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Review

Cardiopulmonary resuscitation coaching for resuscitation teams: A systematic review

Kasper G. Lauridsen[a,b,c,d,*], *Emma Bürgstein*[b,c], *Sabine Nabecker*[e], *Yiqun Lin*[f], *Aaron Donoghue*[d,g], *Jonathan P. Duff*[h], *Adam Cheng*[f,i], *for the International Liaison Committee on Resuscitation Education, Implementation, and Teams Task Force*

Abstract

Aim: Cardiopulmonary resuscitation (CPR) quality is often substandard to guidelines for resuscitation teams. We aimed to investigate if the use of a CPR coach as part of the resuscitation team can improve teamwork, quality of care, and patient outcomes during simulated and clinical cardiac arrest resuscitation.

Methods: We searched PubMed, Embase, and Cochrane from inception until October 9, 2024 for randomized trials and observational studies. We assessed risk of bias using Cochrane tools and assessed the certainty of evidence using the Grading of Recommendations Assessment, Development and Evaluation approach. PROSPERO CRD42024603212.

Results: We screened 505 records and included 7 studies. Overall, 6 were randomized studies involving pediatric resuscitation of which 4 studies were secondary analyses of one simulation-based trial, and one was an observational study on adult out-of-hospital cardiac arrest. Reported outcomes were: CPR performance in a simulated setting (n = 3), workload in a simulated setting (n = 2), adherence to guidelines in a simulated setting (n = 1), team communication in a simulated setting (n = 1), and clinical CPR performance (n = 1). All studies suggested improved CPR quality and guideline adherence when using a CPR coach compared to not using a coach. Risk of bias varied from low to critical and the certainty of evidence across outcomes was low or very low.

Conclusions: We identified low- to very-low certainty of evidence supporting the use of a CPR coach as part of the resuscitation team in order to improve CPR quality and guideline adherence. However, further research is needed, in particular for clinical performance and patient outcomes.

Keywords: Cardiopulmonary resuscitation, Resuscitation teams, Cardiac Arrest Teams, CPR Coach

Introduction

Cardiac arrest is a major cause of sudden death globally affecting millions of people worldwide each year, including both in- and out-of-hospital cases.[1–3] Despite advances in care, survival rates remain low at about 5–16% for out-of-hospital cardiac arrests and 15–30% for in-hospital cardiac arrests with major geographical variations.[4,5] The most effective treatment for cardiac arrest remains high-quality chest compressions.[6–8] Accordingly, high-quality chest compressions are the cornerstone of international resuscitation guidelines, emphasizing adequate compression depth and rate, chest recoil, and minimal interruptions of compressions.[9–12]

Guideline-compliant chest compressions are difficult to achieve.[13–15] The use of chest compression feedback devices has led to improvements in CPR quality.[16,17] Yet, less than 40% of chest compressions performed by in-hospital resuscitation teams have guideline-compliant chest compression depth despite the use of such feedback devices.[18] Therefore, the concept of cardiopulmonary resuscitation (CPR) coaching has been introduced to further improve CPR quality.[19,20] The CPR coach is a member of the resuscitation team whose main role is to provide real-time feedback on CPR quality and to coordinate pauses in CPR for defibrillation, intubation, provider switches and/or pulse/rhythm checks.[19] Studies hypothesized that this would improve CPR quality while cognitively unloading the

* Corresponding author at: Department of Anesthesiology and Intensive Care, Randers Regional Hospital, 8930 Randers NE, Denmark.
E-mail address: kglerup@clin.au.dk (K.G. Lauridsen).

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resuscitation team leader so they can focus on other elements, such as identifying reversible causes of cardiac arrests.[19,21]

The CPR coach was introduced as part of the resuscitation team in many pediatric hospitals around the world and also in some adult settings.[20,21] However, the effectiveness of a CPR coach has not been assessed in any systematic review. Thus, this systematic review aims to investigate if the use of a CPR coach as part of the resuscitation team can improve teamwork, quality of care, and patient outcomes during simulated and clinical resuscitation of cardiac arrest.

Methods

This systematic review was completed as part of the International Liaison Committee on Resuscitation (ILCOR) evidence evaluation process. The review was conducted in accordance with the 2020 Preferred Reporting Items for a Systematic Review and Meta-analysis (PRISMA) statement.[22] The PRISMA checklist is provided in Supplement 1. A protocol was drafted in accordance with general ILCOR practice and registered at the International Prospective Registry for Systematic Reviews (PROSPERO CRD42024603212). No ethical approval was required to conduct this study. The data templates used are not publicly available but may be shared upon reasonable request.

We conducted this systematic review utilizing the PICO format (Population, Intervention, Comparison, Outcome) to address the following research question: Amongst healthcare teams managing adult or pediatric cardiac arrest (P), does the use of a CPR coach as a resuscitation team member (I) as compared to no CPR coach on the resuscitation team (C), improve outcomes. Critical outcomes were identified as: real-life CPR skill performance, adherence to guidelines during real-life cardiac arrests, return of spontaneous circulation (ROSC), survival to hospital discharge, survival at 30 days, survival with favorable neurological outcomes, and survival beyond 30 days after discharge. Important outcomes were identified as: CPR skill performance, adherence to clinical guidelines, teamwork, and provider workload during simulated cardiac arrests.

We included randomized controlled trials, observational studies, and case series with more than 5 cases. We included all studies with an English abstract. We excluded all case reports, conference abstracts, trial protocols, and editorials.

We searched PubMed, Embase, and Cochrane databases from inception through October 9, 2024. We utilized ChatGPT4 to draft proposed search terms based on the PICO question and we subsequently revised the search strategy with support of an information specialist. The search strategy is provided in Supplement 2. Abstracts (authors: KGL, EB, SN, AC) and full texts (authors: KGL, EB, AD, JD) were screened by two independent reviewers using the systematic review management tool Covidence (Covidence, Melbourne, Australia). Any disagreement of judgement was resolved by discussion until agreement and/or a third independent author vote. We did not encounter any need of contacting any authors for missing data or incomplete study description. In order to handle potential intellectual conflicts of interest, reviewers who had authored some of the included papers were not involved in article screening. Moreover, we ensured that no reviewer conducted data extraction or risk of bias assessment on a study which the reviewer had authored.

Study data extraction

Included studies were extracted on an online spreadsheet that specified author, year of publication, publication title, study design, multicenter or single-center study, study population and population characteristics, study intervention, study control, study outcomes and relevant results. The data was extracted by one author and then reviewed independently by another author in a separate step (authors: KGL, EB, SN, AD, YL, JD, AC).

Review definitions

CPR coach was defined as the assigned role of a resuscitation team member whose primary responsibility is to provide real-time coaching and feedback on chest compression performance during cardiac arrest.[19] CPR coaches may also perform additional tasks, including (a) coordinating the initiation of CPR; (b) providing feedback on ventilation performance, and (c) coordinating pauses in CPR for defibrillation, intubation, CPR provider switch, or pulse/rhythm checks. We excluded dispatch-assisted coaching of lay people to provide out-of-hospital CPR or any other type of coaching where the coach was not an active resuscitation team member.

Teamwork was defined as skills and/or attitudes relating to non-technical skills in a team context, including communication skills, decision-making, structured handovers, situational awareness, coordinating behaviors, task allocation, sharing the mental model, team leadership, speaking up with concerns and the acknowledgement of this by a receiver, performance monitoring, backup behavior and mutual trust.[23]

Risk of bias assessment

Risk of bias was assessed by two reviewers for each study (authors: KGL, EB, SN, AD, YL, JD, AC). For randomized trials, we used the revised Cochrane risk-of-bias tool for randomized trials (RoB-2) and for non-randomized studies, we used the 'Risk Of Bias In Non-randomized Studies – of Interventions' (ROBINS-I) tool. Disagreements between the two reviewers were resolved by discussion and involvement of a third reviewer if necessary. We assessed the risk of bias per outcome but we reported the risk of bias per study in all cases where the risk of bias was assessed as identical across outcomes within a study.

Data analysis and synthesis

In case of sufficient data, we defined the following subgroup analyses of interest *a-priori* to the review: A) Adult vs. pediatric cardiac arrest, B) Trained vs. untrained CPR coaching, C) Use of CPR feedback devices vs. no CPR feedback devices during resuscitation. As several of the included studies were based on the same trial and due to significant clinical heterogeneity, we did not conduct a *meta*-analysis. Therefore, we report the findings following the synthesis without *meta*-analysis (SWiM) in systematic reviews reporting guidelines.[24] We reported effect estimates (differences, risk ratios or odds ratios) with confidence intervals whenever possible. We assessed the overall certainty of evidence for each outcome using the Grading of Recommendations Assessment, Development and Evaluation

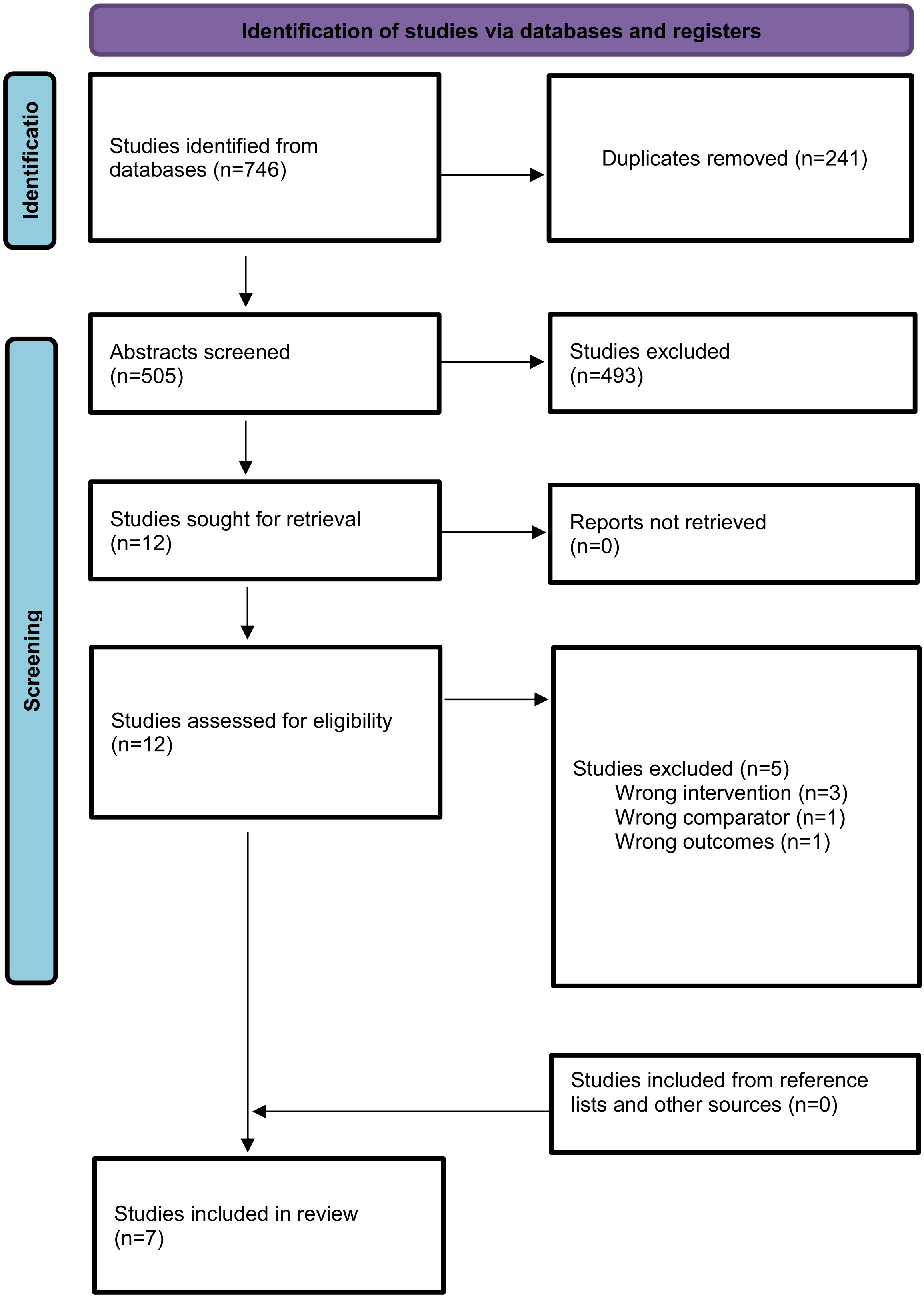

Fig. 1 – Flow chart of inclusion of papers.

approach utilizing the GRADEpro software (McMaster University, 2014).[25]

Results

We identified 746 records. Following removal of duplicates, 505 papers were included for abstract screening. We included 12 papers for full-text screening of which 7 studies were included (Fig. 1).

Study characteristics

We identified 6 randomized controlled trials in a simulated setting[19,26–30] and 1 observational pre-post study on clinical out-of-hospital cardiac arrest.[31] The 6 simulation-based randomized controlled trials were all conducted in a setting of pediatric in-hospital resuscitation of which 5 of the studies were based on the same overall trial conducted across 4 pediatric hospitals in the US and Canada.[19,26,28–30] The different analyses published in this trial included chest compression quality, chest compression pauses, adherence to guidelines, workload, and verbal cues in teams with a CPR coach compared to teams without a CPR coach. One pilot randomized trial on simulated pediatric resuscitation studied CPR quality, workload, and perceived CPR quality.[27] One pre-post study in the clinical setting of adult out-of-hospital cardiac arrest studied CPR quality.[31] The design of each study including a description of the intervention and control groups can be found in Table 1.

Risk of bias assessment and certainty of evidence

Risk of bias assessment for randomized studies is presented in Table 2. Overall, most of the randomized studies had some risk of bias due to deviations from the intended interventions and measurement of outcomes. One observational study was assessed using the ROBINS-I tool and was judged to have critical risk of bias (Supplement 3). The certainty of evidence was rated as very low certainty (downgraded for risk of bias, indirectness, and imprecision) for the outcome of clinical CPR quality. The evidence was also rated as very low certainty for CPR performance in simulation (downgraded for risk of bias and imprecision), teamwork in simulation (downgraded for risk of bias, indirectness, imprecision), and workload in simulation (downgraded for risk of bias, inconsistency, and imprecision). The evidence for guideline adherence in simulation was assessed as low (downgraded for risk of bias, indirectness, and imprecision). The evidence table is presented in Supplement 4.

Outcomes

Detailed outcomes for each study are reported in Table 1. One study reported on clinical CPR performance during out-of-hospital cardiac arrest.[31] They found that the use of a CPR coach was numerically associated with improved fraction of compressions at adequate depth and reduced pre-shock pauses but did not present p-values or confidence intervals assessing statistical significance.

CPR performance in simulation was assessed in 3 studies.[19,27,32] Cheng et al. found a higher fraction of excellent chest compressions, higher fraction of guideline-compliant compression depth, higher chest compression fraction, but no significant difference in guideline-compliant rate for coached vs non-coached teams.[19] In a secondary analysis of this study, they found shorter chest compression pauses for coached vs. non-coached teams.[32] Badke et al. found shorter time to backboard placement when using an untrained CPR coach vs. no coach but no significant differences for other measures of CPR performance, although this study was likely underpowered.[27]

Buyck et al. measured guideline adherence in a simulated setting using a clinical performance tool for teams with vs. without a CPR coach finding higher scores for coached teams vs. non-coached teams.[26] Jones et al. found that CPR-coached teams said more words/per minute compared to non-coached teams, whereas team leaders said less/per minute.[30] Two studies found no significant differences in workload in a simulated setting for team leaders in coached vs. non-coached teams as measured using the National Aeronautics and Space Administration Task Load Index (NASA TLX) questionnaire.[27,28] Tofil et al. found no difference in overall workload for chest compressors but found a lower mental demand and higher physical demand for coached teams vs. non-coached teams.[28]

We identified no evidence for the outcomes of adherence to guidelines in real cardiac arrest and any patient survival outcomes. Moreover, the evidence was insufficient to address any of the pre-specified subgroup analyses.

Discussion

This is the first systematic review to assess the effect of a CPR coach in a resuscitation team treating cardiac arrest patients. We identified 7 studies based on three different cohorts that suggested a positive effect of CPR coaching on CPR quality during cardiopulmonary resuscitation.

The evidence for the use of a CPR coach on resuscitation teams is relevant as CPR coaches are already implemented in several hospitals and emergency medical services systems around the world, and yet no systematic review has assessed their effectiveness.[20,21,31] The identified evidence suggests improved chest compression quality and shorter chest compression pauses when using trained CPR coaches in a setting with feedback devices.[19,31,32] These CPR quality improvements may represent clinically relevant improvements which might be associated with improved survival outcomes in cohort studies.[33–35,7,8] In contrast, we did not find evidence to support that use of a CPR coach reduces cognitive load of the team leader.[27,28] The reason for this is unknown but could possibly be due to a "ceiling effect" as leading a resuscitation attempt is inherently cognitively demanding. Moreover, the studies investigated measures of total workload/ cognitive load as measured by the NASA TLX which may not be affected although the focus and cognitive load may have shifted for specific sub-tasks during CPR, e.g. from CPR quality to addressing reversible causes.

CPR coaches may be used in different ways as part of the resuscitation team. Notably, some settings describe the CPR coach as a new role and a new person on the resuscitation team.[19,21] However, the CPR coach could also be seen as a dynamic role alternating between chest compressors to provide feedback to one another while not doing chest compressions. The latter format may be relevant in limited-resource settings including the pre-hospital setting. Many hospital settings are known to have overcrowding during resuscitations making it feasible to dedicate a separate person to the role of a CPR coach.[36,37] Notably, we only considered CPR coaches being physically present at the time of resuscitation in this review although video coaching has also been described as a potential way to improve CPR quality during out-of-hospital cardiac arrests.[38] Other notable differences in the use of CPR coaches relate

Table 1 – Characteristics of included studies.

Study	Study design	Population	Comparison/ intervention	Results
Infinger 2014[29]	Before-after observational study on clinical OHCA	815 patients. Inclusion criteria: >18y, presumed cardiac etiology. Exclusion: data not available or ROSC prior to EMS arrival	Intervention: Quality improvement initiative including implementation of a fire crew captain to take the role as a CPR Coach, training of the staff, and to optimize location of the monitor during CPR. The comparator was the year before the implementation.	During OHCA, compressions of adequate depth improved from 69.8% to 80.4%. CC depth increased from 43.6 mm to 47.2 mm. Pre-shock pauses reduced from 13.2 s to 7.2 s. No statistical tests reported.
Cheng 2018[16]	RCT	n = 40 teams (200 participants); 20 intervention, 20 control; PICU/PED Healthcare providers as team members with one subject trained as Coach	Control: Team of 5 (two compressors, a team leader, an airway provider, and a bedside nurse). Intervention: Same team but a CPR Coach instead of the bedside nurse. CPR coaches were trained for 1 h including watching a video and simulation training. The coaching role included e.g. standardized phrases to coordinate CC pauses.	The intervention group had higher fraction of excellent CCs (63% vs 31%, $p < 0.001$); higher fraction of correct depth (70% vs 38%, $p < 0.001$), higher CC fraction: (82% vs 77%, $p = 0.04$) but no significant difference in correct CC rate (88% vs 80%, $p = 0.07$).
Badke 2020[25]	Pilot RCT	13 teams; 5 intervention, 8 control. Coaches were critical care nurses > 5 years experience. Team members were PICU providers.	Unannounced in-situ simulations in the PICU. Intervention group, the team leader was instructed to assign the role of CPR Coach to an experienced nurse (not trained for the role). The control group completed the simulation as usual (without a CPR Coach). None had access to CPR feedback devices.	Shorter time to placement of backboard in intervention (22 s vs. 55 s, $p = 0.02$); no difference in CC rate, no flow time, time to first epi, time to first shock, or perishock pause duration. Secondary outcomes: no difference in team leader workload between groups, no difference in perception of CPR quality between groups.
Tofil 2020[26]	RCT	Same cohort as Cheng 2018[16]	Same intervention and control as Cheng 2018[16]	Workload for team leaders was 54.1 (9.8) vs 52.7 (11.6) for teams without vs with a coach, difference: 1.4 (–5.5 to 8.3). There was also no difference for chest compressors: 55.2 (11.2) vs. 55.6 (9.1), diff: 0.4 (–4.9 to 4.2). For chest compressors, there was lower mental demand and higher physical demand for coached teams vs non-coached teams.
Buyck 2021[24]	RCT	Same cohort as Cheng 2018[16]	Same intervention and control as Cheng 2018[16]	Clinical performance tool scores were 73.4 for CPR coached teams vs 68.3 for non-coached teams, (difference: 5.2 points; 95% CI: 1.0–9.3; $p = 0.016$).
Kessler 2021[27]	RCT	Same cohort as Cheng 2018[16]	Same intervention and control as Cheng 2018[16]	Coached teams had a shorter mean CC pause duration than non-coached teams (98.6 s vs 120.9 s; mean difference; 95% CI, 0.6–43.9 s; $p = 0.04$). Coached teams also had shorter pauses for intubation and defibrillation and were more likely to plan interruptions in compressions. There was no significant difference in mean pause frequency between groups (17.6 s vs 15.2 s; 95% CI, –7.17 to 2.47; $p = 0.33$).
Jones 2021[28]	RCT	Same cohort as Cheng 2018[16]	Same intervention and control as Cheng 2018[16]	Coached teams had more words/min (160vs134; $p < 0.05$) overall. Team leaders and others said less/min on coached teams (70.2 vs 88.4 and 30.4 vs 45.6, $p < 0,05$). Total questions/min was reduced on coached teams (2.84 vs 3.66, $p < 0,05$).

Table 1 Study characteristics. RCT: randomized controlled trial, CC: chest compression, CPR: cardiopulmonary resuscitation, PICU: pediatric intensive care unit, PED: pediatric emergency department, ROSC: return of spontaneous circulation, EMS: emergency medical services, OHCA: out-of-hospital cardiac arrest.

Table 2 – Risk of bias assessment for randomized trials (the RoB 2 tool).

	Randomization	Assignment to intervention	Adhering to intervention	Missing outcome	Measurement of outcome	Selection of results	Overall bias
Badke 2020[25]	– (red)	(yellow)	(yellow)	+ (green)	(yellow)	+ (green)	– (red)
Cheng 2018[16]	+ (green)	+ (green)	(yellow)	+ (green)	+ (green)	+ (green)	(yellow)
Buyck 2021[24]	+ (green)	+ (green)	(yellow)	+ (green)	(yellow)	+ (green)	(yellow)
Kessler 2021[27]	+ (green)	+ (green)	(yellow)	+ (green)	(yellow)	– (red)	– (red)
Tofil 2020[26]	+ (green)	+ (green)	(yellow)	+ (green)	– (red)	(yellow)	(yellow)
Jones 2021[28]	+ (green)	+ (green)	(yellow)	+ (green)	– (red)	+ (green)	– (red)

Table 2 Risk of bias assessment using the Cochrane risk-of-bias tool for randomized trials (RoB 2). Red color indicates high risk of bias, yellow indicates uncertain risk of bias, green indicates low risk of bias.

to whether they are trained or not and whether real-time objective feedback is present or not.

Badke et al. investigated the effect of a CPR coach on the resuscitation team without training the CPR coach and without access to real-time feedback from defibrillators.[27] Notably, they only found a shorter time to place a backboard in the CPR coach group without any significant differences in other performance metrics, including chest compression quality. Several reasons may explain this finding if compared to the other studies showing positive effects of implementing a CPR coach.[19,26,29,31] First, training of the CPR coach may positively impact the performance of the CPR coach. Second, lacking access to real-time CPR quality feedback may impede the ability to make a measurable difference in chest compression quality as it is difficult to accurately assess chest compression quality without objective measurements.[39–41] Thus, the use of real-time CPR quality feedback may amplify the effectiveness of CPR coaching. Third, the study by Badke et al. was a pilot study and likely underpowered to show differences in CPR performance.[27]

Overall, the future role and value of a CPR coach may depend on the available staff and equipment. Whether the CPR coach would be an extra team member, a role integrated within an existing role (e.g. managing the defibrillator), or a dynamic person (e.g. alternating between chest compressors) may depend on the setting and available resources. Moreover, the effect of a CPR coach may be more impactful in terms of coordinating placement of team members and equipment, coordinating chest compression pauses and minimizing pause durations and less impactful for improvements in chest compression depth in a setting without access to CPR feedback devices. However, further research is needed to identify how different ways of integrating a CPR coach can impact teamwork and CPR performance.

This review identified several knowledge gaps. There is a pressing need for more evidence on CPR coaches, particularly randomized trials and clinical trials. We did neither identify evidence for guideline adherence in real cardiac arrest, survival outcomes, or cost-effectiveness nor did we identify sufficient evidence to address the pre-specified subgroup analyses. While use of a CPR coach did not affect overall workload of the team leader as measured by the NASA TLX, future studies should investigate more direct measures of cognitive load and whether use of a CPR coach changes task prioritization and cognitive load for sub-tasks during resuscitation attempts. Finally, knowledge gaps remain in terms of how to optimally train for the role of a CPR coach, how to implement the CPR coach in different settings (e.g. the out-of-hospital setting with limited personnel), and how different ways of utilizing the CPR coach affect team performance.

Limitations

This systematic review included predominantly studies from simulated settings of which 5 out of 7 studies were based on the same cohort from a randomized simulation trial.[19] We included studies where a CPR coach was physically present on the team only and did not consider bundled interventions or online video coaching. The risk of bias, indirectness and imprecision led to low certainty evidence. Because of limited evidence, clinical heterogeneity and several studies based on the same cohort, we were unable to conduct any *meta*-analyses.

Conclusions

The available evidence supports the use of a CPR coach as part of the resuscitation team to improve CPR quality and guideline adherence. Current evidence is based on few studies with low certainty evidence and as such, further research is needed, in particular for clinical CPR performance and patient outcomes.

Conflicts of interest

KGL, AD, SN, YL, and AC are members of the ILCOR EIT Task Force (AC as vice chair). YL, JD, and AC are all authors on several of the studies on CPR coaching and did not participate in article screening, data extraction or risk of bias assessment of papers they had authored. KGL is associate editor for Resuscitation Plus and AC is editorial board member. KGL and AC had no role in reviewing or in the decision process for this manuscript at Resuscitation Plus.

CRediT authorship contribution statement

Kasper G. Lauridsen: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Emma Bürgstein:** Writing – review & editing, Investigation, Formal analysis. **Sabine Nabecker:** Writing – review & editing, Investigation, Formal analysis. **Yiqun Lin:** Writing – review & editing, Investigation, Formal analysis. **Aaron Donoghue:** Writing – review & editing, Investigation, Formal analysis. **Jonathan P. Duff:** Writing – review & editing, Investigation, Formal analysis. **Adam Cheng:** Writing – review & editing, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

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Author details

for the International Liaison Committee on Resuscitation Education, Implementation, and Teams Task Force [a]Department of Anesthesiology and Intensive Care, Randers Regional Hospital, Denmark [b]Department of Clinical Medicine, Aarhus University, Denmark [c]Research Center for Emergency Medicine, Aarhus University Hospital, Denmark [d]Department of Anesthesiology and Critical Care Medicine, Children's Hospital of Philadelphia, United States [e]Department of Anesthesiology and Pain Management, Mount Sinai Hospital, Canada [f]KidSIM-ASPIRE Simulation Research Program, University of Calgary, Canada [g]Department of Anesthesia and Critical Care Medicine, University of Pennsylvania Perelman School of Medicine, USA [h]Department of Pediatrics, University of Alberta, Canada [i]Departments of Pediatrics and Emergency Medicine, Alberta Children's Hospital, Canada

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