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Review

# Accuracy of point-of-care focused echocardiography in predicting outcome of resuscitation in cardiac arrest patients: A systematic review and meta-analysis☆

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ABSTRACT

*Objective:* We aim to summarize current evidence on the value of point-of-care (POC) focused echocardiography in the assessment of short-term survival in patients with cardiac arrest.
*Methods:* PubMed and EMBASE were searched from inception to July 2016 for eligible studies that evaluated the utility of POC echocardiography in patients with cardiac arrest. Modified QUADAS was used to appraise the quality of included studies. A random-effect bivariate model and a hierarchical summary receiving operating curve were used to summarize the performance characteristics of focused echocardiography.
*Results:* Initial search identified 961 citations of which 15 were included in our final analysis. A total of 1695 patients had POC echocardiography performed during resuscitation. Ultrasonography was mainly utilized to detect spontaneous cardiac movement (SCM) and identify reversible causes of cardiac arrest. Subcostal, apical and parasternal views were used to identify cardiac tamponade, pulmonary embolism, and pleural view for tension pneumothorax. Results of meta-analysis showed that SCM detected by focused echocardiography had a pooled sensitivity (0.95, 95%CI: 0.72–0.99) and specificity (0.80, 95%CI: 0.63–0.91) in predicting return of spontaneous circulation (ROSC) during cardiac arrest, with a positive likelihood ratio of 4.8 (95% CI: 2.5–9.4) and a negative likelihood ratio of 0.06 (95%CI: 0.01–0.39).
*Conclusion:* POC focused echocardiography can be used to identify reversible causes and predict short-term outcome in patients with cardiac arrest. In patients with a low pretest probability for ROSC, absence of SCM on echocardiography can predict a low likelihood of survival and guide the decision of resuscitation termination.



## Introduction

Each year, approximately 359,400 patients developed out-of-hospital cardiac arrest (OHCA) in the United States.[1] Cardiac arrest is a medical emergency with a grave prognosis. Despite the wide implementation of structured Basic Life Support/Advanced Cardiac Life Support training and quality improvement activities, the outcome of patients with a non-shockable rhythm remained dismal.[1] Overall, less than 8% survived an OHCA. Compared to those with a shockable rhythm (survival rate: 40%), patients with a pulseless electric activity (PEA) has an even lower survival rate (6%).[2,3] The cornerstone for management of cardiac arrest patients with a non-shockable rhythm has been early correction of potentially reversible underlying causes. Reversible causes for patients

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with a non-shockable rhythm were diagnosed solely on clinical diagnosis.[4,5]

Recently, POC focused echocardiography has been used to aid in diagnosing correctable causes of cardiac arrest, prediction of outcome, and in the decision making of terminating resuscitation. Several protocols and trials have been proposed to investigate the potential roles of focused echocardiography during resuscitation.[6–11] Results of these trials are mixed due to non-standardized protocols and heterogeneous study populations. Additionally, there has been a growing interest in the use of POC focused echocardiography to predict short-term outcome and assist in the decision of resuscitation termination. Prompt termination of resuscitation could allow better utilization of healthcare resources. Previous meta-analysis addressing this issue were based on limited small sample-sized studies.[12] Recently, several sufficiently powered and well-designed studies have been published, justifying an updated systematic review and meta-analysis. The objective of this review is to perform a quantitative evaluation of the accuracy of POC focused echocardiography in predicting short-term outcomes in patients with cardiac arrest.

## Materials and methods

### *Data sources and searches*

The meta-analysis was performed in accordance with the Preferred Reporting Items for Systemic reviews and Meta-Analysis Guidelines and Meta-analysis of Observational Studies in Epidemiology guidelines.[13–15] General bibliographic databases (PubMed and EMBASE) were searched from inception to July 2016. The medical subject heading (MeSH) and text words for the term "Echocardiography" were combined with the MeSH term "Cardiopulmonary resuscitation". The search terms for the primary intervention included "emergency echocardiography", "focused echocardiographic evaluation", "critical care ultrasound" and " Ultrasound" and "Echocardiography". The search results were then crosschecked for the population of interest and searched using the terms, "cardiopulmonary resuscitation", "CPR", "Pre-hospital care" and "Advanced life support". The search was limited to human studies, and without publication date, or country restrictions. In addition to the electronic search, reference lists in all known reviews and primary studies were checked manually.

### *Selection criteria*

The study selection and data extraction were independently performed by two authors (PY Tsou and EH Chou). A uniformed search strategy was developed through a consensus meeting. Initial evaluation was based on screening of titles and abstracts. The second round of evaluation was based on full-text review. We included studies that evaluated transthoracic POC echocardiography on adult patients with cardiac arrest in prehospital or emergency department settings. We required the study reporting at least one of the following resuscitation outcomes: return of spontaneous circulation (ROSC), survival to hospital admission, or survival to hospital discharge. We excluded case reports, comments, reviews, guidelines and animal studies. Discrepancies between the reviewers were resolved by a consensus meeting initially and using arbitration by a third reviewer if consensus could not be reached.

### *Data abstraction and quality assessment*

Data were extracted for overall study characteristics, study design, settings, patient characteristics, sonographers' experience, type of ultrasound transducer, protocols of sonographic scanning, criteria for termination of resuscitation, initial cardiac rhythm, definition of various outcomes, and quantitative data required for construction of a $2 \times 2$ table. In studies that reported multiple pairs of sensitivity and specificity data, we consistently used the data with the highest Youden index (sensitivity + specificity $-1$). We used the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) tool to assess the methodological quality of the select studies before meta-analyses.[15] This tool evaluated the characteristics of study designs, population, index tests, and reference standards that may be associated with risk of bias.

### *Quantitative data synthesis*

We calculated the pooled sensitivity and specificity, and positive and negative likelihood ratios, along with the respective 95% confidence intervals (CIs) by different outcome, including return of spontaneous circulation (ROSC), survival to hospital admission, and survival to hospital discharge. Given the grave prognosis of cardiac arrest patients and the low likelihood of further transferring resuscitated patients in tertiary medical centers, the outcome "survival to ED discharge" reported in the included studies was replaced with "survival to hospital admission." A sensitivity analysis was conducted to determine the influence of the change in outcome definition on summary estimates. We used a bivariate model to derive summary effect estimates.[16] When $2 \times 2$ tables contained 0 cells, we performed continuity correction by adding 0.5 to each cell. We constructed a hierarchical summary receiver operating characteristic (HSROC) curve that plots sensitivity versus specificity and calculated the area under the curve (AUROC).[17] We evaluated the degree of between-study heterogeneity by using the $I^2$ test.[18] The presence and the effect of publication bias were examined using a combination of the Egger tests. A statistical analysis was conducted using the statistical package STATA (Version 11.0, Stata Corp, College Station, TX), notably with the user-written "midas" programs. All statistical tests were two-sided and statistical significance was defined as a P value less than 0.05.

## Results

### *Search results and study characteristics*

The flow of inclusion and exclusion is summarized in Fig. 1. Using our search criteria, we identified 961 studies, of which 437 were from PubMed and 524 from EMBASE database. A total of 928 citations were excluded based on pre-defined criteria. A total of 33 articles were retrieved for full-text review, and 18 were excluded due to various reasons detailed in Fig. 1, leaving a total of 15 studies for inclusion. These 15 studies evaluated the accuracy of outcome prediction by detection of SCM. The measurement of outcome for successful resuscitation varied with studies, including ROSC, survival to hospital admission, or survival to discharge.

### *Characteristics of included studies*

The 15 studies included a total of 1695 patients presenting in cardiac arrest. Table 1 lists the characteristics of the 15 studies. Ten studies were carried out in the emergency department,[19–28] 3 in the pre-hospital setting,[29–31] and 2 in both ED and prehospital.[32,33] Two studies recruited traumatic patients,[23,31] while seven studies recruited non-traumatic patients.[19,21,24,27–29,32] The remaining studies either used mixed populations or did not describe the details of patient recruitment. Seven studies have focused echocardiography conducted by an advanced performer.[20,22,23,26,28,30,32] Subcostal, apex, and parasternal views were adopted in most protocols.[19,21,22,24–30,32,33]