

Outcome in Cardiac Arrest Patients Found to Have Cardiac Standstill on the Bedside Emergency Department Echocardiogram

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Abstract. Patients presenting in cardiac arrest frequently have poor outcomes despite heroic resuscitative measures in the field. Many emergency medical systems have protocols in place to stop resuscitative measures in the field; however, further predictors need to be developed for cardiac arrest patients brought to the emergency department (ED). **Objective:** To examine the predictive value of cardiac standstill visualized on bedside ED echocardiograms during the initial presentations of patients receiving cardiopulmonary resuscitation (CPR). **Methods:** The study took place in a large urban community hospital with an emergency medicine residency program and a high volume of cardiac arrest patients. As part of routine care, all patients arriving with CPR in progress were subject to immediate and brief subxiphoid or parasternal cardiac ultrasound examination. This was followed by brief repeat ultrasound examination during the resuscitation when pulses were checked. A 2.5-MHz phased-array probe was used for imaging. Investigators filled out standardized data sheets. Examinations were taped for review. Statistical analysis

included descriptive statistics, positive and negative predictive values, and likelihood ratios. **Results:** One hundred sixty-nine patients were enrolled in the study. One hundred thirty-six patients had cardiac standstill on the initial echocardiogram. Of these, 71 patients had an identifiable rhythm on monitor. No patient with sonographically identified cardiac standstill survived to leave the ED regardless of his or her initial electrical rhythm. Cardiac standstill on echocardiogram resulted in a positive predictive value of 100% for death in the ED, with a negative predictive value of 58%. **Conclusions:** Patients presenting with cardiac standstill on bedside echocardiogram do not survive to leave the ED regardless of their electrical rhythms. This finding was uniform regardless of downtime. Although larger studies are needed, this may be an additional marker for cessation of resuscitative efforts. **Key words:** ultrasound; emergency ultrasonography; cardiac arrest; outcome prediction; emergency medicine. *ACADEMIC EMERGENCY MEDICINE* 2001; 8:616–621

CARDIAC ARREST patients have a high mortality, and few survive to leave the emergency department (ED).¹ Many EDs now have protocols for treating arrest patients as well as cessation of resuscitative efforts. Time of resuscitative effort and “downtime” are sometimes used to gauge progress and thus cease efforts when the patient does not appear to be responding to treatment. However, for patients who arrive in the ED in cardiac arrest, attempts at resuscitation often continue for prolonged periods of time and utilize considerable resources. Frequently, it is difficult to stop resuscitative efforts if electrical activity is still noted on a cardiac monitor or electrocardiogram.

An accurate method of predicting certain death in the ED would be beneficial in the decision making in cardiac arrest patients. Resources could be diverted elsewhere and a great deal of effort could potentially be saved. As bedside ultrasonography becomes more widespread in EDs, it is now possible to use real-time cardiac imaging during cardiac arrest. Previous authors have noted bedside ultrasound to be useful in differentiating fine ventricular fibrillation (VF) from asystole, thus altering their treatment.² Evaluation for pericardial effusion as the cause of pulseless electrical activity (PEA) has also been documented.³ Pericardial effusions can now be accurately diagnosed and quickly treated in appropriate ED patients.^{4,5}

The mechanism used to predict no chance for survival should be accurate and highly reproducible. Patients arriving pulseless in the ED may have a variety of etiologies for their conditions, including poor vascular tone due to sepsis, hypovolemia, or massive myocardial infarction. The patient with visible cardiac contractility might be recoverable with appropriate measures, while those whose myocardium has expended all of its metabolic resources and is at standstill are most

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likely hopeless. Bedside ultrasonography might be useful in stratifying patients into different risk groups, such as those with true asystole and those with contractility but absent pulse. Further, patients with electrical activity on a monitor may not actually have any mechanical contractility on echocardiogram and fall into a very high-risk group with almost no chance for survival.⁶

We have used bedside ultrasound as an aid in the resuscitation of cardiac arrest patients for more than seven years, and have empirically noted that patients with cardiac standstill upon arrival in the ED were much less likely to leave the department alive than patients with cardiac contractility, regardless of other modifying factors. Therefore, we hypothesized that asystole on echocardiogram signifies a uniformly poor outcome in ED resuscitations of cardiac arrest patients, regardless of electrical rhythm. We performed a prospective observational study to evaluate the outcome of patients with echocardiographically confirmed cardiac standstill.

METHODS

Study Design. This was a prospective observational study of patients presenting in cardiac arrest. The institutional review board approved the research with exemption from informed consent.

Study Setting and Population. The study included a convenience sample of patients presenting with ongoing cardiopulmonary resuscitation (CPR) between April 1999 and November 2000. This study was performed at a high-acuity urban community hospital ED. The department has an emergency medicine (EM) residency program and a volume of approximately 70,000 patients per year. The facility has a large population of patients with coronary artery disease and cardiac arrests are seen frequently. Resuscitative efforts for cardiac arrests are generally not stopped in the field and are brought into the ED for continued resuscitation.

The facility has an active ultrasound program in place with approximately 350 bedside ultrasound studies being performed in the ED each month. Emergency medicine residents receive regular didactic and hands-on training in ultrasound applications. An eight-hour basic ultrasound course is taught to all interns within their first month of residency. All EM residents take a two-to four-week ultrasound rotation in their second year of training. Thirty percent of ultrasound examinations are performed primarily by attending physicians. Forty percent of ultrasound examinations are performed by residents with immediate oversight by an attending physician. Residents

perform another 30% without attending physician supervision; these are performed by a senior resident who has undergone a one-month ultrasound elective. Ultrasound credentialing is provided through the department of EM.

Resident and attending emergency physicians (EPs) are present for all cardiac arrest patients arriving in the ED. Staff are notified by radio or telephone prior to patient arrival. In most cases, this allows an ultrasound machine to be moved to the room and set up prior to patient arrival. Multiple resuscitation rooms are available with full resuscitation equipment. Patients are treated per Advanced Cardiac Life Support protocol with cessation of treatment being decided by the attending physician supervising the resuscitation.

Study Protocol. All patients presenting in cardiac arrest, with ongoing CPR, were eligible for enrollment. Patients were enrolled on a convenience basis when a study physician was available. A rapid ultrasound examination was performed shortly after the patient was transferred to the ED bed and when pulses were checked. A single subxiphoid, four-chamber view was obtained. Parasternal views were used if an adequate subxiphoid window could not be obtained. Pertinent patient data were collected from paramedics and family when possible. Data collected included downtime, time down without CPR, time to emergency medical services (EMS) arrival, length of CPR, medications used, shocks administered, echocardiogram findings, final diagnosis, and disposition.

Echocardiograms were performed by ultrasound trained and credentialed EPs. Patients younger than 18 years of age were excluded from the study. Patients in arrest from trauma or obvious noncardiac causes were also excluded from the study. All ultrasound examinations were recorded on VHS tapes and reviewed by the ultrasound quality assurance (QA) committee. The QA committee meets on a weekly basis and reviews all ultrasound examinations from videotape and a written log. Feedback is given to all residents and faculty at regular meetings.

Measures. Standardized data sheets were used to collect patient data and history. Data were entered into a database. Ultrasound examinations were performed using an Aloka 2000 (Aloka, Inc., Tokyo, Japan). Imaging was done with 2.5-MHz curved-array and phased-array transducers.

Patients were believed to be in echocardiographic asystole if no myocardial contractions were seen for the duration of the pulse check. During resuscitation, this lasted from 5 to 10 seconds while the presiding physician checked for presence of carotid or femoral pulses. For patients who were

declared dead in the ED, the final echocardiographic check of the heart lasted for up to approximately 20 seconds. This ensured that in patients being declared dead with a rhythm of asystole, no infrequent myocardial beats were missed on echocardiogram.

Data Analysis. All patient information was entered into a Microsoft Access database (Microsoft Corporation, Redmond, WA). Data were analyzed using a commercially available statistical software package (Analyse-it, Analyse-it Inc., Leeds, Great Britain). Descriptive statistics, positive and negative predictive values, and likelihood ratios were calculated. Confidence intervals were performed on all groups.

RESULTS

One hundred seventy-three patients were enrolled into the study over the 20-month period of the study. Approximately 800 eligible patients were seen during this time. The heart was visualized using bedside echocardiography in all patients studied. Four patients were excluded from the final analysis. Two were found to have traumatic arrests once additional history was gathered from family and ambulance personnel. One patient had a severe drug overdose and the other was determined to be 16 years old, once family identified the patient. In 15 cases, the patient's downtime was unknown or thought to be derived at unreliably by the family or emergency medical personnel. Bedside ultrasonography was not believed to interfere with resuscitative efforts in any of the cases of cardiac arrest. However, this question was not queried in the formal data form. The presence of ultrasound at the bedside for these patients is standard practice for many EPs in the ED.

Mean downtime prior to arrival to the ED was 13.6 minutes (95% CI = 9 to 18 minutes, range = 2 to 44 minutes). Mean downtimes prior to ED arrival were 14.3 minutes (95% CI = 11 to 19 minutes) for the survival group and 13.3 minutes (95% CI = 12.1 to 17.5 minutes) for the nonsurvivors ($p = 0.72$). The mean length of resuscitation in the ED was 16.6 minutes (95% CI = 12.2 to 21 minutes, range = 1 to 28 minutes). For the survival group, the mean length of resuscitation in the ED was 15.1 minutes (95% CI = 11.1 to 19.6 minutes); and 17.1 minutes (95% CI = 13 to 22.3 minutes) for the nonsurvivors ($p = 0.17$). In the survivors, the end of resuscitation was defined as resumption of spontaneous circulation requiring no additional electrical shocks or medical intervention.

Mean patient age was 71 years (95% CI = 63 to 79.4, range = 32 to 97). Mean age for the survivors was 67.2 (95% CI = 59 to 78.9); that for the non-

survivors was 72.3 years (95% CI = 61.3 to 78.8) ($p = 0.4$). Mean time to EMS arrival on scene was 5.8 minutes (95% CI = 2.3 to 9.4 minutes). For the survivors, EMS arrived in 5.6 minutes (95% CI = 2.1 to 10 minutes), and for the nonsurvivors, mean time for EMS arrival was 5.9 minutes (95% CI = 2.3 to 9.2; $p = 0.75$).

Patients found to have cardiac standstill on initial echocardiogram had a mean age of 72.1 years (95% CI = 61 to 78.3), while those with myocardial contractions had a mean age of 68.4 years (95% CI = 59 to 79.6; $p = 0.12$). Mean downtime prior to arrival in the ED for patients presenting with cardiac standstill was 14.1 minutes (95% CI = 9.2 to 18.3 minutes); mean downtime prior to ED arrival for patients with myocardial contractions was 13.2 minutes (95% CI = 7.1 to 17.9 minutes; $p = 0.29$).

Of the 169 study patients, 20 (11.8%, 95% CI = 7% to 17%) survived to leave the ED. Due to the focus of this study, and the amount of data already available on survival to hospital discharge for cardiac arrest patients, we made no attempt to follow all patients who left the ED alive. Of the 20 patients surviving to hospital admission, none were found to have cardiac standstill on bedside echocardiogram at presentation to the ED.

No patient seen to have asystole on initial electrocardiogram or rhythm strip had myocardial contractions identified by ultrasound (Table 1). Sixty-five (38%; 95% CI = 31% to 46%) patients presented with asystole on initial electrocardiogram or rhythm strip. Thirty-eight (22%; 16% to 29%) presented with PEA as the initial finding. Sixty-six patients (39%; 95% CI = 32% to 47%) had an initial rhythm of ventricular fibrillation on presentation.

Of the 20 patients who survived, eight (40%; 95% CI = 22% to 61%) arrived in ventricular fibrillation. The 12 remaining survivors presented in PEA (Table 2). Of the patients with PEA and contractions on ultrasound, 67% (12/18) survived to leave the ED. For patients with ventricular fibrillation with visible myocardial contractions, 53% (8/15) survived to leave the ED. Cardiac standstill on initial echocardiogram in patients presenting with ongoing CPR resulted in a positive predictive value of 100% for death in the ED and a negative predictive value of 58%. The positive likelihood ratio was calculated to be at infinity, and the negative likelihood ratio was 0.17.

DISCUSSION

Out-of-hospital cardiac arrests carry a high rate of mortality, with outcome being influenced at least in part by underlying disease, bystander CPR, and time to EMS response.⁷ In some municipalities, cardiac arrests are run and when appropriate terminated in the field by trained paramedics with established protocols. However, in many locations

patients in cardiac arrest, even with ongoing CPR, are brought to the ED for continued management.

Resuscitation of a patient in cardiac arrest requires a great deal of time and ED resources. The dilemma with patients presenting with ongoing CPR is when to cease unsuccessful resuscitative efforts. Departmental guidelines are often based on the duration of CPR. Resuscitation efforts on patients who arrive pulseless and with no cardiac electrical activity may be quickly stopped if there is no response to therapy; however, this decision is variable, depending on the comfort level of the EP.⁸ Studies do not seem to uniformly agree that this subset of patients has no chance of survival.⁹⁻¹²

While some EPs may feel comfortable ceasing all efforts in these patients shortly after arrival, this decision is more challenging as the arrest team struggles to regain a pulse and blood pressure in patients presenting with electrical cardiac activity. The presence of a rhythm on cardiac monitor was cited as one of the most important factors used by EPs to decide whether continuation of resuscitative efforts is warranted.⁸ The same study found that despite knowledge of previously published criteria defining poor outcome, many EPs routinely initiate or continue resuscitative efforts on most cardiac arrest victims.

Prior to this study, it was observation that our colleagues are almost uniformly more comfortable ceasing resuscitative efforts when they are able to visualize a still heart on ultrasound examination. Perhaps it is this actual visualization that might remove the uncertainty EPs feel when using more nebulous criteria, such as electrical rhythm or response to initial medical management. Development of uniform and accurate criteria for cessation of futile resuscitative efforts could potentially save the medical system and society considerable resources. In busy EDs, halting futile efforts early may free up precious resources for those who are likely to have a better outcome.

Many patients who suffer out-of-hospital cardiac arrest are found to have PEA upon EMS arrival. These patients tend to have a poor prognosis with a low rate of survival compared with those found to be in ventricular fibrillation.¹³ One observational study found that, of all out-of-hospital cardiac arrests, 22% were found to have PEA. Of

TABLE 1. Electrocardiographic Rhythm versus Initial Echocardiographic Findings

Electrocardiographic Rhythm	Cardiac Standstill	Mechanical Contractions
Asystole	65 (38%)	0
Bradycardia/normal (PEA*)	20 (12%)	18 (11%)
Ventricular fibrillation	51 (30%)	15 (9%)

*PEA = pulseless electrical activity.

these, 16% left the ED alive and only 2% lived to hospital discharge.¹³

Bedside emergency echocardiography has been used to evaluate cardiac arrest patients. One study revealed that electromechanical dissociation was largely a misnomer in pulseless patients presenting in arrest, as 86% of patients with electrical activity actually had myocardial contraction on echocardiogram.¹⁴ Although not specifically evaluating outcome based on echocardiogram findings, the only patient in this study with electrical activity but no myocardial contractions who survived arrived in the ED with a viable rhythm and blood pressure, but became asystolic transiently during resuscitation.

Van Der Wouw et al. attempted to evaluate echocardiography as an aid in the resuscitation of cardiac arrest patients and evaluated 48 patients receiving CPR, 20 of whom were in cardiac arrest on arrival in the ED.¹⁵ Each patient was studied with transesophageal echocardiography during resuscitation. Approximately 25% of the patients presented in electromechanical dissociation and another 25% with asystole on initial rhythm strip. Although giving few details, the authors believed that they were able to make some prediction as to survival probability with those patients who have correctable causes of arrest, such as tamponade or myocardial infarction.

In another echocardiographic observational study of patients receiving CPR, Varriale and Maldonado studied 18 in-hospital and two ED cardiac arrest patients with either surface or transesophageal echocardiography.¹⁶ The electrical rhythm was asystole for more than 50% of patients. The remainder suffered either extreme bradycardia or ventricular fibrillation. When echocardiographic findings were included, 35% of patients who had a

TABLE 2. Survival to Leave the Emergency Department for Patients Based on Initial Rhythm and Echocardiographic Findings*

	Electrocardiographic Asystole & Sandstill	PEA & Standstill	PEA & Contractions	VF & Standstill	VF & Contractions
Survived	0	0	12 (67%)	0	8 (53%)
Died	65 (100%)	20 (100%)	6 (33%)	51 (100%)	7 (47%)

*Standstill = sonographic asystole; PEA = pulseless electrical activity; contractions = mechanical contractions on echocardiogram; VF = ventricular fibrillation.

definitive electrical rhythm actually had complete cardiac standstill. Only one of these cardiac standstill patients, who had an in-hospital arrest, survived to discharge.

The predictive value of bedside echocardiography in ED arrests has been briefly described.⁶ The authors noted that patients presenting with cardiac standstill on ultrasound did not survive the arrest. Although the sample of patients studied was also modest, the results of the study are consistent with our findings. Most importantly, the electrical rhythm on monitor or ECG did not matter in final outcome when cardiac standstill was noted on the ultrasound examination.

It has been previously suggested that some patients presenting with PEA have good mechanical contractions of the heart, but that these are too weak to generate a palpable pulse. This subset of patients may be especially amenable to simple interventions such as volume resuscitation as well as inotropic support.^{14,17} It could be postulated that patients experiencing cardiac standstill (despite the presence of electrical activity, as opposed to those having some myocardial contraction) fall into a distinctly different risk group. While patients in both groups may be unlikely to survive to discharge, the patient arriving in the ED with cardiac standstill is more likely to have exhausted myocardial reserve and thus successful resuscitation is impossible, despite the presence of electrical activity on monitor. Our data seem to support this notion, as no patient with cardiac standstill survived to leave the ED, regardless of his or her presenting rhythm.

This observation, if supported in larger studies, may in the future be added to the criteria used to limit resuscitation efforts for cardiac arrest patients who arrive with an unknown downtime and are seen to be asystolic on echocardiogram, but have organized electrical activity on the cardiac monitor. Halting all resuscitation efforts shortly after visualization of the heart in these cases could save manhours and hospital resources. Our finding of uniform poor outcome in patients found to be in cardiac standstill on echocardiogram also has potential implications for out-of-hospital care. The use of progressively smaller and less expensive ultrasound equipment may, in the future, be explored in the out-of-hospital setting.

LIMITATIONS AND FUTURE QUESTIONS

This study has several limitations. Most significant is the relatively small sample size. The study was not blinded. However, study investigators were often not involved in the actual resuscitation. There was no randomization into different groups for comparison. Patients did not receive formal

echocardiograms; however, all taped examinations were reviewed later for accuracy.

The accuracy of information reported by family or ambulance personnel could not be verified, and it is possible that reported times were inaccurate in some cases. Demographic data, CPR times, and transportation times were similar for survivors and nonsurvivors. However, our modest sample size limits our ability to draw the conclusions regarding small to moderate difference in any of these factors between our two study groups. We did not determine whether bedside ultrasonography was thought to have the potential to interfere with acute resuscitation efforts. However, it is our experience from our work in eight different institutions that ultrasound has not posed a hindrance to patient resuscitation in any of those settings, when appropriate equipment and training are available.

Future studies are warranted regarding the use of ultrasound to assist in the decision to cease resuscitation efforts in patients in cardiac arrest. Such studies should include multiple centers with heterogeneous patient populations, and EPs with all levels of ultrasonography experience.

CONCLUSIONS

In this study, patients presenting to the ED with cardiac standstill on bedside emergency ultrasound uniformly did not survive to leave the ED regardless of initial electrical rhythm on monitor or resuscitative efforts. These data suggest that resuscitation efforts may be halted early when cardiac standstill is seen on echocardiogram in arriving cardiac arrest patients. However, before any widespread alteration of clinical practice should be considered, larger studies are needed.

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