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The prognostic value of cardiac ultrasonography in patients with cardiac arrest

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ABSTRACT

Introduction: Echocardiography or cardiac imaging is proposed as a gold standard method for identifying high risk patients for cardiac arrest. In this systematic review, we studied the prognostic value of cardiac sonography in patients with cardiac arrest.

Methods: PubMed was searched for the relevant articles. Case reports were not included. Inclusion criteria were all the studies applied transthorasic echocardiography in patients with cardiac arrest arrived at emergency department that studied the efficacy of this modality on patients survived to emergency discharge and returned to spontaneous circulation.

Result: Overall, 870 articles were obtained through initial search and only nine articles were included after the evaluation of the title, abstract, and the full text. Echocardiography has high sensitivity and specificity in predicting the return of spontaneous circulation.

Conclusion: Cardiac sonography is a fairly effective (not definitive) modality in predicting death in patients with lack of cardiac activity during resuscitation. Echocardiography should not be the sole basis for the decision to cease resuscitative efforts.

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Introduction

Ventricular fibrillation and sustained ventricular tachycardia are two major sources of sudden cardiac death (SCD), which is known as a leading cause of mortality, especially in industrialized areas (1). Cardiac arrest leads to the absence of pulse and circulation, initially confirmed by pulse check despite its low sensitivity, specificity, and accuracy (2).

Based on one report, one cardiac arrest occurs each 12 minutes in Canada, which shows the high prevalence of this hearth condition (3).

This condition is a serious medical emergency with poor prognosis specifically in those that cardiac arrest occurs out of hospital. Nowadays various intervention strategies not only prevent such serious arrhythmias which lead to cardiac arrest, but also detect patients at high risks for cardiac failure (4).

Different factors could lead to inefficient cardiac contractions that some might be more reversible including hypo/hyperkalemia, hypovolemia, hypothermia, acidosis, cardiac tamponade, compared to more serious factors which might be associated with lower possibility of patient.

Rapid detection and management of the cardiovascular complication reverse the underlying cause, thus the possibility of patient survival will be increased.

Cardiopulmonary resuscitation (CPR) is frequent-

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ly performed at emergency department and is associated with poor prognosis. Precise guidelines are existed on how to deliver advanced life support at emergency departments, however there is not a lot to know regarding the time that resuscitation efforts can be stopped (5,6). Although, bystander CPR, duration of resuscitative efforts, initial electric rhythm, and age are proposed as accepted prognostic parameters, these criteria are not reliable to make a decision on stopping resuscitation efforts (7).

In emergency department, ultrasound could be used for ultrasound-guided interventions as a diagnostic tool which is noninvasive and rapid with high potential in revealing the patient's condition. Emergency physicians could perform transthoracic echocardiography or echo in life support during advanced life supports for patients with cardiac arrest (8).

Due to developed and advanced portable handheld battery-operated ultrasound systems, ultrasound could be performed in patients under prehospital conditions (9-11). The efficacy of this modality has been only studied in inhospital cardiac arrest.

Moreover, it is applying for controlling and managing serious conditions in emergency departments; some emergency departments use this modality routinely.

Echocardiography or cardiac imaging is proposed as a gold standard method for identifying high risk patients for cardiac arrest. Some studies has shown that performing transthoracic echocardiography could be beneficial in revealing effusions, right ventricular (RV) dilatation, a pulmonary embolus (PE) in arrest and periarrest states, presence or absence of ventricular wall motion (VWM) in pulseless electrical activity (PEA) conditions. Cardiac sonography might have a significant prognostic value in predicting outcome of in-hospital CPR patients.

In this systematic review, we studied the prognostic value of cardiac sonography in patients with cardiac arrest.

Methods

This a systematic review of literature is prepared based on preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement.

PubMed was used as the main database to search the most relevant articles. No time and language limitation were posed to the literature search, except definite search keywords which were as follow: (heart arrest OR cardiopulmonary resuscitation OR cardiopulmonary OR CPR OR cardiac arrest) AND (echocardiography OR ultrasonography OR echocardi* OR cardiac ultrasound OR cardiac ultrasonography OR TTE OR transthoracic echocardiography OR trans-thoracic echocardiography OR ultrasound OR sonogram) AND (prognos*).

Relevant articles were searched based on inclusion and exclusion criteria to prevent any bias and irrelevant issues. All the articles which studied the efficacy of performing transthoracic echo in patients with cardiac arrest undergoing CPR were eligible to be included in this review. Those which applied transesophageal echo and case reports were not included. Studies relevant to the review topic were first extracted based on title and abstract obtained through initial search, eventually the full texts of the articles were studied. References of the extracted articles were also studied to prevent missing any additional article.

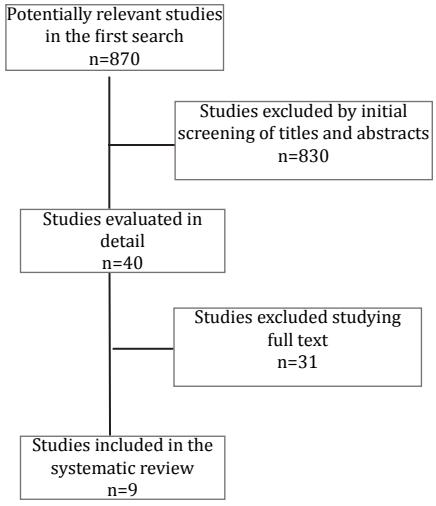
Results

Totally, 870 articles were retrieved following the initial search.

Overall, nine articles were included which consisted of 978 patients who underwent echo during cardiac arrest; relevant data are provided in Figure 1.

Detailed information of the included articles in this review and quality assessment of articles are presented in Table 1.

Figure 1. Flowchart of the included studies



In the study of Hayhurst et al., subxiphoid view and parasternal (long axis) view were the most applied views during performing echocardiography.

Discussion

Although detailed guidelines are provided on the exact resuscitation methods, the decision criteria for stopping these efforts are not clearly defined. Performing echocardiography to detect potentially reversible causes of cardiac arrest has previously been surveyed. Not only resuscitation of patients with PEA is associated with poor prognosis but also needs significant time and efforts (17).

Table 1. Detailed information of the included studies

Author Year Reference	Patients	US[1] method	Findings	Same intervention for all the patients? Described selection criteria?
Hayhurst 2011 (12)	n=50 adult patients in traumatic and nontraumatic arrests	Subxiphoid view: 80% Parasternal view (40%) Primary view obtained was xiphoid using a curvilinear probe with the option to proceed to another window using either a curvilinear or a phased array probe	Cardiac activity: 20(40%) ROSC[2]: 11/20 ED[3] discharge: 4/20 Pericardial Effusion: 3(6%) Further intervention due to ultrasound: 7(14%)	Y/Y[4]
Aichinger 2012 (13)	n = 42 Nontraumatic arrests Nonconsecutive sample Mean age:70.3	(EPs) received a two-hour course in focused echocardiography, including video demonstrations, hands-on training, and an introduction into an ultrasound algorithm in accordance with recent ILCOR guidelines The EE[5] was performed using a 4–2-MHz microconvex transducer on a SonoSite 180 Plus portable handheld ultrasound system (SonoSite, Bothell, WA)	Heart could be visualized successfully in all patients. Cardiac movement: 10 (23.8%) on first EE Hospital admission 4/10 Cardiac movement on every EE: 7 (16.7%) Cardiac standstill on initial EE resulted in a positive predictive value of 96.9% for death and 40% positive predictive value	Y/Y
Blaivas (14)	n=169 Mean patient age was 71 years	A 2.5-MHz phased-array probe	136 cardiac standstill Hospital admission:20 With no cardiac standstill on initial echo	Y/Y
Salen 2001 (15)	n=102 Nonconsecutive convenience sample	Cardiac ultrasonography was carried out ranging from one to five scans, during the cardiac resuscitation using the subxiphoid view during pauses for central pulse evaluation	A mean of 1.8 cardiac ultrasound scans during the resuscitation. Emergency discharge/ positive cardiac activity 11/41(27%) Emergency discharge/negative cardiac activity 2/61 (3%)	Y/NA[6]
Tayal 2003 (16)	n=20 Nontraumatic arrests	EPs were trained with a 20-hour US course Shimadzu SDU-400 gray-scale, 3.5-MHz probe	No cardiac motion:8/20 (40%) Cardiac motion on echo:12/20 (60%)	-/-
Salen 2005 (17)	n=70 61% males and 39% females a convenience sample of nontrauma pulseless adult subjects	EP ultrasonographers 3.5-MHz curvilinear or sector probes	Admission to hospital/ROSC: 4/7 ROSC/cardiac motion: 8/11	Y/Y
Schuster 2009 (18)	n=27 Average age of 49 years. Traumatic and non-traumatic All patients presenting in or progressing to PEA	US-trained residents performed US under supervision of credentialed EP or trauma surgeon Phillips EnVisor, 5-MHz curvilinear probe for subxiphoid images or phased array for parasternal views	Cardiac activity: 12 /28 cases with PEA[7] Return of spontaneous pulse:5/12	Y/Y
Breitkreutza 2010 (8)	n=88 suspected PEA and asystole	Emergency physician trained in periresuscitation echo Modified hand-held US device with 3.5-MHz probe SonoSite i-Look 15 with a curved array probe	Wall motion/hospital admission: 30/88 No wall motion/hospital admission:5/88	Y/Y
Cebicci 2014 (19)	n=410	CHISON 8500 with a 3.5 MHz curvilinear transducer which is used for bedside ultrasound	Cardiac activity:81/410 24 hr survival:79/81	Y/Y

[1]US: ultrasound, [2]ROSC: return of spontaneous circulation, [3]ED: emergency department, [4]Y: yes, [5]EE: echocardiography, [6]NA: not available, [7]PEA: pulseless electrical activity,

Major motivation for conducting echo in life support (ELS) is the early diagnosis of a reversible cause, leading to improved survival of patients with cardiac arrest. Identifying pneumothorax, hypovolemia, pericardial tamponade, and even pulmonary embolism during resuscitation could be a promising diagnostic criterion which needs further studies on the ultrasound performing during advanced life support efforts (14).

According to some studies echocardiography in patients with cardiac arrest should be performed in less than 10 seconds; in cases with more than 10 seconds of scanning time, CPR should be conducted instead. It is also noticed that performing ultrasound should not compromise advanced life support managements in patients with cardiac arrest (12,15). In the study of Aichinger, et al., no decision was made based on the emergency echocardiography, and CPR was continued for 15 min after echo.

All the included articles studied the beneficial effects of performing echocardiography in emergency department during advance life support management of patients with cardiac arrest. In one study, observation of cardiac motion was demonstrated to be associated with almost 55% positive predictive value of cardiac activity for the incidence of return of spontaneous circulation (ROSC) in patients. In this study, lack of cardiac activity has shown almost 97% negative predictive value for death (12). In other studies, it was also proposed that only cardiac movement could be proposed as a prognostic factor for patients survival, ROSC and hospital admission, or emergency discharge; however lack of cardiac movement and presence of cardiac standstill were associated with 97% positive predictive value of death. Cardiac movements could be shown through performing emergency echocardiography in patients with cardiac arrest (13-15,17). In one study, cardiac motion during emergency cardiac sonography was proposed as a putative predictor of ROSC (17).

Hayhurst et al. showed the need for additional interventions following scan results including pericardiocentesis, thrombolysis, and insertion of a chest drain; however they did not achieve desired results and improved outcome regarding survival to hospital discharge for out-of-hospital arrests. Additional advantages of performing emergency echocardiography in patient with cardiac arrest has been shown in some case reports including evaluation of pacemaker capture of cardiac electrical activity, pericardial effusion in patients with pulseless electrical tachycardia, and ventricular fibrillation (20-22).

In patients with cardiac arrest, lack of cardiac motion by performing echo life supporting, might be associated with death and stopped resuscitation.

In the study of Hayhurst et al., one patient recovered and survived despite the absence of VWM during echo life supporting. They suggested that performing only 10 seconds of echocardiography was not sufficient to stop CPR in patients with the lack of VWM . However lack of VWM might be a reasonable reason for stopping CPR after prolonged efforts for patients' survival, but not at the early stages of resuscitation. Adversely, the presence of VWM was a significant indicator for persisting resuscitation efforts. Furthermore, other studies showed that cessation of CPR should not be based on one initial single scan showing cardiac standstill. According to these studies, patients with cardiac standstill in one ultrasound scan, survived to emergency department discharge (13-15). In this regard, performing echocardiography could reveal some treatable and reversible underlying conditions of cardiac arrest and determine the subsequent and further treating strategies.

Based on one recent study, the putative ability of fast cardiac sonography in patients at emergency department was confirmed regarding patients` survival rate; emergency sonography in cardiac arrested patients was reported as a valuable predictor of 24-hour survival which could be integrated with CPR procedures (19).

Conclusion

Echocardiography is a feasible procedure that could be performed as an additional intervention in pre-hospital or emergency department in patients with cardiac arrest, due to its potential in revealing cardiac activity and pericardial effusions. Although lack of cardiac motion in ultrasound is not sufficient to quit resuscitation, the presence of cardiac activity could be an indicator of persisting resuscitation efforts.

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Conflict of Interest

The authors declare no conflict of interest.

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