Original article

Assessment of ventricular wall motion with focused echocardiography during cardiac arrest to predict survival

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A B S T R A C T

Objectives: Our primary goal is to investigate the hypothesis that in patients with a detectable ventricular wall motion (VWM) in cardiac ultrasonography (US) during cardiopulmonary resuscitation (CPR), survival rate is significantly more than in patients without VWM in US.
Material and methods: In our prospective, single center study, 129 adult cardiac arrest (CA) patients were enrolled. Cardiac US according to Focus Assessed Transthoracic Echo (FATE) protocol was performed before CPR. Presence of VWM was recorded on forms along with demographic data, initial rhythm, CA location, presence of return of spontaneous circulation (ROSC) and time until ROSC was obtained.
Results: 129 patients were included. ROSC was obtained in 56/77 (72.7%) patients with VWM and 3/52 (5.8%) patients without VWM which is statistically significant (p > 0.001). Presence of VWM is 95% (95% CI: 0.95–0.99) sensitive and 70% (95% CI: 0.58–0.80) specific for ROSC. 43/77 (55.8%) patients with VWM and 1 (1.9%) of 52 patients without VWM survived to hospital admission which was statistically significant (p < 0.001). Presence of VWM was 100% (95% CI: 0.87–1.00) sensitive and 54% (95% CI: 0.43–0.64) specific for survival to hospital admission.
Conclusion: No patient without VWM in US survived to hospital discharge. Only 3 had ROSC in emergency department and only 1 survived to hospital admission. This data suggests no patient without VWM before the onset of CPR survived to hospital discharge and this may be an indication to end resuscitative efforts early in these patients.

1. Introduction

Cardiopulmonary resuscitation (CPR) results either with the return of spontaneous circulation (ROSC) or with the decision of terminating resuscitative efforts. While achieving ROSC is the primary goal, a successful CPR must also result with good neurological outcome. Many factors such as initial cardiac rhythm, early defibrillation and early chest compressions, patient's age, comorbidity, prolonged CPR affect the outcome of resuscitation.[1,2] Termination of CPR is a more controversial subject. Guidelines and studies suggest terminating CPR efforts on normothermic, elderly patients with an initial rhythm of asystole, and whose brain stem reflexes are absent.[3–5] Clinical judgement of the rescuer is also a key factor.[4] Lately, considering more objective endpoints such as lower end

tidal CO_2 values and absence of ventricular wall motion (VWM) on cardiac ultrasound (US) are recommended.[6]

US is a widely used, beneficial tool of emergency medicine practice. Many protocols are described for different patient groups. Focus Assessed Transthoracic Echo (FATE) is a commonly used and recognized protocol for bedside echocardiography. Since this protocol is performed faster than a regular transthoracic echocardiography, it is preferred in more acute settings such as management of critically ill patients and resuscitation. Many researchers investigated the use and advantages of US in CPR.[7–15] In many studies, absence of VWM in CPR implies a poor survival rate and it is discussed to use US as a predictor of outcome and as another key factor to consider when deciding to terminate CPR.

In our study, our primary goal was to investigate the hypothesis ROSC is obtained significantly more in patients with a detectable VWM during CPR. As a secondary goal, we aimed to study the correlation between presence or absence of VWM in cardiac US and survival until hospital admission and after hospital discharge.

2. Material and methods

2.1. Study design and setting

This is a prospective, single-center, observational study held in [blinded] between January 2014 and July 2014. Our primary goal was to investigate the clinical predictive value and utility of VWM for the estimation of ROSC. Secondary goals were to investigate the utility of VWM for the estimation of survival-to-hospital admission and long-term survival (1-month).

2.2. Sample size estimation and selection of participants

In order to test our primary hypothesis, required sample size was estimated using the data from a study in 2005 by Salen et al.[11] According to this data, the sample size necessary to investigate the statistical significance with a 0.01 Type I error and 0.01 Type II error (with 99% power and $p < 0.01$) was calculated to include a sum of 57 patients, 9 with VWM and 48 without VWM in US. Considering missing data and patients, 3 folds of the necessary sample size was intended. Using consecutive sampling, all patients who presented with CA and had CA during their stay in emergency department (ED) and on whom a cardiac US was performed were enrolled until the planned sample size was achieved. Patients younger than 18 years of age, patients with thoracic deformities or injuries that prevents US examination and pregnant patients were excluded. During the planned time frame of the study, 177 patients received CPR, however, 30 patients were missed mainly due to rapid evaluation and transfer to operating room, missing personal data and high patient volume of the ED. A total of 147 patients were enrolled to the study. 18 of those 147 patients were then removed from the study due to incomplete data, lost to follow-up. Study and follow-up was completed with a final sample-size of 129 patients.

2.3. Observations, measurements and data collection

Cardiac US is a routine examination performed without intervening CPR in all CA patients in our clinic. US was performed by senior emergency medicine residents (EMRs) with at least 2 years of clinical experience. Senior EMRs are required to complete Basic and Advanced US Training Courses certified by the Emergency Medicine Association of Turkey (EMAT). In this study, a senior EMR performed cardiac US with FATE protocol and evaluated the presence or absence of VWM from subxiphoid window. FATE protocol suggests checking for more obvious conditions such as pericardial effusion and tamponade, first. Measurements of ventricular wall thickness and volumes, evaluating ventricular functions, pleural imaging and interpreting these findings with patient's clinical state are other suggested steps.[16] During acute settings such as CPR, checking for obvious conditions and VWM would be sufficient for clinical evaluation.[16] In a study on echocardiographies performed by emergency physicians (EPs), Bustam et al[17] reported interrater correlation of EPs as 0.79 (95% CI 0.77–0.84). This kappa value was compatible with previous studies of EPs performing echocardiography.[18,19] According to this and previous researches, FATE evaluations by different EPs with required training is accepted as highly correlated with each other. Therefore, we assumed that all senior EMRs with EMAT US certification would be highly correlated with each other and data gathered by different EMRs are collected together for the primary aim of the study.

CPR was performed according to AHA 2010 guidelines in patients with CA. Cardiac US was only performed during the hands-off periods of pulse checks. If it was not technically possible to perform US due to extensive thoracic injury, thickness, obesity or rapid evaluation and transfer to operating room, those patients were excluded from the study.

A data collection form was prepared and US examination findings (according to FATE protocol), absence or presence of VWM, age, sex, location of CA (in-hospital or out-of-hospital), and initial rhythm (VT/VF or PEA/asystole) were recorded. If ROSC was achieved, duration until ROSC was also recorded. Follow-up of the patients were performed using the Hospital Information System (HIS) and survival to hospital admission and survival at 1-month was recorded, as well.

Hitachi Aloka Prosound 6 Ultrasound was used in all examinations with an UST-9123 3.5 Mhz convex abdominal probe.

2.4. Power of the study

In our study, ROSC was achieved in 72.7% and 5.8% of the patients with and without VWM, respectively. The post-hoc achieved power of our study for the primary aim is calculated as 100%. Similarly, for our secondary goals, the post-hoc achieved power of our study is also 100%.

2.5. Statistical analysis

Categorical variables are reported as numbers and percentages with ranges. Fisher's Exact test was used to compare categorical variables. Continuous variables are reported as means with standard deviations and 95% confidence intervals (CI). Normality analysis of the continuous measures was performed using the Kolmogorov–Smirnov and Shapiro–Wilks tests and Q–Q plots. For normally distributed variables, Student's t-test was used. If the variables were not normally distributed, the data were transformed (if applicable) or nonparametric tests were performed. The sensitivity, specificity, positive (PPV) and negative predictive values (NPV), positive likelihood ratio (+LR), and negative likelihood ratio (−LR) of the VWM to estimate ROSC, short-term (admission) and long-term (1-month) survivals were calculated using MedCalc and an online calculator (Richard Lowry, Vassarstat.Net). In this study, MedCalc Software version 15.4 (MedCalc Software bvba, Mariakerke, Belgium), SPSS v20 (SPSS Inc., IBM, Chicago, IL), and G*Power statistical software package version 3.1.2 (Franz Faul, Universitat Kiel, Kiel, Germany) were used for analyses. This research is conducted after the approval by [blinded] University Ethics Committee.

3. Results

Of the 129 patients, 46 (35.6%) were female and 83 (64.4%) were male. Mean age of female patients was 68.96 ± 16.44 (95% CI: 64.07–73.84), male patients was 63.08 ± 15.94 (95% CI: 59.60–66.56) and mean difference was 5.87 ± 2.96 (95% CI: 0.01–11.74) which was statistically insignificant (t-test, $p = 0.053$). Only 4 (3.1%) of 129 patients had CA due to trauma. Flowchart of the patients is presented in Fig. 1.

When we compared the outcomes and results according to sex, no significant difference was observed for the presence of VWM (Female: 29 (63.0%); Male: 48 (57.8%); $p = 0.580$), rate of ROSC (Table 1), rate of initial rhythms (VT/VF: Female: 7 (15.2%); Male: 23 (27.7%); $p = 0.130$), survival rate to hospital admission (Female: 14 (30.4%); Male: 30 (36.1%); $p = 0.565$), and long-term survival at 1-month (Female: 2 (4.3%); Male: 6 (7.2%): $p = 0.711$). Sex was not found to be a confounding factor for any of the outcomes.

Comparison of demographic data of the patients according to the primary aim (VWM for ROSC) and secondary aim (VWM for short term survival) of the study was presented in Tables 1 and 2. In patients with VWM, ROSC was obtained in 72.7% (n = 56; $p < 0.001$) but VWM was present in 97.7% (n = 43/44) patients who had ROSC