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REVIEW ARTICLE

Does Point-of-care Ultrasound Improve Survival when Used During Cardiac Arrest? A Systematic Review and Meta-analysis

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ABSTRACT

Aim of the review: This review aimed to evaluate the impact of Point-of-care Ultrasound during cardio- pulmonary resuscitation for adult non-traumatic CA on clinical outcomes and survival.

Data sources: This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The PubMed and Embase databases were searched on 14 November 2022. The eligibility criteria were studies including: adults with non-traumatic cardiac arrest and Point-of-care Ultrasound utilisation, a control group, and an analysis of short- and long-term outcomes and neurological outcomes. The risk of bias and certainty of evidence were assessed using the Grading of Recommendations Assessment, Development and Evaluation form. Data are reported as risk of ratios for each outcome.

Results: From the two databases, 7658 studies were identified, of which 3 met the predefined eligibility criteria. The main findings showed no difference in rate of return of spontaneous circulation (RR 0.83, 95% CI 0.24–1.66, p=0.60) (very low certainty of evidence) and a significant decrease in rate of survival to hospital discharge (RR 0.44, 95% CI 0.22–0.88, p=0.02) (very low quality of evidence). No study reported data regarding neurological status at hospital discharge, 30-day survival rate, or neurological outcome.

Conclusion: The impact of Point-of-care Ultrasound during cardiopulmonary resuscitation on clinical outcomes during cardiac arrest is hampered by the very low certainty of evidence, heterogeneity, and high risk of bias. Studies have shown no difference in return of spontaneous circulation but a significant decrease in survival to hospital discharge when Point-of-care Ultrasound was performed.

Keywords: POCUS, cardiac arrest, resuscitation, systematic review, meta-analysis

Introduction

Point-of-care ultrasound (POCUS) has been implemented as an assessment tool for free fluids in cavities to aid surgeons in determining management in trauma cases, known as Focused Assessment with Sonography in Trauma, which was introduced as a mandatory part of emergency medicine in 2010.[1] One emerging use of POCUS is to evaluate cardiac activity or standstill. Cardiac activity assessment can also be used to identify pseudo-pulseless electrical activity (PEA) which is the presence of ventricular contractility with electrical activity but without pulse.[2] Pseudo-PEA may be caused by reversible aetiologies such as pulmonary embolism, hypovolaemia, tachydysrhythmia, tamponade, and tension pneumothorax.[3] The largest study to date was a non-randomised, prospective, observational, multicentre study across the USA and Canada and included 793 patients with PEA or asystole and examined cardiac activity with POCUS at the beginning and end of resuscitation. Results showed that 33% of patients had cardiac activity which was associated with the achievement of return of spontaneous circulation (ROSC) (51% in cardiac activity group) and a significant increase in survival to hospital discharge (SHD) of 3.8%. Several studies have reported that patients with cardiac activity who underwent POCUS examination have a significantly higher degree of ROSC, survival to hospital admission (SHA), and SHD.[4-9] Several POCUS protocols have been developed to standardise POCUS utilisation during cardiac arrest (CA).[10-19] Most protocols reflect expert opinions and have not been validated. The earliest protocols, published in 2007, focused on assessment of the cardiac view alone.[10] Later protocols include other window views such as lung, deep vein thrombosis, and abdomen/pelvis in their algorithm. Point-of-care ultrasound utilisation has a direct impact on resuscitation management through pericardiocentesis, thrombolysis, and insertion of thoracic drainage in 12% (6/50) of cases.[4] Most recent reviews and meta-analyses have focused on the prognostic value and general application of POCUS with reported sensitivities and specificities on reversible aetiologies of CA, cardiac activity, and clinical outcomes.[20, 21-24] Reynolds et al. published a systemic review without meta-analysis because no combination of studies had a sufficiently low risk of bias, inconsistency, and imprecision.[24] Long et al. concluded that although recent literature supports the diagnostic value of POCUS, it does not impact clinical outcomes.[21, 23, 25, 26] Current recommendations for the use of POCUS during cardio-pulmonary resuscitation (CPR) is based on the review conducted by the International Liaison Committee on Resuscitation (ILCOR) in 2015, which included only one study by Prosen et al.[27, 28] This review aimed to evaluate the impact of POCUS during CPR for adult non-traumatic CA on clinical outcomes and survival. The secondary objective was to conduct a follow-up review of the ILCOR recommendations from 2015 and evaluate the progression of the last 7 years of research on the topic. Currently, POCUS is widely performed during CPR for non-traumatic CA to increases the probability of survival in

clinical practice. This review also aimed to determine if sufficient data with adequate certainty of evidence exists to support the current recommendations and investigate the impact of current practices on ROSC and survival.

Methods

SEARCH STRATEGY

In collaboration with an experienced librarian, we developed a broad search strategy based on the project protocol. Only the population, intervention, and timeframe of the (PICOST) format were included in the search string to obtain a broad number of available articles. The relevant search strings are provided in Appendix A1. On the 14th of November 2022, the first author conducted a systematic search of the PubMed and EMBASE databases. All references from both the included studies and identified systemic reviews relevant to the predefined inclusion criteria were manually reviewed and included if they fulfilled the eligibility criteria (Figure 1).

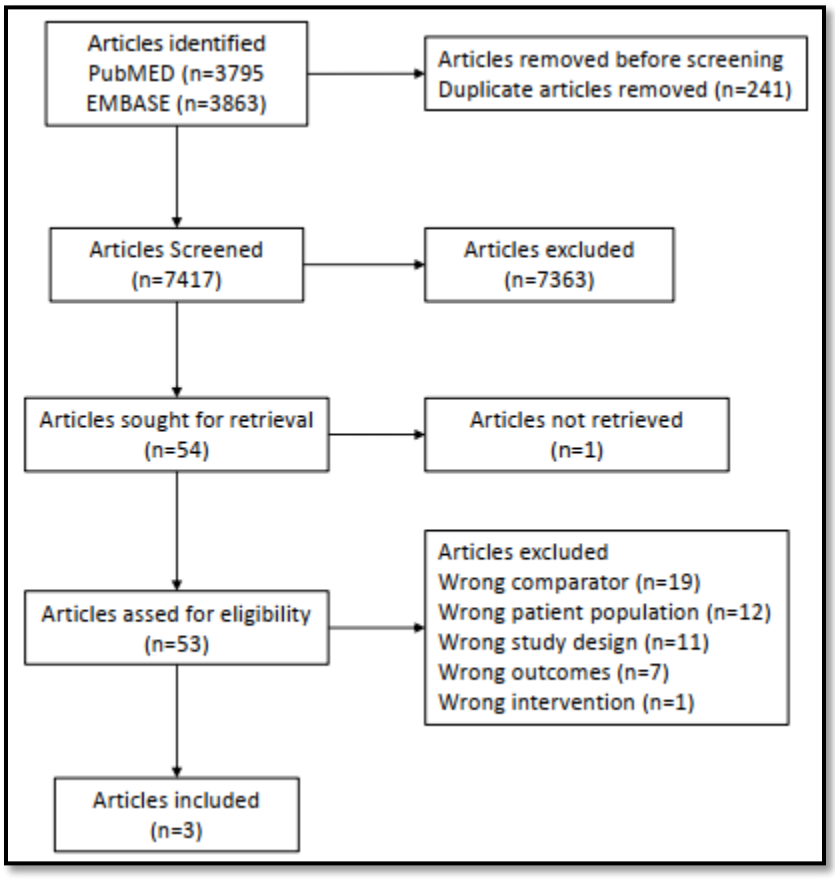

Figure 1. A summarised flow diagram of the results of the literature search

ELIGIBILITY CRITERIA

The study question was designed using the PICOST format: selected population (P), adults (age >18 years) with non-traumatic CA in any setting; intervention (I), POCUS performed in conjunction with CPR; compared (C) to CPR performed without POCUS; primary outcome (O) for survival was

ROSC, and the secondary outcomes were SHD, 30-day survival, and neurological outcome; study design (S), randomised controlled trials and observational studies; timeframe (T), last three decades (1992–2022). Studies meeting the following exclusion criteria were excluded: those concerning paediatric or traumatic CA; reviews and meta-analyses; and studies where the full text was not available in English or Swedish from the Lund Universities subscription or following request from the corresponding author. All published peer-reviewed papers fulfilling the eligibility criteria with obtainable and comparable quantitative reported outcome data for each treatment group (intervention vs. control) for at least one of the pre-determined outcome measurements were included.

INFORMATION SOURCES

The databases PubMed and EMBASE were searched according to the predefined eligible criteria on the fourteenth of November 2022.

SELECTION OF SOURCES OF EVIDENCE

Full-text study selection was conducted using the Covidence Systemic Review Software (Veritas Health Innovation, Melbourne, Australia), available at www.covicence.org. Using predefined eligibility criteria, the first author of this report independently screened all titles and abstracts. Full-text versions of the selected articles were obtained and reviewed for assessment and eligibility. All uncertainties regarding assessment and proper inclusion were discussed with the supervisor (BMH).

DATA CHARTING PROCESS

Full-text study selection was conducted using the Covidence Systemic Review software (Veritas Health Innovation). Using predefined eligibility criteria, the authors of this report independently screened all titles and abstracts, but all uncertainties regarding assessment and proper inclusion were discussed with the supervisor (BMH). Full-text versions of the selected articles were obtained and reviewed for assessment and eligibility. The following data categories were extracted from the included studies: study population, setting, country, study type, years of enrolment, study aim, eligibility criteria, study arms, study arm size, operator and ultrasonography window views, and main results. A summary of these characteristics is presented in Table 1.

Table 1. Summary of the characteristics of included studies. Columns represent items extracted to evaluate the characteristics of included studies.

First author, year	Subjects/ setting/ country	Study type	Year of enrolment	Aim of study	Inclusion	Exclusion	Arms, n in each arm	Sonograph operator and window view	Window view
Chardoli 2012	100, ED, Iran	Prospective interventional study	2009	Examine utility of bedside echocardiography in detecting reversible aetiology during cardiac arrest	Patients with pulseless electrical activity	None stated	Group A; ECHO evaluation and ACLS/ Group B; ACLS only. N int/con= 50/50	Ultrasound trained emergency physicians	Subxiphoid view only. ECHO performed at first no flow time, during pulse check, maximum 10sec.
Atkinson 2019	223, ED, Canada	Retrospective study	2010–2014	Examine potential relationship between POCUS use and the length of resuscitation, the frequency of interventions and clinical outcome during cardiac arrest	Adult out-of-hospital cardiac arrest	Termination of resuscitation OR due to end-of-life decisions, in-hospital cardiac arrest	POCUS assessment during ACLS/ POCUS not preformed. PCOUS group was further stratified into positive cardiac activity on POCUS a negative cardiac activity on POCUS. N int/con= 144/43	Competent personal with experience in POCUS	Subxiphoid, parasternal or apical four chambers
Chou 2020	210, ED, USA	Retrospective study	2016–2017	Determine the association of POCUS related to interruptions during cardiopulmonary resuscitation with patient's outcome in ED	Adults, out-of-hospital cardiac arrest and cardiac arrest while in ED	Trauma-related arrest, pediatric arrest, ROSC before first pulse check, lack of chest compression and lack of video recordings	ECHO preformed/ ECHO not preformed. N int/con= 142/68	All emergency medicine residents and attending physicians received basic training.	Video recordings of resuscitation bays. ECHO preformed subxiphoid view and/or parasternal view.

ED = emergency department, ECHO = echocardiography, ACLS = advanced cardiovascular life support, int/con = intervention/control group, POCUS = point-of-care ultrasound.

OUTCOME MEASURES

Outcome measurements defined as critical were in accordance with the Utstein consensus definition of core elements in the outcome domain and were as follows: ROSC, survival to hospital discharge, 30-day survival, and neurological outcome.[31]

STUDY BIAS ASSESSMENT

The first author independently reviewed the risk of bias of individual studies using the GRADE assessment tool for observational studies.[32] The Grading of Recommendations, Assessment, Development, and Evaluations system (GRADE) classifies study quality as either "very low", "low", "moderate", or "high".[32, 33] Reasons for downgrading an article include risk of bias, inconsistency, indirectness, imprecision, and publication bias. Publication bias was not assessed, and as a rule of thumb, conducting a funnel plot asymmetry is advisable only when at least 10 studies are included in the meta-analysis, as the power of the test is too low to differentiate

between real asymmetry.[29] The decision to use the GRADE system was based on the ILCOR evidence evaluation which states that the GRADE system is to be used when assessing and reviewing resuscitation-related questions.[33] All uncertainties regarding quality assessment were discussed with the supervisor.

STATISTICS AND SYNTHESIS OF RESULTS

The meta-analyses utilised a random-effects model and Mantel–Haenszel method in RevMan software (Review Manager (RevMan, [Computer program], Version 5.4, The Cochrane Collaboration, 2020) with results presented as risk ratio (RR), 95% confidence interval for dichotomous outcomes, and alpha level of $p<0.05$. To measure heterogeneity of results, the Higgins I^2 statistic was utilised.[29, 34] As a small study sample and low numbers of studies are provided in this meta-analysis, a p-value <0.10 or I^2 statistic >50% indicated substantial heterogenicity.[29, 34] When a meta-analysis was not appropriate, a narrative synthesis was provided.

Results

SEARCH RESULTS AND SELECTION OF ARTICLES

A total of 7658 studies were identified during the initial search of the two databases. A total of 241 were removed because they were duplicates, resulting in the review of titles and abstracts of 7417 unique original papers. A total of 7363 studies were deemed irrelevant, leaving 54 studies reviewed for eligibility via full-text assessment. Altogether, three studies that fulfilled the predefined eligibility criteria were included in the current meta-analyses.[44-46] Nineteen articles were identified as having incorrect comparators, most often having no comparator at all, and were excluded. One study by Pyo et al.[38] appeared to meet the inclusion criteria but was excluded after a discussion with the supervisor. The study had no available data to provide information meeting the predefined eligibility criteria for this meta-analysis, as stratification of no POCUS and POCUS study groups was pooled together in the reported outcome measures.[39] Efforts were made to resolve this by emailing the corresponding author of the article, but this failed as no answer was received. A summary flow diagram presenting the search results and selection of articles is presented in Figure 1.

ARTICLE TYPES AND PUBLICATION YEARS

All included studies were observational and included a total of 533 patients[35-37]. Publication dates were between 2012–2020 with the year of enrolment of patients in the studies between 2009–2017.

DESCRIPTION OF REGIONS, POCUS PERFORMANCE, AND PERSONNEL

The three included studies were conducted in Iran[36], Canada[35], and the USA[37]. All studies were set in the emergency department (ED), with one study exclusively enrolling adults with out-of-hospital cardiac arrest (OHCA), one study with OHCA patients and patients who experienced CA in the ED, and the last study involved PEA including CA in the ED. These three studies used POCUS with the subxiphoid view, two studies utilised the parasternal view, and one study utilised the apical four-chamber view. The sonographer was either an ultrasound-trained emergency medicine (EM) physician, a person competent in POCUS, or a senior EM physician or resident EM physician with basic training in POCUS.

No specific POCUS protocol was used for any study. The aims of the included studies were as follows: to examine the effectiveness of POCUS for identifying a reversible aetiology during CA, to examine the relationship between POCUS utilisation with length of resuscitation with a focus on the frequency of intervention impacting clinical outcomes during CA, and to examine the association between POCUS-related interruptions during CPR and clinical outcomes. A summary of study characteristics is presented in Table 2.

Table 2. Quality of the included studies. Studies are assessed using the Grading of Recommendations Assessment, Development and Evaluation assessment tool for observation studies. Studies are judged in four domains of risk of bias in three classifications, and summarised as low, unclear, or high risk of bias.

First author, year	Eligibility criteria	Exposure/outcome	Confounding	Follow up
Atkinson 2019	Low	Low	High[a]	Low
Chardoli 2012	Unclear[b, c]	Low	High[a]	High[d]
Chou 2020	Low	High[e]	Low	Low

[a]Assumed or confirmed aetiology of cardiac arrest unreported, [b]Enrolled convenience sample of subjects, [c]Unclear classification of cardiac arrest, [d]Clinical outcome beyond return of spontaneous circulation not measured, [e]Point-of-care ultrasound was no protocolised.

CERTAINTY OF EVIDENCE

Overall, the quality of included studies was low. Studies tended to have a high risk of bias in the domains of exposure/outcome, confounding factors, and follow-up. Atkinson et al.'s study presented with a high risk of bias regarding confounding factors, as suspected or confirmed data on the aetiology of CA were not presented.[44] Chardoli et al.'s[36] study presented with the same issue, as well as an unclear risk of bias regarding the eligibility criteria as the enrolled patients were a convenient number of 100 patients with 50 in each study arm and they did not provide classification of type CA. Moreover, Atkinson et al.[35] and Chou et al.[37] received a high risk of bias for exposure/outcome because the POCUS examinations were not protocolised. Chardoli et al. also had a high risk of bias regarding follow-up, as no long-term survival outcomes were presented.[36] A summary of study quality is presented in Table 3.

Table 3. Summary of findings addressing the research question, does POCUS utilisation improve survivability during CPR in adults with non-traumatic cardiac arrest? The basis of the anticipated number and its 95% CI for ROSC and SHD expected when POCUS is used during CPR are based on the relative effect available from case analysis. Relative effect is expressed as risk ratio.

Outcome	Author	Subjects (n)/ location/ study design	Anticipated absolute effect (95% CI)		Risk ration range	Certainty of evidence
			POCUS	Control		
ROSC	Atkinson (2019) Chardoli (2012)	323 (2 studies) OHCA & IHCA Observational	**291 per 1,000 (147 to 582)** [a]	333 per 1,000	**0.83 [0.42–1.66]**	**Very low** [b] due to imprecision
SHD	Atkinson (2019) Chou (2020)	433 (2 studies) OHCA & IHCA Observational	**47 per 1,000 (25 to 95)** [c]	129 per 1,000	**0.44 [0.23–0.89]**	**Very low** [b] due to imprecision

POCUS = point-of-care ultrasound, CPR = cardiopulmonary resuscitation, CI = confidence interval, ROSC = return of spontaneous circulation, OHCA = out-of-hospital cardiac arrest, IHCA = in-hospital cardiac arrest, SHD = survival to hospital discharge, ACLS = advanced cardiovascular life support. [a]Anticipated absolute effect expected ROSC, no significant difference (p=0.52), [b]Serious imprecision due to low number events of patient survival in included studies to ensure sufficient precision in data, [c]Anticipated absolute effect of expected SHA, a significant decrease of survival in patients with POCUS utilisation (p=0.02).

MAIN RESULTS

Two observational studies reported ROSC.[35,36] There was a total of 323 patients with sample sizes of 100 and 223, respectively. One prospective interventional study on adult CA with PEA with unspecified background causes and one retrospective study on adult OHCA were included. However, there was no significant difference in the rate of ROSC with the use of POCUS during CPR (RR 0.83, 95%CI 0.24–1.66, p=0.60; Figure 2, low quality of evidence). The certainty of evidence was downgraded owing to imprecision, as the total number of events reported (91 events) was below 100, which did not meet the threshold for optimal information size.[39] Moreover, substantial heterogeneity was detected (I^2=71%). A plausible explanation for the identified heterogeneity could be the different study populations, study aims, study designs, and POCUS windows used.

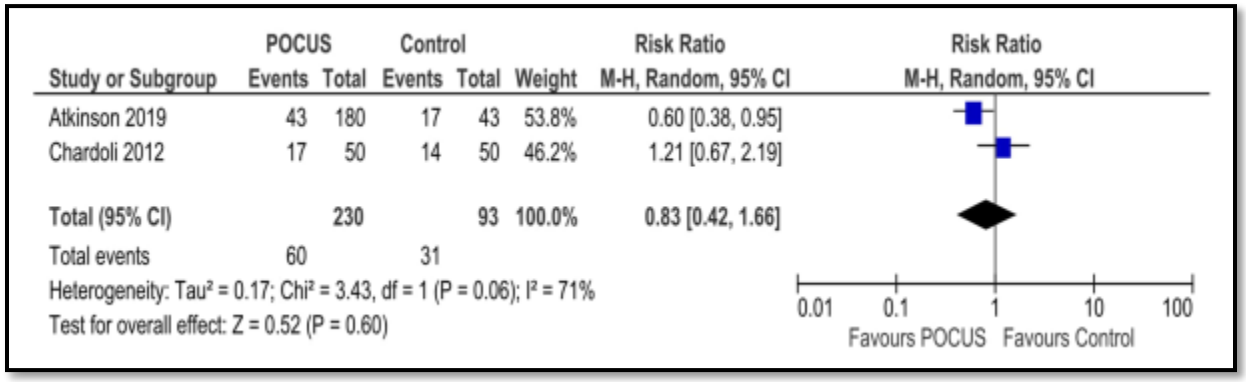

Figure 2. Forest plot over return of spontaneous circulation outcome for POCUS utilisation and CPR vs. control group, CPR only. A random-effects model and Mantel–Haenszel analysis are utilized. Estimated effects are presented as RR. POCUS = point-of-care ultrasound, CPR = cardiopulmonary resuscitation, RR = risk ratio, CI = confidence interval.

Two observational studies reported data on SHD in a total of 427 patients with sample sizes of 213 and 223, respectively.[35, 36] Both were retrospective studies representing adult OHCA, and one also included CA in the ED. There was a significant difference in the rate of SHD, favouring the control group (RR 0.44, CI 95 % 0.22–0.88, p=0.02, Figure 3, very low quality of evidence). The certainty of evidence was downgraded owing to imprecision, as the total number of events reported (29 events) was below 100 and did not meet the threshold for optimal information size.[48] No substantial heterogeneity was detected (I^2=0%). A summary of these findings is shown in Figure 3.

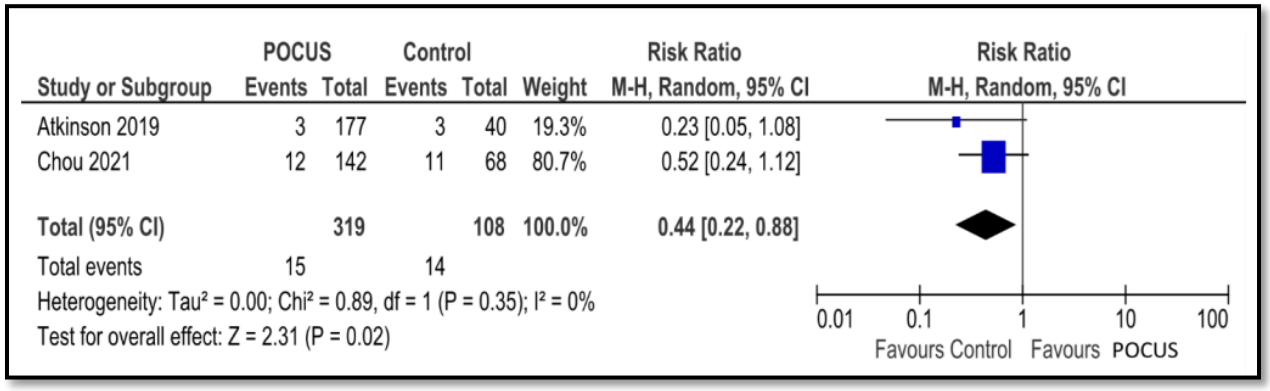

Figure 3. Forest plot over survival to hospital discharge analysis results POCUS utilisation and CPR vs. control group, CPR only. A random-effects model and Mantel–Haenszel analysis are utilized. Estimated effects are presented as RR. The blue squares represent the effects of individual studies. POCUS = point-of-care ultrasound, CPR = cardiopulmonary resuscitation, RR = risk ratio, CI = confidence interval.

The study by Atkinson et al.[39] was the only included study which presented SHA data; therefore, no meta-analysis was conducted because of an insufficient number of available studies. The study's available data reported a higher rate of SHA in patients with cardiac activity on POCUS (33.3%, 95% CI 13.2–53.5, p<0.001) compared to those with no activity (6.9%, 95% CI 2.97–10.86). The study revealed no SHA advantage in the POCUS-pooled group and the no POCUS examination group, with or without cardiac activity. However, no such analyses were reported in this article. None of the studies reported data on neurological status at hospital discharge, 30-day survival rates, or neurological outcomes.

ADDITIONAL FINDINGS

One study reported the impact of resuscitation length and intervention frequency.[35] The mean duration of resuscitation efforts were longer in patients receiving POCUS with cardiac activity (27.33, 95% CI 17.7–37.0 min) than those with no cardiac activity (11.51, 95%CI 10.2–12.8 min) and longer in patients who did not receive POCUS examination (14.36 min, 95%CI 9.89–18.8 min, p=0.001). Moreover, a higher frequency of intervention was observed in patients undergoing POCUS with cardiac activity. A higher rate of endotracheal intubation was reported in patients with POCUS with cardiac activity (95.23%, 95% CI 86.13–104.35%) compared to patients with POCUS without cardiac activity (46.54%, 95% CI 38.79–54.29%) and those receiving no POCUS (65.11%, 95% CI 50.87–79.36, p<0.001). The same pattern was seen with epinephrine administration for those with cardiac activity (100%, 95%CI 100–100%) compared to those without cardiac activity (82.39%, 76.50–88.31%) and those receiving no POCUS (81.39%, 95% CI 69.76–93.03%), p<0.001). Another included study by Chou et al.[37] reported a positive association between SHD and an optimal echocardiography (ECHO)-interrupted no-flow time of between 77 s–122 s (OR 7.31, CI 95 % 1.59–33.59, p=0.01) and ECHO-related interruption ≤2 (OR 5.55, 95% CI 2.44–12.61, p<0.001).

Discussion

The evidence for ROSC and SHD had a very low certainty of evidence when using the GRADE system, suggesting that the true effect might be substantially different from the estimated effect, giving us very little confidence in the findings of this paper.[32] The rating of very low categorisation of both measured outcomes stems from the approach that initially ranks observational studies as low certainty of evidence and from a downgrade due to the imprecision of the included studies. This imprecision stems from the low number of events reported. Both meta-analyses only contained two studies each, with one study included in both analyses. Moreover, they had a low number of enrolled patients and did not obtain a satisfactory number of events to avoid downgrades due to imprecision. Therefore, the risk of bias in the included studies was categorised as high. The studies were rated as high-risk or unclear in one or several risk-of-bias domains. Previous reviews have also concluded that a high risk of bias exists in published studies in the field and there is a lack of evidence on outcome improvements.[22, 24, 26] This produces

a further concern in our interpretation of the main findings, as previous data reporting on risk of bias on a general sample of disease and intervention show that a high risk of bias tends to create an over- or underestimation of the true effect.[40, 41] This review involved a low number of studies with few events, and the included studies were observational in design with a high risk of bias. The obvious solution to these limitations is to conduct randomised control trials with greater patient populations and with the specific aim of measuring clinical outcomes. The diagnostic value of POCUS during advanced cardiovascular life support (ACLS) has earned it a modest recommendation and its implementation during CPR is considered good clinical practice according to the current American Heart Association guidelines.[43] Attrition bias due to the exclusion of reversible diagnoses could exclude many positive outcomes. Moreover, patients requiring POCUS cannot provide consent for inclusion in clinical trials. This creates an unthinkable scenario in which the value of science triumphs over the good of the patient. This leaves us with the option of analysing observational studies with or without comparators and accepting the difficulties associated with obtaining high certainty of evidence of the role of POCUS and management implications during CPR. Current studies in the field aim to answer research questions related to prognostic and diagnostic value, cardiac activity, education in examination, and to ensure that POCUS interruptions of chest compressions are kept short.[5, 20, 21-23, 38, 44, 46]

Taking the main findings of the current study at face value, POCUS during CPR did not influence ROSC, but there was a significant decrease in SHD. These estimated effects could be explained by both the direct effect of POCUS and indirect effects of confounders emerging during inpatient interventions dependent on the aetiology of CA, clinical history, current clinical status, and hospital practice. Of the included studies, only Chou et al. included a sufficient analysis of independent variables in the baseline patient characteristics.

The greatest concern for POCUS utilisation during CPR is the interruption of chest compressions. Unnecessary interruptions can endanger CPR quality and potentially increase the time to ROSC. Shorter duration of CPR is proportionately and positively associated with achieving ROSC and good neurological outcomes.[48] A longer duration of downtime between onset of CA to ROSC is significantly correlated with a decreased chance of good neurological outcomes.[47] As such, a plausible explanation is that extension of CPR duration resulting in adverse effects such as loss of circulation due to POCUS utilisation, which results in a sustained rate of ROSC, but a lower rate of long-term SHD. This dynamic probability of SHD has also been reported to be independently associated with the CPR duration required to achieve ROSC.[47]

Additionally, Chou et al. reported on the non-linear association of increased probability of SHD due to ECHO-related no-flow time between 77 s and 122 s.[37] The results of the study also indicated an increase in survivability when there were ≤2 POCUS-related interruptions during CPR. This infers that if enough time is given to POCUS

utilisation to rule in or out reversible aetiologies, without lingering, an extra window of probability for achieving ROSC is obtained.

As shown by Atkinson et al., POCUS examination also changes the rate of resuscitation effort and resuscitation management, with a greater extent of utilisation of endotracheal intubation and epinephrine administration.[35] This finding could be interpreted as POCUS findings lead to better resuscitation management or as evidence of a self-fulfilling prophecy in which clinicians extend management effort to achieve ROSC in patients with cardiac activity on examination. Gaspari et al. provided evidence of this self-fulfilling prophecy whereby extended CPR durations were provided to patients with indications of cardiac activity from POCUS utilisation.[46] In previous studies by Kim et al. and Lien et al., a predetermined mandatory 30 min of CPR was included prior to termination of resuscitation to eliminate the risk of this self-fulfilling prophecy.[49, 50] The study by Pyo et al.,[38] which was excluded from the current review because of no comparator, conducted a pre- and post-intervention study to compare non-specific POCUS examination with implications for education and implications of the modified SEASAME protocol. The reported results indicated an increase in POCUS utilisation from 32.2% to 78.9% pre- vs. post-intervention. No significant differences in SHA, SHD, or neurological outcomes were observed. Resuscitation management compromising thrombolysis, emergency transfusion, tube thoracotomy, and pericardiocentesis had significantly increased from pre- to post-intervention 0.6% vs. 4.9% (p=0.016).[38]

Changes to resuscitation management due to POCUS utilisation during CPR have been reported in pre-hospital helicopter emergency services in the Netherlands, and POCUS utilisation changed treatment plans in 21% of patients.[51]

LIMITATIONS

In the article by Chardoli et al.,[36] data were pooled for observation of the assessment of bias, a meta-analysis, and certainty of evidence of ROSC outcomes. The reason for this decision was the rudimentary methodology presented by Chardoli et al., which produced hesitation if the study fulfilled the definition of a clinical interventional study. In addition, the current review used traumatic CA as an exclusion criterion, and Chardoli et al.[36] defined the inclusion criteria as CA with PEA presented in the ED. Chardoli et al.[36] suggested a distinction between traumatic and non-traumatic patients. Uncertainty regarding the traumatic arrests did occur; however, they were included in the current review after discussion with the supervisor. To address these limitations, Chardoli et al.'s[36] study could have been defined as an interventional study. However, the results of the meta-analysis would not change even if subgrouping had occurred, and although the certainty of evidence would have been conducted differently, the same conclusion of a very low rating would have been achieved. Instead, the risk of bias was assessed in randomised controlled trials. Alternatively, this study should have been excluded from

the current review because of the uncertainty of the eligibility criteria. Another limitation was that this review was not registered in International Prospective Register of Systematic Reviews (PROSPERO) which is register that provide a comprehensive listing of systematic reviews registered at inception to help avoid duplication and reduce opportunity for reporting bias. The first author of this report independently screened all titles and abstracts which could be a limitation, however, all uncertainties regarding assessment and proper inclusion were discussed with the supervisor.

Conclusion

Our meta-analysis found a significant decrease in SHD and no difference in ROSC during POCUS use. These findings were hampered by the very low certainty of evidence and high risk of bias. Heterogeneity was detected in the meta-analysis of ROSC. As such, we cannot conclude that POCUS utilisation is a tool that impacts clinical outcomes during CPR. This review identified that additional studies that specifically evaluate clinical outcomes are critical so that a larger number of events can be evaluated, and the possibility of a large effect size is increased. In addition, a more protocolised and unified application of POCUS is recommended. This should be conducted to address imprecision, lack of effect, and high risk of bias to obtain a higher certainty of evidence.

Conflict of Interest Statement:

None

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Availability of data and materials

Detailed documentation on the search strategy has been submitted as supplementary material (Appendix A1).

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None

References

1. Smallwood N, Dachsel M. Point-of-care ultrasound (POCUS): unnecessary gadgetry or evidence-based medicine? *Clin Med (Lond)* 2018;18(3):219–24.

2. Labovitz AJ, Noble VE, Bierig M, et al. Focused cardiac ultrasound in the emergent setting: a consensus statement of the American Society of Echocardiography and American College of Emergency Physicians. *J Am Soc Echocardiogr* 2010;23(12):1225–30.

3. Desbiens NA. Simplifying the diagnosis and management of pulseless electrical activity in adults: a qualitative review. *Crit Care Med* 2008;36(2):391–6.

4. Hayhurst C, Lebus C, Atkinson PR, et al. An evaluation of echo in life support (ELS): is it feasible? What does it add? *Emerg Med J* 2011;28(2):119–21.

5. Ozen C, Salcin E, Akoglu H, Onur O, Denizbasi A. Assessment of ventricular wall motion with focused echocardiography during cardiac arrest to predict survival. *Turk J Emerg Med* 2016;16(1):12–6.

6. Salen P, O'Connor R, Sierzenski P, et al. Can cardiac sonography and capnography be used independently and in combination to predict resuscitation outcomes? *Acad Emerg Med* 2001;8(6):610–5.

7. Salen P, Melniker L, Chooljian C, et al. Does the presence or absence of sonographically identified cardiac activity predict resuscitation outcomes of cardiac arrest patients? *Am J Emerg Med* 2005; 23(4):459–62.

8. Tomruk O, Erdur B, Cetin G, Ergin A, Avcil M, Kapci M. Assessment of cardiac ultrasonography in predicting outcome in adult cardiac arrest. *J Int Med Res* 2012;40(2):804–9.

9. Aichinger G, Zechner PM, Prause G, et al. Cardiac movement identified on prehospital echocardiography predicts outcome in cardiac arrest patients. *Prehosp Emerg Care* 2012;16(2):251–5.

10. Breitkreutz R, Uddin S, Steiger H, et al. Focused echocardiography entry level: new concept of a 1-day training course. *Minerva Anestesiol* 2009;75(5):285–92.

11. Breitkreutz R, Walcher F, Seeger FH. Focused echocardiographic evaluation in resuscitation management: concept of an advanced life support-conformed algorithm. *Crit Care Med* 2007;35(5 Suppl):S150–61.

12. Hernandez C, Shuler K, Hannan H, Sonyika C, Likourezos A, Marshall J. C.A.U.S.E.: Cardiac arrest ultra-sound exam--a better approach to managing patients in primary non-arrhythmogenic cardiac arrest. *Resuscitation* 2008;76(2):198–206.

13. Gardner KF, Clattenburg EJ, Wroe P, Singh A, Mantuani D, Nagdev A. The Cardiac Arrest Sonographic Assessment (CASA) exam - A standardized approach to the use of ultrasound in PEA. *Am J Emerg Med* 2018;36(4):729–31.

14. Reed MJ, Gibson L, Dewar A, Short S, Black P, Clegg GR. Introduction of paramedic led Echo in Life Support into the pre-hospital environment: The PUCA study. *Resuscitation* 2017;112:65–9.

15. Testa A, Cibinel GA, Portale G, et al. The proposal of an integrated ultrasonographic approach into the ALS algorithm for cardiac arrest: the PEA protocol. *Eur Rev Med Pharmacol Sci* 2010;14(2):77–88.

16. Lichtenstein D, Malbrain ML. Critical care ultrasound in cardiac arrest. Technological requirements for performing the SESAME-protocol--a holistic approach. *Anaesthesiol Intensive Ther* 2015;47(5):471–81.

17.Atkinson P, Bowra J, Milne J, et al. International Federation for Emergency Medicine Consensus Statement: Sonography in hypotension and cardiac arrest (SHoC): An international consensus on the use of point of care ultrasound for undifferentiated hypotension and during cardiac arrest. *CJEM* 2017;19(6):459–70.

18. Bughrara N, Herrick SL, Leimer E, Sirigaddi K, Roberts K, Pustavoitau A. Focused Cardiac Ultrasound and the Periresuscitative Period: A Case Series of Resident-Performed Echocardiographic Assessment Using Subcostal-Only View in Advanced Life Support. *A A Pract* 2020;14(10):e01278.

19. Perera P, Mailhot T, Riley D, Mandavia D. The RUSH exam: Rapid Ultrasound in SHock in the evaluation of the critically lll. *Emerg Med Clin North Am* 2010;28(1):29–56.

20. Hussein L, Rehman MA, Jelic T, et al. Transoesophageal echocardiography in cardiac arrest: A systematic review. *Resuscitation* 2021;168:167–75.

21. Botker MT, Jacobsen L, Rudolph SS, Knudsen L. The role of point of care ultrasound in prehospital critical care: a systematic review. *Scand J Trauma Resusc Emerg Med* 2018;26(1):51.

22. Dudek M, Szarpak L, Peacock FW, et al. Diagnostic performance of point-of-use ultrasound of resuscitation outcomes: A systematic review and meta-analysis of 3265 patients. *Cardiol J* 2021. https://doi.org/10.5603/CJ.a2021.0044.

23. Long B, Alerhand S, Maliel K, Koyfman A. Echocardiography in cardiac arrest: An emergency medicine review. *Am J Emerg Med* 2018;36(3):488–93.

24. Reynolds JC, Issa MS, Nicholson TC, et al. Prognostication with point-of-care echocardiography during cardiac arrest: A systematic review. *Resuscitation* 2020;152:56–68.

25. Brooke M, Walton J, Scutt D. Paramedic application of ultrasound in the management of patients in the prehospital setting: a review of the literature. *Emerg Med J* 2010;27(9):702–7.

26. Rudolph SS, Sorensen MK, Svane C, Hesselfeldt R, Steinmetz J. Effect of prehospital ultrasound on clinical outcomes of non-trauma patients--a systematic review. *Resuscitation* 2014;85(1):21–30.

27. Soar J, Callaway CW, Aibiki M, et al. Part 4: Advanced life support: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation* 2015;95:e71–120.

28. Prosen G, Križmarić M, Završnik J, Grmec S. Impact of modified treatment in echocardiographically confirmed pseudo-pulseless electrical activity in out-of-hospital cardiac arrest patients with constant end-tidal carbon dioxide pressure during compression pauses. *J Int Med Res* 2010;38(4):1458–67.

29. Higgins JPT, Thomas J, Chandler J, et al. Cochrane Handbook for Systematic Reviews of Interventions version 6.3 (updated February 2022). *Cochrane*, 2022. Available from: www.training.cochrane.org/handbook.

30. Guyatt G, Oxman AD, Akl EA, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol* 2011;64(4):383–94.

31. Perkins GD, Jacobs IG, Nadkarni VM, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: a statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian and New Zealand Council on Resuscitation, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia); and the American Heart Association Emergency Cardiovascular Care Committee and the Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. *Circulation* 2015;132(13):1286–300.

32. Balshem H, Helfand M, Schünemann HJ, et al. GRADE guidelines: 3. Rating the quality of evidence. *J Clin Epidemiol* 2011;64(4):401–6.

33. Morley PT, Atkins DL, Finn JC, et al. Evidence Evaluation Process and Management of Potential Conflicts of Interest: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation* 2020;156:a23–a34.

34. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ* 2003;327(7414):557–60.

35. Atkinson PR, Beckett N, French J, Banerjee A, Fraser J, Lewis D. Does Point-of-care Ultrasound Use Impact Resuscitation Length, Rates of Intervention, and Clinical Outcomes During Cardiac Arrest? A Study from the Sonography in Hypotension and Cardiac Arrest in the Emergency Department (SHoC-ED) Investigators. *Cureus* 2019;11(4):e4456.

36. Chardoli M, Heidari F, Rabiee H, Sharif-Alhoseini M, Shokoohi H, Rahimi-Movaghar V. Echocardiography integrated ACLS protocol versus conventional cardiopulmonary resuscitation in patients with pulseless electrical activity cardiac arrest. *Chin J Traumatol* 2012;15(5):284–7.

37. Chou EH, Wang CH, Monfort R, et al. Association of ultrasound-related interruption during cardiopulmonary resuscitation with adult cardiac arrest outcomes: A video-reviewed retrospective study. *Resuscitation* 2020;149:74–80.

38. Pyo SY, Park GJ, Kim SC, Kim H, Lee SW, Lee JH. Impact of the modified SESAME ultrasound protocol implementation on patients with cardiac arrest in the emergency department. *Am J Emerg Med* 2021;43:62–8.

39. Guyatt GH, Oxman AD, Kunz R, et al. GRADE guidelines 6. Rating the quality of evidence--imprecision. *J Clin Epidemiol* 2011; 64(12):1283–93.

40. Wood L, Egger M, Gluud LL, et al. Empirical evidence of bias in treatment effect estimates in controlled trials with different interventions and outcomes: meta-epidemiological study. *BMJ* 2008;336(7644):601–5.

41. Ioannidis JP, Haidich AB, Pappa M, et al. Comparison of evidence of treatment effects in randomized and nonrandomized studies. *JAMA* 2001;286(7):821–30.

42. Lalande E, Burwash-Brennan T, Burns K, et al. Is point-of-care ultrasound a reliable predictor of outcome during atraumatic, non-shockable cardiac arrest? A systematic review and meta-analysis from the SHoC investigators. *Resuscitation* 2019;139:159–66.

43. Soar J, Berg KM, Andersen LW, et al. Adult Advanced Life Support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation* 2020;156:a80–a119.

44. Blanco P, Martinez Buendia C. Point-of-care ultrasound in cardiopulmonary resuscitation: a concise review. *J Ultrasound* 2017;20(3):193–8.

45. Reynolds JC, Nicholson T, O'Neil B, Drennan IR, Issa M, Welsford M. Diagnostic test accuracy of point-of-care ultrasound during cardiopulmonary resuscitation to indicate the etiology of cardiac arrest: A systematic review. *Resuscitation* 2022;172:54–63.

46. Gaspari R, Weekes A, Adhikari S, et al. Emergency department point-of-care ultrasound in out-of-hospital and in-ED cardiac arrest. *Resuscitation* 2016;109:33–9.

47. Reynolds JC, Frisch A, Rittenberger JC, Callaway CW. Duration of resuscitation efforts and functional outcome after out-of-hospital cardiac arrest: when should we change to novel therapies? *Circulation* 2013;128(23):2488–94.

48. Kim WY, Ahn S, Hong JS, et al. The impact of downtime on neurologic intact survival in patients with targeted temperature management after out-of-hospital cardiac arrest: National multicenter cohort study. *Resuscitation* 2016;105:203–8.

49. Kim HB, Suh JY, Choi JH, Cho YS. Can serial focussed echocardiographic evaluation in life support (FEEL) predict resuscitation outcome or termination of resuscitation (TOR)? A pilot study. *Resuscitation* 2016;101:21–6.

50. Lien WC, Hsu SH, Chong KM, et al. US-CAB protocol for ultrasonographic evaluation during cardiopulmonary resuscitation: Validation and potential impact. *Resuscitation* 2018; 127:125–31.

51. Ketelaars R, Beekers C, Van Geffen GJ, Scheffer GJ, Hoogerwerf N. Prehospital Echocardiography During Resuscitation Impacts Treatment in a Physician-Staffed Helicopter Emergency Medical Service: an Observational Study. *Prehosp Emerg Care* 2018;22(4):406–13.