# Variability in Interpretation of Cardiac Standstill Among Physician Sonographers

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**Study objective:** Cardiac standstill on point-of-care ultrasonography has been widely studied as a marker of prognosis in cardiac arrest. Return of spontaneous circulation has been reported in as few as 0% and as many as 45% of patients with cardiac standstill. When explicitly documented, the definition of cardiac activity in these studies varied from any slight change in echogenicity of the myocardium to any kinetic cardiac activity. We hypothesize that the variability in research definitions of cardiac activity may affect interpretation of video clips of patients in cardiac arrest. The goal of this study is to assess the variability in interpretation of standstill among physician sonographers.

**Methods:** We surveyed physician sonographers at 6 conferences held at 3 academic medical centers in the Greater New York area. Survey respondents were allotted 20 seconds per slide to determine whether each of 15 video clips of patients in cardiac arrest were standstill or not. Data were collected anonymously with radio frequency remotes.

**Results:** There were 127 total participants, including faculty, fellows, and resident physicians specializing in emergency medicine, critical care, and cardiology. There was only moderate interrater agreement among all participants ($\alpha$=0.47). This lack of agreement persisted across specialties, self-reported training levels, and self-reported ultrasonographic expertise.

**Conclusion:** According to the results of our study, there appears to be considerable variability in interpretation of cardiac standstill among physician sonographers. Consensus definitions of cardiac activity and standstill would improve the quality of cardiac arrest ultrasonographic research and standardize the use of this technology at the bedside. [Ann Emerg Med. 2017;■:1-6.]

Please see page XX for the Editor's Capsule Summary of this article.

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SEE EDITORIAL, P. XXX.

## INTRODUCTION

### Background

Because early studies showed no survivors of cardiac standstill on point-of-care ultrasonography, it has been widely adopted for prognostic use in arrest as an alternative to end tidal $CO_2$ ($ETCO_2$) monitoring, duration of cardiopulmonary resuscitation (CPR), and clinical gestalt, each of which has limitations.[1,2] The 2010 American Society of Echocardiography and American College of Emergency Physician consensus statement explicitly recommends point-of-care echocardiography to guide termination or continuation of resuscitative efforts.[3] Out-of-hospital providers are increasingly using ultrasonography for futility determination.[4] Although a recent meta-analysis questioned the utility of cardiac standstill, studies to date have had widely varying outcomes and have not used a uniform definition (Table 1), and none have reported survivors to discharge or neurologic outcomes.[5,6]

### Importance

Delineating the utility of cardiac standstill in cardiac arrest is critically important. Objective measures of prognosis in arrest allow focus of limited resources on where they are most likely to benefit patients. Imprecise definitions in previous studies may have led to variability in the interpretation of standstill and the resultant reported outcomes.

### Goals of This Investigation

In this study, we sought to determine the degree of variability in interpretation of cardiac standstill among physicians who have access to point-of-care ultrasonography in their practice.

## MATERIALS AND METHODS

### Study Design and Setting

This was a cross-sectional convenience sample survey of physicians who have access to point-of-care

**Editor's Capsule Summary**

*What is already known on this topic*

Emergency physicians often use bedside ultrasonography to guide termination or continuation of cardiopulmonary resuscitation. Its utility may be limited by variability in the interpretation of cardiac standstill.

*What question this study addressed*

Using 6-second sonographic clips from a convenience sample of 15 pulseless arrests, the authors examined the interrater reliability of 124 physician ultrasonographers in detecting or excluding cardiac standstill. Physicians were not told the rhythm.

*What this study adds to our knowledge*

Physicians exhibited only moderate agreement in their assessments of cardiac standstill. Disagreement was greatest in cases with valve flutter with weak or no cardiac contraction, cardiac movement caused by mechanical ventilation, and profound bradycardia. Agreement was greatest in cases with strong or absent contractions, or with ventricular fibrillation.

*How this is relevant to clinical practice*

Variability in interpretation potentially undermines the use of sonographic assessment of cardiac standstill and suggests the need for clarification on the definitions and assessment of cardiac arrest.

ultrasonography in their practice. All study procedures were reviewed and exempted by the institutional review board of participating medical centers.

### Selection of Participants

Survey respondents were recruited during a 9-month period at 6 conferences held at 3 Greater New York area academic medical centers: the Icahn School of Medicine at Mount Sinai, Beth Israel Medical Center, and St. Luke's–Roosevelt Hospital. The conferences were emergency medicine weekly conferences at each of these centers, the Icahn School of Medicine ED-ICU combined ultrasonographic rounds, the St. Luke's–Roosevelt City Wide Ultrasound Rounds, and the NYC Resuscitative Ultrasound rounds at Beth Israel Medical Center. Attending these conferences were physicians who practice in public and private academic hospitals who had access to ultrasonography at the point of care in their practices. Eligible residents, fellows, and faculty from the specialties of emergency medicine, critical care, and cardiology were invited to participate. Attendees who had participated at an earlier conference were excluded. We did not collect data on conference attendees who elected not to participate.

### Methods of Measurement

At each of 6 meetings, a study investigator introduced the study with a brief presentation on the existing literature on the prognostic use of cardiac standstill on point-of-care ultrasonography. Cardiac standstill was defined only as the absence of cardiac activity. No definition of cardiac activity was given, but participants were made aware of the variability of definitions that appear in the literature. Physicians who agreed to participate were given remote polling devices (RCRF-02; TurningPoint ResponseCard RF; Turning Technologies, Youngstown, OH), and several multiple-choice primer slides were presented to familiarize participants with the audience response system used to collect data. Responses were transmitted wirelessly from these remotes to a receiver and collected in a TurningPoint database (versions 5.2 and 5.3; Turning Technologies) on the computer used for the presentation. No identifying information was transmitted or collected during this study, other than specialty (emergency medicine, critical care, and cardiology), training level (resident, fellow, and attending physician), and self-reported ultrasonographic skill level (none, basic, advanced, and expert).

Data collection with the remote polling devices was performed on subsequent slides in the same presentation. Slides with multiple-choice questions collected the following demographics: specialty, level of training, and self-reported level of ultrasonographic proficiency. Participants were then given this clinical scenario for the final 15 slides: "Your patient is a 55-year-old man in cardiac arrest who remains pulseless after 20 minutes of CPR." These question slides (Appendix E1, available online at http://www.annemergmed.com) consisted of 6-second deidentified clips of patients in pulseless arrest, obtained from our quality assurance database. Fifteen clips were chosen to reflect a range of sonographic cardiac findings that may be observed in arrest (Videos E1 to E15, available online at http://www.annemergmed.com). This was the cohort of clips we intended to analyze, understanding that there would be variability in that group, including absent cardiac activity, weak cardiac activity, strong cardiac activity, valve flutter, ventricular fibrillation, and even simply motion caused by bag-valve-mask ventilation. The clips used for this study were obtained from either a SonoSite M-Turbo with P21 phased-array or C60 curvilinear probes (SonoSite, Inc., Bothell, WA) or Mindray M7 Machine with the P4-2s phased-array probe (Mindray DS USA Inc, Mahwah, NJ).

**Table 1.** Definitions of cardiac activity from the existing literature.

| Study | Definition of Cardiac Activity |
|---|---|
| Bocka JJ, 1988[11] | "Synchronous change in chamber diameter" or "synchronous change in the echocardiographic density of the myocardium" |
| Blaivas M, 2001[1] | "Visible cardiac contractility" |
| Salen P, 2001[12] | Not defined. Mentions "contractions" in "Results" section. |
| Tayal VS, 2003[2] | "Presence of ventricular wall motion" |
| Salen P, 2005[13] | "Any detected motion within the heart: atrial, valvular or ventricular" |
| Schuster KM, 2009[14] | "Organized contractile activity with a decrease in chamber size" |
| Breitkreutz R, 2010[15] | "Cardiac motion" |
| Tomruk O, 2012[6] | Not defined |
| Bolvardi E, 2016[16] | "Presence of any heart activity including the ventricles, galleries, valves, etc" |

Each 6-second clip was looped for 20 seconds total, during which participants were asked to select whether each clip demonstrated cardiac standstill or not. At 20 seconds, polling for that clip was closed and polling on the next clip was started. The format and timing of the interpretation of these clips are consistent with those in our clinical practice. Our machines are preset to record 6-second retrospective clips and to loop them on the screen when the "clip" button is pressed. We minimize any interruption to CPR by obtaining 6-second subxiphoid or parasternal long-axis clips during a rhythm check and review the looping clip while chest compressions resume. We did not seek to assess whether providers could make a determination of termination of resuscitation, which would usually include other information such as length of resuscitation, monitor rhythm, $ETCO_2$ pressure, arterial line pressure, and cerebral oximetry. Similarly, providers managing a patient in arrest have the benefit of obtaining multiple views and spending more time analyzing looped clips during an arrest. The purpose of our study was simply to determine whether there is agreement in regard to interpretation of cardiac activity on a single clip of point-of-care ultrasonography in arrest.

### Outcome Measures

The primary outcome measure was the variability in interpretation of cardiac standstill among all respondents. Secondary outcomes measured included variability among the subgroups of specialty, training level, and self-described point-of-care ultrasonographic experience level.

### Primary Data Analysis

We assessed interrater reliability among physician sonographers and by subgroup, using Krippendorff's $\alpha$ coefficient. This statistical variable is similar to Fleiss's $\kappa$, but rather than measuring observed and expected agreement, it measures observed and expected disagreement. Krippendorff's $\alpha$ is thought to be more reliable, especially in situations with missing data points, as occurs frequently in survey research. Data analysis was performed in the R statistical computing language with use of the "irr" package for interrater reliability to compute Krippendorff's $\alpha$. We did not assess intrarater reliability.

## RESULTS

### Characteristics of Study Subjects

We surveyed 127 physician sonographers, composed of faculty, fellows, and residents from the specialties of emergency medicine, critical care, and cardiology. The most represented specialty was emergency medicine (74%); training level was resident (63%) and self-reported ultrasonographic experience was basic (54%). Comprehensive demographics are listed in Table 2.

We excluded from subgroup analysis respondents who did not register the demographic information for that subgroup. Fourteen respondents did not register a specialty and 12 did not register a training level. We excluded from the subgroup analysis of self-reported ultrasonographic experience 5 respondents who did not provide an experience level and 10 who reported none. Of the respondents who reported no ultrasonographic experience, 4 were residents, 2 were fellows, and 4 did not respond with their specialty. Although we cannot be certain, these likely represented incoming interns and fellows who had received introductory instruction in point-of-care ultrasonography but did not have enough experience to consider themselves basic users.

**Table 2.** Demographics and agreement of respondents.

| Characteristics | N | % | $\alpha$ | Agreement |
|---|---|---|---|---|
| **Specialty** | | | | |
| Emergency medicine | 94 | 74 | .49 | Moderate |
| Critical care | 15 | 12 | .40 | Fair |
| Cardiology | 4 | 3 | .43 | Moderate |
| Did not answer | 14 | 11 | NA | NA |
| **Training level** | | | | |
| Resident | 80 | 63 | .45 | Moderate |
| Fellow | 11 | 9 | .55 | Moderate |
| Attending | 24 | 19 | .44 | Moderate |
| Did not answer | 12 | 9 | NA | NA |
| **Self-reported ultrasonographic skill level** | | | | |
| None | 10 | 8 | NA | NA |
| Basic | 68 | 54 | .43 | Moderate |
| Advanced | 37 | 29 | .53 | Moderate |
| Expert | 7 | 6 | .44 | Moderate |
| Did not answer | 5 | 4 | NA | NA |

*NA*, Not applicable.

## Main Results

Among all 127 participants, there was only moderate interrater agreement ($\alpha$=.47). The Figure demonstrates this variability in agreement across the 15 ultrasonographic clips. Certain clips, such as 2, 5, 6, 7, 9, 10, and 15, resulted in stronger agreement whether for cardiac standstill or the presence of cardiac activity. Clips 1, 3, 4, 8, 11, 12, and 13, with subtler findings, resulted in larger percentages of respondents favoring contradictory interpretations. For clips with worse agreement, valve flutter with no or weak myocardial contraction was present in 5 cases, movement caused by mechanical ventilation was observed 3 times, weak myocardial contraction was observed twice, and profound bradycardia with strong myocardial contraction was observed once. Clips with better agreement were characterized largely by strong myocardial contractions or no myocardial contraction, with one example of ventricular fibrillation. There were fewer missed responses in cases with better agreement (mean=9; N=66) than cases with worse agreement (mean=4; N=28), suggesting, as would be expected, that there may have been less provider confidence when more difficult cases were interpreted (Mann-Whitney $U$=0.02).

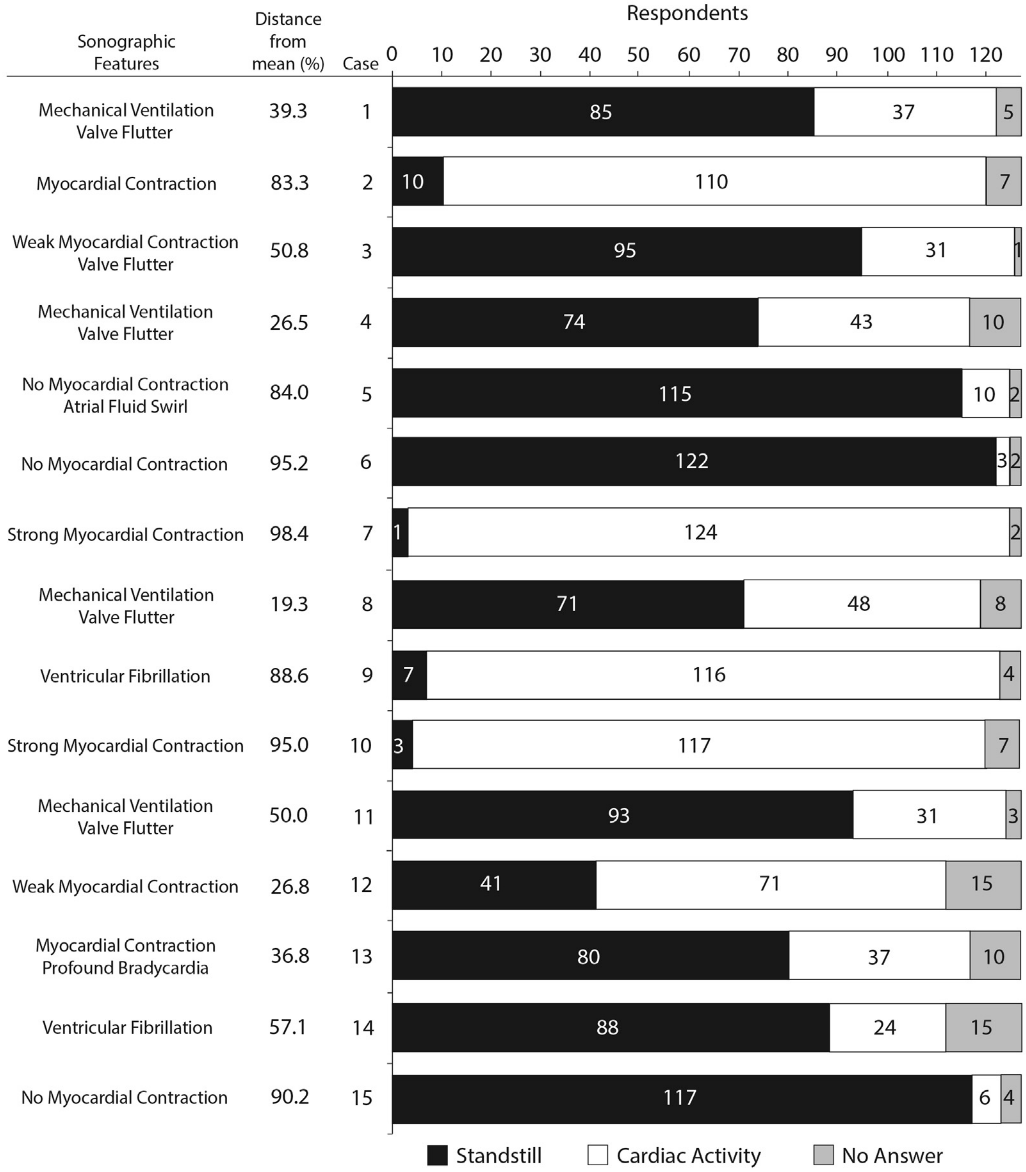


**Figure.** All survey responses. Cases with more disagreement have larger areas of both colors. *VENT*, Mechanical ventilation; *VALVE*, valve flutter; *MC*, myocardial contraction; *WMC*, weak myocardial contraction; *NMC*, no myocardial contraction; *FLUID*, atrial fluid swirl; *SMC*, strong myocardial contraction; *VFIB*, ventricular fibrillation; *BRADY*, profound bradycardia.

Regardless of specialty, training level, or ultrasonographic experience, all subgroups had only moderate interrater agreement, with the exception of critical care physicians, who had fair agreement. Among subgroups, fellows had the highest agreement (moderate; $\alpha$=.55) and critical care physicians had the lowest agreement (fair; $\alpha$=.40). Our response rate was 95% (1,810 responses out of 1,905 possible respondent clip evaluations) for the entire cohort. Respondents were unable to make a decision about whether a clip was standstill or not within the 20-second time limit for only 5% of possible responses. Cases averaged 120.7 responses (SD=4.5), with a range of 112 to 126 responses.

## LIMITATIONS

This study was subject to the limitations of any cross-sectional convenience sample survey. Our selection of respondents was nonrandom because we recruited at 6 academic conferences of point-of-care ultrasonographic users in the Greater New York area who may have differed from the average point-of-care ultrasonographic user. We attempted to minimize convenience sampling bias by repeating the study at multiple regional conferences to capture as many eligible providers as possible. Approximately half of our respondents reported a basic level of ultrasonographic skill, which may have skewed the overall analysis toward more disagreement. However, our subgroup analysis found no better agreement among self-reported advanced or expert users. This large layer of basic respondents may, in fact, represent well the majority of physicians using ultrasonography who have not undergone advanced training.

We selected a range of clips intended to represent the variety of findings we have encountered in our practice. However, we do not know the true incidence of each of these findings in patients with cardiac arrest. Therefore, our results may not be easily generalizable to the larger population of patients in cardiac arrest. It is also possible that in the conference rooms used for the study, clips projected differently than they would have appeared to point-of-care users when they were obtained. We did not measure this difference, but subjectively believe there was no significant degradation in image quality. Finally, because participants were not isolated from one another, communication and discussion among them may have occurred. However, this would be more likely to inflate rather than decrease agreement.

## DISCUSSION

Our results support the possibility that previous studies have been subject to variability in the interpretation of cardiac standstill. The physicians we surveyed had widely varying interpretations of clips of patients in cardiac arrest. Among all of our respondents, there was only moderate agreement about whether a particular clip reflected cardiac standstill. Clips with the least agreement were characterized by one or more of the following: valve flutter, mechanical ventilation, weak myocardial contraction, or profound bradycardia. Finding valve flutter in 5 of the most disagreed-on clips is not surprising because previous authors have used definitions that differ in regard to whether valvular motion represents myocardial activity. It is easy to conceive how mechanical ventilation, bradycardia, and subtle wall contraction may lead to disagreement. Interpreting the finding of faint but present cardiac activity (pseudo–pulseless electrical activity) as standstill would result in the incorrect finding of more survivors of standstill. These patients with pseudo–pulseless electrical activity are by definition in profound circulatory failure and benefit the most from aggressive resuscitation.[7,8] In the future, for these subtle cases, transesophageal echocardiography may provide better assessment of transthoracic findings, decreasing variability in interpretation.[9]

Decreasing variability of interpretation of standstill is central to the use of ultrasonography in futility determination. The goal of resuscitation is not simply return of spontaneous circulation, the outcome used in studies to date. The true goal of cardiac arrest resuscitation is meaningful survival or Negovsky's "reanimation," the restoration not just of cardiac activity but also of the mind and spirit.[10] To our knowledge, no cardiac standstill study to date has reported survivors leaving the hospital and no mention has been made of neurologic outcomes.[1-5] Considering the reported outcomes to date, the risk of misinterpreting cardiac standstill does not appear to be missed saves because no neurologically intact survivors to hospital discharge have been reported, to our knowledge. The greater risk may be placing patients, providers, and systems at risk when providers attempt to return circulation to a patient who will not survive to discharge with any significant neurologic function.

According to the results of our study, there appears to be considerable variability in the interpretation of cardiac standstill among physician sonographers. A clear and consistent definition of cardiac activity and standstill would improve the quality of cardiac arrest ultrasonographic research and standardize the use of this technology at the bedside. Future studies of cardiac standstill may investigate further the sonographic features that lead to disagreement in cardiac arrest and ought to include the publication of clips of survivors of standstill from which the academic community can learn.

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