Effects of team coordination during cardiopulmonary resuscitation: A systematic review of the literature

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Abstract
Purpose: The purpose of this study is to identify and evaluate to what extent the literature on team coordination during cardiopulmonary resuscitation (CPR) empirically confirms its positive effect on clinically relevant medical outcome.
Material and Methods: A systematic literature search in PubMed, MEDLINE, PsycINFO and CENTRAL databases was performed for articles published in the last 30 years.
Results: A total of 63 articles were included in the review. Planning, leadership, and communication as the three main interlinked coordination mechanisms were found to have effect on several CPR performance markers. A psychological theory–based integrative model was expanded upon to explain linkages between the three coordination mechanisms.
Conclusions: Planning is an essential element of leadership behavior and is primarily accomplished by a designated team leader. Communication affects medical performance, serving as the vehicle for the transmission of information and directions between team members. Our findings also suggest teams providing CPR must continuously verbalize their coordination plan in order to effectively structure allocation of subtasks and optimize success.
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1. Introduction

Every 5 years, international resuscitation organizations (eg, such as the European Resuscitation Council) publish updated guidelines based on the latest medical research on cardiopulmonary resuscitation (CPR) [1]. The Advanced Life Support (ALS) Guidelines provide an algorithm for how CPR subtasks should be optimally organized and synchronized during the resuscitation process. Task synchronization requires assignment and coordination of responsibilities among rescue team members, which can be an additional challenge yet essential for efficiency of CPR as well as patients' and team members' safety [2,3].

During CPR, the team of health care providers typically functions in a setting characterized by high levels of stress [4], time pressure, and impending danger to the patient [5]. It is because of these inherent characteristics of CPR—high-stakes, complex, team-administered, and clarity of shared goal—that we conduct a systematic literature review of team

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coordination in CPR to establish how team coordination contributes to the quality of CPR.

Team coordination is defined as the management of interdependencies of subtasks by regulated action and information flow in order to achieve a common goal, that is, the performance of high quality CPR [6]. This comprises task management, leadership, and communication as essential prerequisites of effective teamwork and, thus, the resulting quality of CPR and patient safety [7]. Faulty team coordination has been widely recognized as a factor contributing to medical errors [8], and the positive relationship between effective teamwork and patient outcome is supported in other dynamic domains of healthcare [9].

The coordination requirements of CPR are well described by Tschan et al [10], who provide a hierarchical task analysis (HTA) on the basis of the aforementioned ALS Guidelines. Their HTA identifies the goal dependencies which emergency teams have to manage during CPR and what types of coordination mechanisms are suitable to successfully accomplish these goal dependencies. The core goals outlined are (1) diagnosing the cardiac arrest, (2) oxygenating the brain, and (3) attempting to re-establish spontaneous blood circulation, which are further broken down into hierarchies of subgoals.

The benefits of effective team coordination in CPR are substantive. For example, Fernandez Castelao et al [11] showed a positive relationship between well phrased leadership utterances, functioning as a coordination mechanism, and no-flow time. The provision of less or poorly articulated leadership utterances was found to be related to treatment delays, which in turn correlate with morbidity [12].

International guidelines [1,13] all focus on describing the optimal sequence of medical actions during a CPR but without specific reference to coordination as the facilitator for seamless transition between completions and beginnings of each subgoal to avoid time loss and thereby increase survival rate [14]. Based on task analysis [10] and related empirical findings [9,15], team coordination and CPR performance seem to be closely linked. The literature also contains a rich body of research regarding team coordination methods in emergency medical teams, how the nature of a task defines whether explicit or implicit methods are optimal, and how these 2 general methods interact to achieve team goals [16–18].

This review examines whether and to what extent team coordination in CPR is empirically confirmed as affecting clinically relevant outcome, with particular focus on findings that contribute to improvement of current ALS Guidelines. Furthermore, the quality of the included articles will be assessed by defining level of evidence (LOE)—which indicates risk of bias—and level of concreteness (LOC)—which indicates lucidity of the reckoning coordination behavior. Finally, we aim to organize the findings into meaningful patterns by deducing a coordination mechanism model based on Hacker's (2003) action regulation theory (ART) [19]. As the ART perceives thought and action of individuals as an interlinked process it was widely used as a

theoretical approach for structuring and designing work processes [20]. Thus, the ART provides the necessary background for creating a model to reflect and analyze goal-oriented interpersonal action processes like CPR in order to improve effectiveness [19].

2. Methods

2.1. Search strategy for identification of relevant papers

The procedure to identify publications relevant for this review is based on the Cochrane guidelines for designing systematic reviews [21].

2.1.1. Step 1
A computerized literature search of electronic databases PubMed, MEDLINE, PsycINFO, and CENTRAL was performed in September 2011, limited to the last 30 years. The search focus was journal articles on potential impact of coordination behavior regarding CPR, using all meaningful combinations of two groups of search terms (Fig. 1). Keyword combinations within each of the 2 groups were not applied. Duplicates were excluded from the sample resulting from Step 1.

2.1.2. Step 2
All study titles were screened by the lead author (EFC) for relevance to this review. To assure selection reliability, a second author (MR) independently reviewed a random 20% subset of the titles (n = 1008). The inter-rater agreement was almost perfect (κ = 0.91) [22].

2.1.3. Step 3
The abstracts of the remaining publications were further screened for relevance. Inter-rater agreement between EFC and MR—based on the decision whether to include or discard each of the remaining articles (n = 462)—at this step was also almost perfect (κ = 0.81) [22]. The references of the end-selected articles were perused to identify further appropriate literature, which were then added to the starting pool of this same step.

2.1.4. Step 4
The remaining articles were screened according to our two criteria: (1) the main findings offer empirical evidence of team coordination in CPR or related medical emergencies (eg, trauma resuscitation) concerning a link between coordination efforts and performance effectiveness; and (2) the article was published in a peer reviewed journal. Once again, inter-rater reliability between EFC and MR was calculated based on the decision whether to include or discard the remaining articles (n = 191) (κ = 0.81) [22].

2.1.5. Step 5
The selected articles were sorted into topic categories and assessed for quality, with particular attention to the