.

[5]. Blyth, L., Atkinson, P., Gadd, K. and Lang, E. (2012). Bedside Focused Echocardiography as Predictor of Survival in Cardiac Arrest Patients: A Systematic Review. Acad Emerg Med; 19:1119–1126.

[6]. Breitkreutz, R., Price, S. and Steiger, HV. (2010). Focused echocardiographic evaluation in life support and peri-resuscitation of emergency patients: a prospective trial. Resuscitation; 81:1527–33.

[7]. Callaham, M. and Barton, C. (1990). Prediction of outcome of cardiopulmonary resuscitation from end-tidal carbon dioxide concentration. Crit Care Med; 18: 358–62.

[8]. Cantineau, JP., Lambert, Y. and Merckx, P. (1996). End-tidal carbon dioxide during cardiopulmonary resuscitation in humans presenting mostly with asystole: a predictor of outcome. Crit Care Med; 24: 791–6.

[9]. Corbett, SW. and O"Callaghan, T. (1997). Detection of traumatic complications of cardiopulmonary resuscitation by ultrasound. Ann Emerg Med; 29:317-22.

[10]. Cummins, RO. (ed). (2014). American Heart Association Advanced Cardiac Life Support Textbook. Dallas :AHA.

[11]. Cummins, RO. editor. (2002). ACLS provider manual, 2001. Dalas, TX: American Heart Association. p. 97—8.

[12]. Deakin, CD., Nolan, JP. and Soar, J. (2010). European Resuscitation Council Guidelines for Resuscitation 2010. Section 4. Adult advanced life support. Resuscitation;81:1305–52.

[13]. Ettin, D. and Cook, T. (1999). Using ultrasound to determine external pacer capture. J Emerg Med.; 16:1007–9.

[14]. Flato UAP., Paiva, EF., Carballo, MT., Buehler, AM., Marco, R. and Timerman, A. (2015). Echocardiography for prognostication during the resuscitation of intensive care unit patients with non-shockable rhythm cardiac arrest. Resuscitation 92, 1–6.

[15]. Hayhurst, C., Lebus, C. and Atkinson, PR. (2011). An evaluation of echo in life support (ELS): is it feasible?What does it add? Emerg Med J.; 28:119–21.

[16]. Horsted, TI., Rasmussen, LS., Lippert, FK. and Nielsen, SL. (2004). Outcome of out-of-hospital cardiac arrest—why do physicians withhold resuscitation attempts? Resuscitation; 63:287.

[17]. Idris, AH., Staples, ED. And O'Brien, DJ. (1994). End-tidal carbon dioxide during extremely low cardiac output. Ann Emerg Med; 23:568–72.

[18]. Kern, KB., Sanders, AB. and Raife J. (1992). A study of chest compression rates during cardiopulmonary resuscitation in humans: the importance of ratedirected chest compressions. Arch Intern Med; 152: 145–9.

[19]. Kirkpatrick, LA. and Feeney, BC. (2013). A simple guide to IBM SPSS statistics for version 20.0. Student ed. Belmont, Calif.: Wadsworth, Cengage Learning.

[20]. Kotz, S., Balakrishnan, N., Read, CB. and Vidakovic, B. (2006). Encyclopedia of statistical sciences. 2nd ed. Hoboken, N.J.: Wiley-Interscience.

[21]. Levine, RL., Wayne, MA. And Miller, CC. (1997). End-tidal carbon dioxide and outcome of out-of-hospital cardiac arrest. N Engl J Med; 337:301–6.

[22]. Lippert, FK., Raffay, V., Georgiou, M., Steen, PA. and

Bossaert, L. (2010). European Resuscitation Council guidelines for resuscitation 2010,section 10. The ethics of resuscitation and end-of-life decisions. Resuscitation; 81:1445–51

[23]. Estari Mamidala, Rakesh Davella , Swapna Gurrapu and Pujala Shivakrishna , In Silico Identification of Clinically Approved Medicines Against the main Protease of Sars-Cov-2 – A Causative Agent of Covid-19.(2021). *Int. J. Life Sci. Pharma Res*. 11(1), L107-122. http://dx.doi.org/10.22376/ijpbs/lpr.2021.11.1.L107-122

[24]. Nadkarni, VM., Larkin, GL., Peberdy, MA., Carey, SM., Kaye, W., Mancini, ME., Nichol, G., Lane-Truitt, T., Potts, J., Ornato, JP. and Berg, RA. (2006). First Documented Rhythm and Clinical Outcome From In-Hospital Cardiac Arrest Among Children and Adults. JAMA;295:50-57.

[25]. Salen, P., O'Connor, R. and Sierzenski, P. (2001). Can cardiac sonography and capnography be used independently and in combination to predict resuscitation outcomes? Acad Emerg Med; 8:610–5.

[26]. Sanders, AB., Kern, KB., Otto, CW., Milander, MM. and Ewy, GA. (1989). End-tidal carbon dioxide monitoring during cardiopulmonary resuscitation: a prognostic indicator for survival. JAMA; 262: 1347–51.

[27]. Varriale, P. and Maldonado, JM. (1997). Cardiac sonography observations during inhospita cardiopulmonary resuscitation. Critical Care Med; 25:1717-20.

****