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Finding a window: timing of cardiac ultrasound acquisition during cardiac arrest

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Point-of-care cardiac ultrasound (POCUS) use during cardiac arrest remains a controversial issue due to conflicting opinions regarding its utility and potential harms. Some prior investigators have found that intra-arrest ultrasound findings can help with guiding management.[1-4] Several small observational studies have also found that cardiac standstill, especially when persistent in spite of several minutes of resuscitation, is associated with near 100% mortality, suggesting utility for prognostication. [5, 6] A systematic review however found that, even with cardiac standstill, return of spontaneous circulation does still occur on occasion, cautioning against using this finding in isolation to guide decisions regarding termination of resuscitation efforts.[7] Supporting the use of caution, a study in the past year found only moderate levels of agreement between ultrasound readers in determining when cardiac standstill was present.[8] Due to the lack of evidence showing any effect of POCUS on cardiac arrest outcomes, the International Liaison Committee on Resuscitation was unable to recommend for or against its use during cardiopulmonary resuscitation (CPR) in 2015. They concluded that it is however reasonable to use if qualified personnel are present to perform it and can do so without interfering with timely, high quality chest compressions. [9, 10]

Due to the lack of a clear benefit, some investigators have begun to focus more explicitly on whether POCUS use during CPR may cause harm by interrupting chest compressions. Two observational studies published recently in this journal, both of which were based on observations of video recordings done as routine monitoring in resuscitation bays in tertiary care medical centers, found significant increases in the duration of rhythm checks when POCUS was used, with pauses well beyond the recommended maximum of 10 seconds.[11, 12] As high quality chest compressions are one of the few interventions known to improve survival, this is clearly concerning, but the many observational studies suggesting that POCUS can help guide treatment and decision making make it hard to abandon this imaging modality entirely as a clinical tool.

The quandary of potential harm from an intervention that is hoped, but not proven, to be beneficial is perhaps what inspired the recent work by Aagaard and colleagues, which appears in this issue of *Resuscitation*. [13] In this study, the investigators asked anesthesiologists who had been trained in basic POCUS techniques to obtain subcostal

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ultrasound images during CPR for any in-hospital cardiac arrest they attended. They obtained images during 3 phases of resuscitation: chest compressions, mask ventilations and pauses for rhythm checks. Participants saved the images they thought would be better quality, but were asked to save at least one from each phase. Images were reviewed at a later time by both senior anesthesiologists and by cardiologists who were experts in echocardiography. The echocardiography experts were blinded to the phase of resuscitation and viewed images on computers with specific software designed for ultrasound viewing. The anesthesiologists also assessed the images, but were not blinded to phase of resuscitation and viewed images on the screen of the portable ultrasound device that had been used.

The primary endpoint was the percentage of images deemed useful for interpretation by the echocardiography experts in each phase of resuscitation. Usefulness was defined as being good enough to show at least one of the following: whether the right ventricle was larger than the left, whether pericardial fluid was present, or whether the ventricles were collapsing. The anesthesiologists' assessments of the same criteria were evaluated as a secondary outcome. Other secondary endpoints included the percentage of "useful" images that showed a positive finding and the percentage that showed a pericardial effusion greater than 1cm. Finally, an intensive care specialist reviewed all patient records to attempt to determine the cause of cardiac arrest. They did not attempt to correlate these causes of arrest with ultrasound findings.

The investigators found that of all the images saved, 65-75% were useful for interpretation in the rhythm check and mask ventilation phases (not significantly different between phases), compared to only 47-58% during chest compressions. For an individual patient, at least one useful image was obtained during rhythm checks in 70% of patients, compared to 52% and 48% of patients during mask ventilation and compressions, respectively. Similar differences between phases were seen in the anesthesiologists' assessment, but absolute percentages were somewhat lower across the board. Of note, each ultrasonographer obtained multiple images per arrest, and later images were more likely to be useful than the first few obtained for each patient.

The authors assessed the usable images for the frequency of findings suggestive of possible causes of arrest and did a clinical assessment of causes of arrest based on the medical record, but did not attempt to correlate these. The study was likely too small for such correlations to be meaningful, but it is intriguing, for example, that collapsible ventricles, classically taught as a sign of hypovolemia, were not noted on any of the images even though hypovolemia was thought clinically to be the cause of arrest in 17% of cases. Notably, doubt has been cast on whether ultrasound findings during cardiac arrest can be interpreted in the same way as non-arrest echo findings. Some of the same authors from this group have reported previously, in a porcine model of cardiac arrest, that right ventricular dilation is common in all causes of arrest (although more extreme in pulmonary embolism) and can be seen in hypovolemic arrest instead of collapsing ventricles. [14, 15] Thus, the absence of collapsing ventricles on POCUS may not contradict the clinical assessment of hypovolemia as a cause.

These findings suggest that although images during mask ventilation may not be obtainable in as many patients, if images can be obtained they are likely to be of as good quality as those obtained during rhythm checks. The authors therefore suggest that time used for mask ventilations may be an opportunity to obtain POCUS images during resuscitation, in addition to the times allowed by rhythm checks.

The clinical applicability of these findings will vary by institution. Although it appears that at the investigators' institution compressions are stopped during mask ventilation, this is not true at all centers. The recent CoSTR from ILCOR states that either approach (30:2 compression:ventilation ratio or continuous compressions while administering 10 breaths per minute by bag mask) in the pre-intubation phase is acceptable.[16] In medical centers where compressions are held for breaths however, utilizing those brief pauses to obtain images may be helpful.

In summary, POCUS during cardiac arrest continues to be appealing in its potential to help us find a treatable cause to save someone's life, or even to identify when we should stop resuscitative efforts. This potential has not yet, however, been definitively realized. Efforts such as those reported here, aimed at enabling clinicians and researchers to continue to use POCUS during cardiac arrest without harming patients are therefore important as a means of bringing us closer to a verdict on the benefit of POCUS in the cardiac arrest setting without jeopardizing patient safety.

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