

# Assessment of Cardiac Ultrasonography in Predicting Outcome in Adult Cardiac Arrest

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**OBJECTIVE:** A prospective follow-up study to evaluate the ability of cardiac ultrasonography performed by emergency physicians to predict resuscitation outcome in adult cardiac arrest patients. **METHODS:** Ultrasonographic examination of the subxiphoid cardiac area was made immediately on presentation to the emergency department with pulseless cardiac arrest. Sonographic cardiac activity was defined as any detected motion within the heart including the atria, ventricles or valves. Successful resuscitation was defined as any of: return of spontaneous circulation for  $\geq 20$

min; return of breathing; palpable pulse; measurable blood pressure. **RESULTS:** The study enrolled 149 patients over an 18-month period. The presence of sonographic cardiac activity at the beginning of resuscitation was significantly associated with a successful outcome (19/27 [70.4%] versus 55/122 [45.1%] patients without cardiac activity at the beginning of resuscitation). **CONCLUSIONS:** Ultrasonographic detection of cardiac activity may be useful in determining prognosis during cardiac arrest. Further studies are needed to elucidate the predictive value of ultrasonography in cardiac arrest patients.

**KEY WORDS:** CARDIAC ULTRASONOGRAPHY; CARDIAC ARREST; CARDIOPULMONARY RESUSCITATION; PREDICTION OF RESUSCITATION OUTCOME; RETURN OF SPONTANEOUS CIRCULATION

## Introduction

Any patient presenting with cardiac arrest should be managed initially according to basic and advanced life support (ALS) treatment guidelines and assessed for potentially treatable or reversible causes of cardiac arrest.<sup>1</sup> Initial electrocardiographic monitoring is the most important factor

contributing to successful resuscitation in the emergency room.<sup>2</sup> Cardiac ultrasonography is becoming a vital diagnostic tool with increasing applications in emergency situations. It has the potential to be used as an effective diagnostic tool during cardiac arrest, in particular to observe the presence or absence of ventricular wall motion in pulseless electrical activity (PEA) arrests.<sup>3-6</sup>

The absence of a pulse in cardiac resuscitation does not always reflect cardiac

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standstill because inefficient cardiac contractions may still be occurring.<sup>4,7</sup> Some causes of inefficient cardiac contractions are potentially treatable and reversible.<sup>4,7,8</sup> Cardiac ultrasonography provides information on the contractility of the heart in pulseless patients, regardless of cardiac rhythm.<sup>9</sup> The early identification of cardiac contractions in pulseless patients may provide additional information regarding prognosis and increase the likelihood of predicting successful resuscitation. Studies have evaluated the prognostic value of ultrasonography in cardiac arrest patients but no consensus on its value has emerged.<sup>10,11</sup>

The objective of the present study was to evaluate the ability of cardiac ultrasonography, performed by emergency physicians, as a predictor of resuscitation outcomes in adult cardiac arrest patients.

## Patients and methods

### PATIENTS

This prospective, observational study included consecutive adults (aged  $\geq 18$  years) who presented in cardiac arrest at the Department of Emergency Medicine, Süleyman Demirel University, Isparta, Turkey, between 1 February 2009 and 1 August 2010. All adults who presented with no pulse and who were having a cardiac arrest resulting from a traumatic or nontraumatic event, either while in or out of hospital, were eligible for inclusion. Exclusion criteria were terminal illness, drowning, hanging and severe hypothermia ( $< 30^\circ\text{C}$ ).

Ethics committee approval was obtained from the Süleyman Demirel University Institutional Review Board. Individual verbal and written informed consent was obtained from the patients' relatives.

### EXAMINATIONS AND EVALUATIONS

All patients underwent immediate

ultrasonographic evaluation by emergency physicians during their initial assessment. Ultrasound examination was conducted via the subxiphoid cardiac approach to visualize the heart for the presence or absence of sonographically identifiable cardiac activity. The procedure was performed rapidly and care was taken not to interfere with ALS-mandated interventions. Ultrasound examinations were performed using a Chison 600M with a 7 MHz curvilinear transducer (Chison Medical Imaging, Wuxi City, China). All participating emergency physicians received theoretical and hands-on training on the use of cardiac ultrasonography. Sonographic cardiac kinetic activity was defined as any detected motion within the heart, including atrial, valvular and/or ventricular motion.<sup>7</sup> A successful outcome was defined as any of: return of spontaneous circulation sustained for  $\geq 20$  min; return of breathing (more than an occasional gasp, coughing, or movement); evidence of a palpable pulse; measurable blood pressure.<sup>12</sup> Heart rhythm was determined from the readout attached to the defibrillator machine.

### STATISTICAL ANALYSES

Patients were categorized into subgroups using a series of variables, and the frequencies and percentages for each subgroup were reported. Bivariate comparisons between subgroups of patients were made using the  $\chi^2$ -test. Sensitivity, specificity, and positive and negative predictive values were calculated. Statistical analyses were performed using SPSS® version 17.0 (SPSS Inc., Chicago, IL, USA) for Windows®. A *P*-value  $< 0.05$  was considered statistically significant.

## Results

The study recruited 149 patients in cardiac

## Cardiac ultrasonography and resuscitation outcome

arrest (97/149 [65.1%] males; mean  $\pm$  SD age  $61.6 \pm 17.9$  years; 129/149 [86.6%] aged  $> 40$  years). A total of 41 (27.5%) of the cardiac arrests were due to a traumatic event, including 36 (24.2%) resulting from nonpenetrating injury. Table 1 lists the clinical and demographic characteristics of the patients stratified according to resuscitation outcome. Successful resuscitation was significantly more likely in patients who had entered cardiac arrest while in hospital ( $P < 0.001$ ) and who had cardiac arrest of nontraumatic aetiology ( $P = 0.02$ ). The presence of ultrasonographically detectable cardiac activity was also significantly associated with a successful resuscitation outcome ( $P = 0.017$ ).

Data regarding resuscitation outcome stratified according to initial cardiac rhythm

and the presence of ultrasonographically detectable cardiac activity are given in Table 2. The sensitivity and specificity of cardiac ultrasonography for successful resuscitation were 25% and 90%, respectively, and the negative and positive predictive values were 60% and 70%, respectively.

## Discussion

The present study demonstrated that ultrasonographic detection of cardiac activity at the beginning of the resuscitation process in patients with cardiac arrest was significantly associated with successful resuscitation, a finding in accordance with other reports.<sup>4,5,7,13-18</sup>

The goal of cardiac ultrasonography in cardiac arrest is to improve the outcome of cardiopulmonary resuscitation by

**TABLE 1:**  
Clinical and demographic characteristics of the adult patients with cardiac arrest who were included in the present study of cardiac ultrasonography for the prediction of resuscitation outcome, stratified according to outcome

| Characteristics                     | Total | Successful resuscitation <sup>a</sup> | Unsuccessful resuscitation | Statistical significance <sup>b</sup> |
|-------------------------------------|-------|---------------------------------------|----------------------------|---------------------------------------|
| Total                               | 149   | 74 (49.7)                             | 75 (50.3)                  | –                                     |
| Gender                              |       |                                       |                            |                                       |
| Male                                | 97    | 47 (48.5)                             | 50 (51.5)                  | NS                                    |
| Female                              | 52    | 27 (51.9)                             | 25 (48.1)                  |                                       |
| Age, years                          |       |                                       |                            |                                       |
| 18 – 40                             | 20    | 6 (30.0)                              | 14 (70.0)                  | NS                                    |
| > 40                                | 129   | 68 (52.7)                             | 61 (47.3)                  |                                       |
| Arrest location                     |       |                                       |                            |                                       |
| In hospital                         | 77    | 52 (67.5)                             | 25 (32.5)                  | $P < 0.001$                           |
| Out of hospital                     | 72    | 22 (30.6)                             | 50 (69.4)                  |                                       |
| Initial rhythm                      |       |                                       |                            |                                       |
| PEA                                 | 64    | 35 (54.7)                             | 29 (45.3)                  | NS                                    |
| Asystole                            | 77    | 35 (45.5)                             | 42 (54.5)                  |                                       |
| VF/VT                               | 8     | 4 (50.0)                              | 4 (50.0)                   |                                       |
| Arrest aetiology                    |       |                                       |                            |                                       |
| Traumatic                           | 41    | 14 (34.1)                             | 27 (65.9)                  | $P = 0.02$                            |
| Nontraumatic                        | 108   | 60 (55.6)                             | 48 (44.4)                  |                                       |
| Cardiac activity on ultrasonography |       |                                       |                            |                                       |
| Yes                                 | 27    | 19 (70.4)                             | 8 (29.6)                   | $P = 0.017$                           |
| No                                  | 122   | 55 (45.1)                             | 67 (54.9)                  |                                       |

Data presented as number (*n*) of patients (%).

<sup>a</sup>Successful resuscitation defined as any of: return of spontaneous circulation (sustained for  $\geq 20$  min); return of breathing (more than an occasional gasp, coughing, or movement); evidence of palpable pulse; measurable blood pressure.

<sup>b</sup> $\chi^2$ -test.

PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, ventricular tachycardia; NS, not statistically significant ( $P \geq 0.05$ ).

**TABLE 2:** Resuscitation outcome in adult patients with cardiac arrest ( $n = 149$ ) stratified according to initial cardiac rhythm and ultrasonographically detectable cardiac activity

| Initial rhythm <sup>a</sup> | Cardiac activity <sup>b</sup> | Total     | Successful resuscitation <sup>c</sup> | Unsuccessful resuscitation |
|-----------------------------|-------------------------------|-----------|---------------------------------------|----------------------------|
| PEA                         | Standstill                    | 42 (28.2) | 20 (47.6)                             | 22 (52.4)                  |
|                             | Contractions                  | 22 (14.8) | 15 (68.2)                             | 7 (31.8)                   |
| Asystole                    | Standstill                    | 72 (48.2) | 31 (43.1)                             | 41 (56.9)                  |
|                             | Contractions                  | 5 (3.4)   | 4 (80.0)                              | 1 (20.0)                   |
| VF/VT                       | Standstill                    | 8 (5.4)   | 4 (50.0)                              | 4 (50.0)                   |
|                             | Contractions                  | 0         | 0                                     | 0                          |

Data presented as number ( $n$ ) of patients (%).

<sup>a</sup>Assessed by examination of defibrillator machine readout.

<sup>b</sup>Assessed by cardiac ultrasonography

<sup>c</sup>Successful resuscitation defined as any of: return of spontaneous circulation (sustained for  $\geq 20$  min); return of breathing (more than an occasional gasp, coughing, or movement); evidence of palpable pulse; measurable blood pressure.

No statistically significant differences ( $P \geq 0.05$ ,  $\chi^2$ -test).

PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, ventricular tachycardia.

identifying organized cardiac contractility. This enables the clinician to distinguish between PEA and pseudo PEA, and to determine a cardiac cause such as massive pulmonary embolism, cardiac tamponade or severe hypovolaemia.<sup>3,9,10,13,14,16,18,19</sup> There is insufficient evidence either to support or refute the routine use of ultrasonography to predict the success of resuscitation,<sup>10</sup> although it has been demonstrated that focused cardiac ultrasonography can be used to define cardiac activity during cardiopulmonary resuscitation.<sup>7,13,15,16,20 - 22</sup> Cardiac ultrasonography has been used as an effective diagnostic tool during cardiac arrest, in particular for determining the causes of PEA and true asystole.<sup>3</sup>

The ultrasonographic detection of cardiac activity has been shown to be significantly associated with survival after resuscitation<sup>15</sup> and return of spontaneous circulation (resumption of a palpable pulse and blood pressure).<sup>7</sup> Ultrasonographic detection of cardiac activity in a similar manner at the beginning of the resuscitation process in the present study was associated with survival

regardless of initial electrical rhythm. It has been shown that patients presenting with cardiac standstill on the bedside echocardiogram did not survive regardless of their electrical rhythm,<sup>16</sup> with a positive predictive value for death of 100% and a negative predictive value of 58%.<sup>16</sup> The negative and positive predictive values of cardiac motion for successful resuscitation were 60% and 70%, respectively, in the present study.

Asystole is defined as the complete absence of any motion in the heart including the valves, atria or ventricles.<sup>7</sup> The results of the present study showed that 6.5% (5/77) of patients presenting with asystole had ongoing cardiac activity identified by ultrasonography and that four patients survived. This is in accordance with the findings of others where a proportion of asystolic patients were found to have ultrasonographically observable cardiac activity.<sup>7,13,15,16</sup>

Cardiac ultrasonography in the resuscitation setting may have a further role in determining whether the patient has pseudo or true PEA.<sup>3,21,23,24</sup> Pseudo PEA is

defined as myocardial electrical activity with no detectable pulse but with coordinated cardiac activity, and true PEA is myocardial electrical activity with no detectable pulse and no detectable cardiac activity.<sup>17</sup> In the current study 34.4% (22/64) of patients with PEA had ultrasonographically detectable cardiac activity and 68.2% (15/22) of these patients were successfully resuscitated. Pseudo and true PEA can be considered different stages of the same spectrum of disease. Pseudo PEA results from tissue hypoxia, with electrolyte and metabolic disturbances ultimately leading to cessation of mechanical activity and asystole.<sup>3,23</sup>

This study has several limitations. First, patient survival was defined as successful resuscitation rather than long-term outcome. Secondly, ultrasonographic evaluations were made from the subxiphoid cardiac area only in order to avoid treatment delay, and there is a small possibility that this could have resulted

in misinterpretation of cardiac activity.<sup>9</sup> Finally, cardiac arrest patients present relatively infrequently at the Department of Emergency Medicine, Süleyman Demirel University, resulting in a modest sample size.

In accordance with other studies,<sup>3,8,13,15,16</sup> the present study supports the prognostic value of ultrasonographic detection of cardiac activity at the beginning of a resuscitation procedure. The presence of cardiac activity at the beginning of resuscitation was significantly associated with successful resuscitation. Cardiac ultrasonography may be a useful procedure in determining prognosis of a cardiac arrest, but further studies are needed to elucidate the predictive value of ultrasonography in these patients.

## Conflicts of interest

The authors had no conflicts of interest to declare in relation to this article.

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