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Effects of team leaders' position in cardiopulmonary resuscitation teams on leadership behavior and team performance

A prospective randomized interventional cross-over simulation-based trial

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Abstract

Background: Leadership is an important performance factor in resuscitation teams. Medical guidelines for cardiopulmonary resuscitation (CPR) advise team leaders to keep hands off patients. There is little evidence for this recommendation that is based purely on observational data. Accordingly, the aim of this trial was to investigate the effect of leaders' position during CPR on leadership behavior and team performance.

Method: This is a prospective randomized interventional crossover simulation-based single center trial. Teams of 3 to 4 physicians each, representing a rapid response team, were confronted with a simulated cardiac arrest. Team leaders were randomly assigned and assigned team leaders were 1:1 randomized to 2 leadership positions: position at the patient's head; and hands-off position. Data analysis was performed from video-recordings. All utterances during the first 4 minutes of CPR were transcribed and coded based on a modified "Leadership Description Questionnaire." The primary endpoint was the number of leadership statements. Secondary outcomes included CPR related performance markers like hands-on time and chest compression rate, and the behavioral related endpoints Decision Making, Error Detection, and Situational Awareness.

Results: Data from 40 teams (143 participants) was analyzed. Leaders in hands-off position made more leadership statements (28 ± 8 vs 23 ± 8; $P < .01$) and contributed more to their team's leadership (59 ± 13% vs 50 ± 17%; $P = .01$) than leaders in the head position. Leaders' position had no significant effect on their teams' CPR performance, Decision Making, and Error Detection. Increased numbers of leadership statements lead to improved hands-on time ($R = 0.28$; 95% confidence interval 0.05–0.48; $P = .02$).

Conclusions: Team leaders in a hands-off position made more leadership statements and contributed more to their teams' leadership during CPR than team leaders actively involved in the head position. However, team leaders' position had no effect on their teams' CPR performance.

Abbreviations: AHA = American Heart Association, CPR = cardiopulmonary resuscitation.

Keywords: cardiopulmonary resuscitation; leadership; medical team leader; simulation; team performance

1. Introduction

Leadership is important for teams.[1] Medical teams often are fluid in the sense that members may not know each other or at least are not familiar with each other to a degree that enables implicit coordination.[2–4] Explicit leadership therefore suggests itself, and in teams dealing with a task that does not pose many problems for diagnosis and consists of well-defined steps, such as cardiopulmonary resuscitation (CPR), directive leadership may be most appropriate.[5–7]

High-quality CPR and early defibrillation in patients with cardiopulmonary arrest are key elements for improving patient survival and morbidity. High-quality CPR is defined by early

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

This is an investigator-initiated trial without external funding. The local ethics committee approved the study (Institutional Review Board, www.eknz.ch; 85/04). The trial was registered (Clinical.Trials.gov NCT04824508). Video recordings are strictly confidential and cannot be shared. Extracted data supporting reported results are available on request from the corresponding author.

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and correctly applied chest compression rates, chest compression depth and minimal interruptions of the process.[8–11] Even minimal delay of CPR has been associated with poor outcomes, and survival decreases at 5% 10% per minute without CPR. Despite this knowledge and development of easy-to-use algorithms for cardiac life support, observational data have repeatedly demonstrated insufficient quality of CPR, even among healthcare professionals.[12–16]

In 1999 Cooper found that quality of resuscitation, team structure, and team cooperation significantly increased if the leaders worked "hands-off" as compared to "hands-on" (leaders also perform resuscitation tasks).[6] Subsequent investigations revealed a relationship of resuscitation performance with poor team collaboration, team building, and leadership, which is in line with results showing better performance after training in non-technical skills.[17] Especially the absence of leadership behavior was associated with poorer team performance.[5,12,15,18–21] In line with such findings, recommendations for teamwork and leadership skills training,[22,23] and also the recommendation for team leaders to stay away from the patient and not to be involved in active treatment have been implemented into international guidelines for advanced life support.[24]

The advantages of a so called "lighthouse leadership" seem very plausible. But in CPR of patients without prior monitoring and in situations with limited numbers of advanced resucers as for instance in the very first minutes of an in-hospital cardiac arrest or prehospital care a position that allows overview is at the head of the patient. Although this allows a good overview in the beginning, often, the leader takes over patient ventilation and other patient interactions in this position, which may distract.

Given the recommendation by the American Heart Association (AHA) and its apparent plausibility but a dearth of confirming evidence, we investigated differences in leadership and performance between teams with assigned team leaders being in a hands-off versus in a head position. We hypothesized that leaders in the hands-off position would exhibit more leadership statements, and that teams with leaders in hands-off position would show better CPR performance.

2. Materials and methods

2.1. Setting and participants

This is a prospective, interventional, randomized, cross-over, single-blind, and single-center trial conducted in the Simulation Center of a Medical Intensive Care Unit (ICU) of a Swiss University Hospital. Participants were experienced in-house physicians and general practitioners participating in voluntary simulator-based educational workshops and were randomly assigned to teams of 3 to 4 participants each. During their simulation, participants were not aware of the purpose of the trial (single-blind design). All participants provided written informed consent after having watched the video recorded during their simulation and being informed on the purpose of the trial.

2.2. Simulator

We used a remote-controlled high-fidelity mannequin (SimMan® 3G; Laerdal Medical AS, Stavanger, Norway). The cardiac arrest was displayed by absent pulses and heart sounds, absence of breathing, closed eyes, and ventricular fibrillation visible once the patient was connected to a monitoring device. In addition, an intravenous line was already in place for this simulation. With its life-size, the mannequin allows for realistic interactions. More detailed information has been published previously.[12,25] The simulator room was equipped according to a trauma bay with a standard monitor, oxygen wall mounts, suctioning tools, a manual external defibrillator, emergency medication, and advanced airway procedure equipment. Participants were instructed on technicalities of the simulator immediately before the start of the scenario.

2.3. Scenario

The participants were instructed to represent the rapid response team of the facility. The scenario was a witnessed in-hospital cardiac arrest due to ventricular fibrillation of an adult person in the emergency department who shortly before presented with acute chest pain. The nurse (embedded simulation participant), who detected the patient unresponsive to verbal stimulus while in the patient's bay, called the teams to the scene. The patient was in supine position on a hospital bed and not connected to a monitor.

The nurse was present during the scenario to support the participants in case of problems with handling of devices or for scenario-based questions and could be asked to perform any task during the scenario like any team member. However, the nurse was instructed not to act unless asked, and not to provide any information about advanced life support algorithms. Every team underwent 2 successive, equal scenarios of a duration of 4 minutes. Scenarios were stopped after 4 minutes regardless of the current teams' activities. The investigation of the first 4 minutes was based on the consideration that effective cardiopulmonary life support in the very first minutes after cardiopulmonary arrest has the highest impact on survival and morbidity.[8,11] During the study time of 4 minutes the patient stayed in ventricular fibrillation rhythm regardless of interventions performed.

2.4. Randomization and interventions

Randomization was carried out by a study physician using sealed envelopes. For every scenario, 1 team member was randomly assigned to be the designated team leader and was wearing a colored vest to be identified in the subsequent coding process. Block randomization was used to enable equal gender distribution among leaders. Moreover, the designated team leader was randomly assigned to lead the team from either the head position or the hands-off position. The study physician instructed the team leaders about their role immediately prior to the scenario. Leaders in the hands-off position were instructed to lead their team "without touching anything" and standing clear of the patient. Leaders in the head-position were given the instruction to "lead their team from the position on the patient's head" while fulfilling additional tasks that they may encounter during the scenario. Furthermore, it was randomly determined whether the first scenario started with the team leader in the head-position or hands-off. Apart from the leaders' position allocation, scenarios were identical in both study arms.

2.5. Data coding and analysis

Based on video-recordings of the scenarios we transcribed every utterance and referenced them to the source team member in a second-per-second protocol. In a second step, the utterances were coded into categories of leadership as defined below, or other statements. In the same second-per-second protocol, we also coded team members' actions (e.g., defibrillations, chest compressions, ventilation). Data were analyzed within the first 240 seconds of the scenario, starting when a team member first touched the patient (defined as the first interaction with the mannequin after receiving the scenario information by the study nurse).

2.6. Outcomes

2.6.1. Primary endpoint. The primary endpoint was the number of leadership statements. Leadership statements referred to "task distribution" (e.g., "I want you to perform chest compressions"), "decision what to do" (e.g., "we need to defibrillate now"), "decision how to do" (e.g., "We need to shock with 200 Joules!"), "commands," "corrections," "planning work ahead," and "meaningful measures without further comment" based on a modified "Leadership Description Questionnaire" used in previous studies,[25] adapted from

Cooper and Wakelam,[6] which, in turn, is based on the Leadership Behavior Description Questionnaire.[26]

2.6.2. Secondary endpoints. Secondary endpoints referred to total leadership statements and to quality markers of cardiopulmonary resuscitation. We assessed hands-on time, a core indicator of CPR performance,[25] and broke it down to the time windows of the first 60, 120, 180, and 240 seconds. Further quality markers were chest compression rate,[27] time to the first critical decision (see below), time to first defibrillation, and premature administration of epinephrine, defined as administration of the first dose of epinephrine prior to the second countershock or the administration of the second dose of epinephrine prior to 3 minutes after the first dose.[24] We also assessed to what degree team members reacted to a leadership statement, in terms of task fulfillment, which we called followership.[28]

We defined hands-on-time as time (seconds) of continuous chest compressions or defibrillation/ventilation. Each defibrillation counted up to 10 seconds of hands-on-time unless the interruption of chest compression exceeded 10 seconds. Interruptions of chest compressions to allow for ventilation were considered as continuous chest compressions if the interruption was ≤ 5 seconds.[11,29,30] We calculated the average of chest compression rate during the third minute after the onset of the cardiac arrest using a previously published formula[27]: Compression rate = (compressions per 60-second segment) × 60/(60 − total pause time in the 60-second segment). Pause time indicates periods of time in which ≥ 2 seconds (necessary amount of time to code in the per-second-protocol) pass without chest compressions.[25,27]

Behavioral markers in secondary outcomes were leaders' task violation, defined as the time spent with any task deferring from their allocated role in the hands-off or head position respectively (e.g., operating defibrillator in hands-off position); utterances leading to deviation from resuscitation guideline algorithms; Decision Making; Error Detection; and Situational Awareness, following Saiboon and colleagues.[31,32] We adapted and analyzed these parameters as follows:

For Decision Making, we followed Hochstrasser et al[33] and used the term "critical treatment decision" to define a small number of crucial leadership statements leading to critical treatment changes or decisions. Specific decisions could count for the total of "critical treatment decisions" only once (e.g., "start CPR now," "start ventilation," "give epinephrine"), others multiple times (e.g., "defibrillate now," "restart CPR"). Performing such a task without prior request by any team member was also treated as a "critical treatment decision." For Error Detection we coded utterances or actions leading to avoid deviations from AHA[8] or European resuscitation council[29] algorithms (e.g., timing of defibrillation, timing of epinephrine administration) or to improve crucial parameters for CPR performance (CPR frequency, ventilation, mask positioning, etc.). For Situational Awareness we compared the time to the first rhythm diagnosis and to the first critical decision (first critical decision; i.e. beginning of ventilation, CPR, defibrillation, epinephrine, or precordial thump) between the groups.[33]

For leadership statements leading to deviation from the algorithm (according to the resuscitation guidelines), we assessed the accuracy of timing of rhythm analysis/defibrillation (after 2 minutes or 5 cycles of CPR respectively) and timing of specific drug administration and dosage; accurate timing of CPR cycles was defined as the time interval recommended by the guidelines +/− 10%.[8,29]

2.7. Statistics

A power analysis revealed that 34 teams had to be included to detect an effect size of 0.5 with an α of 0.5 and a β of 0.8. To account for drop-outs we decided to include 40 teams.[34]

Data are expressed as means ± standard deviation unless otherwise stated. Statistical analysis was performed using SPSS (IBM Corp, Released 2021, IBM SPSS Statistics for Windows, Version 28.0, Armonk, NY: IBM Corp) and included the paired *t* test, the chi-square test, and regression analysis as appropriate. A $P < .05$ (2-tailed) was considered to represent statistical significance.

3. Results

Of 40 Teams (143 participants) included, 1 team (4 participants) had to be excluded in the primary endpoint analysis due to missing audio recording, so data from 39 teams/143 participants were analyzed (Fig. 1). Leader in head position was the first scenario in 20 teams and leader in hands-off position was the first scenario in 20 teams. 35/80 team leaders were male and 45/80 female respectively, whereas 16/40 team leaders in the head position were male and 24/40 female respectively (Table 1). Seven percent of our participants were senior physicians in intensive care, 27% resident physicians in intensive care, 5% senior physicians in internal medicine, 40% general practitioners, and 20% resident physicians in internal medicine respectively. We have no additional information about the participants' professional education, degrees, or last update in advanced cardiopulmonary life support.

3.1. Primary outcome

Leaders in the hands-off position made significantly more leadership statements than leaders in the head position (Fig. 2; Table 1) and contributed more to their teams' total number of leadership utterances. However, the total number of all within-team leadership statements did not depend on the position of the team leader.

3.2. Secondary outcomes

During de scenarios the leaders displayed great adherence to the interventional task they had been given. The time spans in which they did not adhere to the assigned leadership task consumed less than 10% of the simulation duration and showed no significant difference between the groups (hands-off vs head position; 14 ± 27 seconds vs 18 ± 47 seconds; $P = .58$).

3.2.1. Leadership statements and CPR performance. In regard to subgroups of leadership statements, leaders in the hands-off position made more leadership statements related to task distribution and planning ahead (Table 2). There was no difference in other leadership statements.

The investigation of CPR performance showed that team leaders irrespective of their position contributed around 90% to utterances leading to deviation from the algorithm but there was no significant difference in overall leadership utterances leading to deviation from the algorithm between the groups. The overall followership was very high. Looking at the quality markers of CPR (Table 3), we could not show a significant difference between the 2 groups. Overall, around 60% of both groups showed premature administration of epinephrine independent on the leaders' positions.

Regardless of the leaders' position, their total number of leadership statements were significantly associated with hands-on time (Fig. 3; $R = 0.28$; 95% confidence interval 0.05–0.48; $P = .02$), meaning more leadership statements lead to increased hands-on time. Leadership utterances within teams, that is, regardless of their source, did not correlate significantly with any quality marker (performance) of CPR.

3.2.2. Behavioral markers. Looking at Situational Awareness the team leaders in hands-off position contributed more frequently to recognition and verbalization of ventricular fibrillation or initiation of defibrillation without any comment (Table 2). Nonetheless, the leaders' positions had no significant

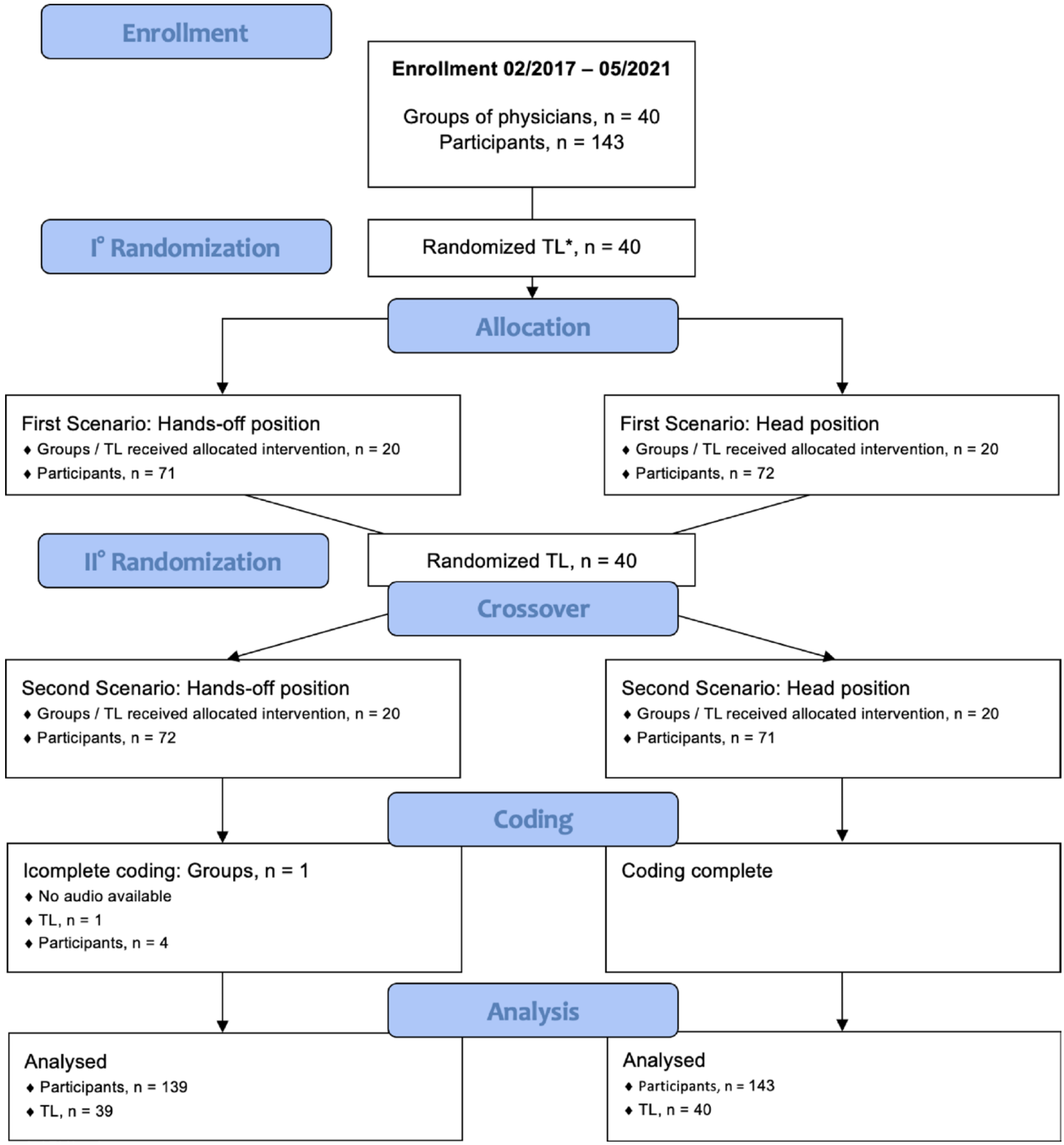

Figure 1. CONSORT flow diagram. TL = team leaders.

effect on the timing of the first rhythm diagnosis or the first critical decision.

Regarding Decision Making and Error Detection, we could not demonstrate significant differences with regard to the teams or the leaders only. The prevalence of utterances and actions for Error Detection was very low throughout all participants (Table 2).

4. Discussion

The present study demonstrates that resuscitation team leaders in a hands-off position make more leadership statements and contribute more to their teams' leadership than leaders positioned at the head of the patient within the first 4 minutes of cardiopulmonary resuscitation. In addition, team leaders standing clear of the patient provide more leadership statements with "task distribution" and "planning ahead." Nevertheless, the position of the team leader did not affect team performance in CPR. However, regardless of the leaders' positioning, active leadership of team leaders, in terms of the total number of leadership statements, was associated with better CPR performance in regards of hands-on times. These results converge with those of Saiboon and colleagues[31] who also reported that the physical positioning of the leader had no effect on situational attentiveness, error detection and decision making. It may be due to the plausibility for the hands-off leader that team leader positioning during resuscitation has hardly been investigated. But surprisingly, these researchers found a trend towards better performance of leaders at the head-end position, despite the majority of participants preferring the leg-end position. However, these authors did not investigate the effects of positioning on leadership statements. Moreover, all non-leading team members in

Table 1

Baseline characteristics and primary endpoint results.

	Hands-off (n = 40)	Head (n = 40)	Paired Diff.	SD	95% CI	*P* value
Baseline characteristics						
Team size (mean)	4	4				
Female Team members (mean)	2	2				
Female Leaders [n]	21	24				
First Scenario [n]	20	20				
First Scenario Female Leader [n]	11	8				
I° Endpoint						
Total LS by Team [n]	48 ± 10	47 ± 7	1.6	8	-1.2-4	.25
Total LS by Leader [n]	28 ± 8	23 ± 8	5	11	2-8	<.01
Relative LS by Leader [%]	59 ± 13	50 ± 17	9	21	2-15	.01

CI = confidence interval, LS = leadership statements, SD = standard deviation.

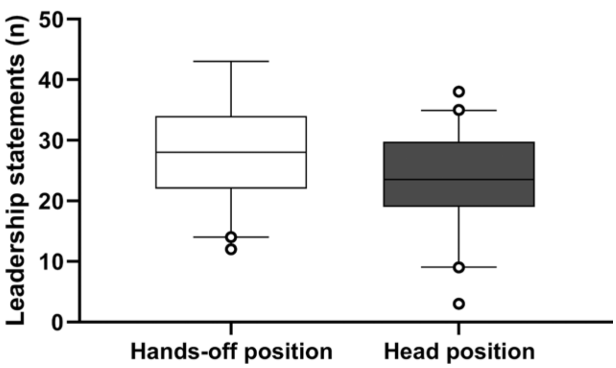

Figure 2. Leadership statements by team leaders according to team leader position.

their study were confederates, so that many important aspects of teamwork as well as performance were not assessable.[31]

The current study is one of very few investigating physical positioning of team leaders, which may be particularly important in teams in which task execution is tied to specific physical positions. In spite of the findings by Cooper and Wakelam[6] and the recommendations by the International Consensus on Cardiopulmonary Resuscitation[23] and their apparent plausibility, we did not find performance differences associated with physical positioning of the leader. We surmise that this result is due to the team members' expertise relative to the task. They most likely were able to work with a minimum of cues on which they could base their actions, including leadership statements. This could enable them to enact the necessary behavior based on few leadership statements, akin to implicit coordination.[2–4] Alternatively, leadership may have a ceiling effect so that additional leadership does not have much benefit. It also is possible that counting leadership statements is too crude a measure of leader behavior and needs to be refined and complemented, for instance by assessing nonverbal communication that often accompanies verbal statements.[17] Clearly, this issue needs further investigation.

Even though we could not show performance differences in CPR dependent on the leaders' position, we could show a significant difference regarding subgroups of leadership statements. Utterances concerning "task distribution" and "planning ahead" can be considered more complex leadership statements than for example, "commands" or "decision what" should be done, since a task has to be assigned to specific team members or multiple tasks have to be processed and put into an order. We conclude that team leaders standing clear of the patient are capable of performing more complex cognitive tasks, and able to adjust their leadership behavior more flexibly. Moreover, the first means of actions during AHA and European resuscitation council resuscitation algorithms are very basic and contribute to the first couple of minutes in a resuscitation scenario.[8,29] After the first interactions with the patient, more complex processes start to become necessary, for example, taking patient history, decision for diagnostic measures or treatment options and further patient management. These steps require more cognitive flexibility and team leaders clear of the patient could be expected to excel fulfilling these tasks as compared to leaders at the patients' head. However, it is important to note that once the primary resuscitation is under way, task distribution and decision-making is not as time dependent anymore as it is in the very first sequence when encountering a patient with cardiac arrest. Therefore, in this crucial period, it might be more difficult to show a difference in CPR performance influenced by team leaders' position.

Interestingly, regardless of the team leaders' position more than 50% of our teams administered epinephrine prematurely: time to the first administration averaged by about 150 seconds while the time to the first defibrillation averaged by about 110 seconds. The reason for the premature adminstration of epinephrine remains unclear and might result from many factors like lack of knowledge, unfamiliar team members and environment, and stress, of course.[35]

The finding that a higher number of leadership statements was associated with better performance underscores the role of directive leadership in situations that are characterized by a clear algorithm regarding necessary actions, and by considerable time pressure. This does not imply, however, that directive leadership is appropriate throughout,[36] and leaders should be able to flexibly adjust their leadership behavior to situational requirements, with directive leadership being especially appropriate if urgency is high.[37] In previous studies it was shown how human factors and training of leadership behavior can positively influence CPR performance, which aligns with the findings in this study that the total number of leadership statements goes along with better hands-on time.

However, if we look closer at our results in hands-on time irrespective of the leaders' positions there is still a lack of performance especially in the first minute, when the groups did not start CPR within the first 30 seconds. Also, with every additional minute the groups lost about 10 seconds or 16% of possible hands-on time. This resulted mostly from teambuilding difficulties before or during start of CPR, from secondary medical interventions (e.g., pulse check, rhythm check) as well as dealing with devices such as defibrillator and monitors. In this case, leadership is only one of multiple means to address the lack of performance during these known situations.[3,15,20,37] Moreover, it was mostly team leaders who contributed to utterances leading to deviation from the CPR treatment algorithms in our findings. Together with the high followership throughout the teams, this carries the risk of "mis-leading" the team into committing errors. We therefore emphasize not only the importance to train and encourage team leaders in utilizing brief leadership statements in time critical situations like resuscitation but also—as a matter of course—being aware of recent guidelines.[12,20,25] Furthermore, team members should be encouraged to speak up if they notice inappropriate actions and suggestions.[38]

4.1. Limitations and strengths

The fact that we assessed videotaped simulated in-house cardiac arrest scenarios with a mannequin instead of real-life events implies several limitations, which are well known and previously described.[39] Thus, we tried to conduct the study in an environment that was equipped as realistic as possible (e.g., the possibility to make phone calls). Furthermore, some of our measures, such as Situational Awareness, represent proxies rather

Table 2

Secondary endpoint results.

]	Hands-off (n = 40)	Head (n = 40)	Paired Diff.	SD	95% CI	*P* value
Task Violation by Leader [s]	14 ± 27	18 ± 47	–5	53	–22 to 12	.58
LS by Leaders—Subgroups						
Task Distribution [n]	7.9 ± 4.5	5.3 ± 2.6	2.7	4.5	1.2 to 4.1	<.01
Decision What [n]	9.0 ± 3.8	9.4 ± 5.7	–0.4	5.8	–2.3 to 1.5	.66
Decision How [n]	3.1 ± 2.3	2.5 ± 1.9	0.6	3.1	–0.4 to 1.6	.21
Commands [n]	5.5 ± 3.7	5.2 ± 4.4	0.3	5.3	–1.4 to 2.0	.72
Corrections [n]	0.3 ± 0.6	0.3 ± 0.7	0.02	0.9	–0.3 to 0.3	.86
Planning Ahead [n]	1.3 ± 1.4	0.6 ± 0.8	0.7	1.3	0.2 to 1.1	<.01
Performance						
LS to Deviation from Algorithm						
Total [n]	2.4 ± 2	2.5 ± 2	–0.2	2	–1 to 0.5	.65
Leader [%]	91 ± 24	87 ± 24	4	33	–7 to 16	.46
Followership [%]	92 ± 6	91 ± 5				.97
Behavioral						
SA						
Time to Rhythm Diagnosis [s]	97 ± 50	83 ± 26	14	55	–4 to 32	.12
Rhythm Diagnosis by Leader [%]	72 ± 45	44 ± 50	28	45	13 to 42	<.01
FCD commanded by Leader [%]	64 ± 49	72 ± 46	–8	66	–29 to 14	.47
ED						
Total by Team [n]	0.6 ± 0.8	0.5 ± 0.6	0.1	1.1	–0.3 to 0.5	.56
ED by Leader [%]	41 ± 68	38 ± 63	3	100	–32 to 37	.88
DM						
Total by Team [n]	6.6 ± 1.9	7 ± 1.6	–0.4	2.4	–1.1 to 0.4	.35
DM by Leader [%]	80 ± 18	72 ± 26	8	5	–3 to 18	.14

CI = confidence interval, DM = decision making, ED = error detection, FCD: first critical decision (i.e., beginning of ventilation, CPR, defibrillation, epinephrine, or precordial thump), LS: leadership statement, SA = situational awareness, SD = standard deviation.

Table 3

Performance parameters—secondary endpoint results.

	Hands-off (n = 40)	Head (n = 40)	Paired Diff.	SD	95% CI	*P* value
Hands-on Time						
0–60 s [s]	28 ± 13	30 ± 12	–1.5	17	–7 to 4	.59
0–120 s [s]	79 ± 16	80 ± 14	–1	19	–7 to 5	.74
0–180 s [s]	131 ± 23	129 ± 18	1.8	24	–6 to 10	.64
0–240 s [s]	182 ± 28	180 ± 22	1.4	25	–7 to 10	.75
Chest Compression Rate [min^{-1}]	108 ± 14	113 ± 16	–4.6	15	–9 to 0.1	.06
Time to FCD (SA) [s]	31 ± 14	30 ± 15	1.3	19	–5 to 7	.67
Time to Defibrillation [s]	117 ± 40	107 ± 32	9	45	–5 to 24	.21
Time to Epinephrine [s]	157 ± 45	148 ± 50	8	58	–16 to 32	.50
Premat. Epinephrine [n]	22	25				.65

CI = confidence interval, FCD = first critical decision (i.e., beginning of ventilation, CPR, defibrillation, epinephrine, or precordial thump), Premat = epinephrine: premature administration of epinephrine, SA = situational awareness, SD = standard deviation.

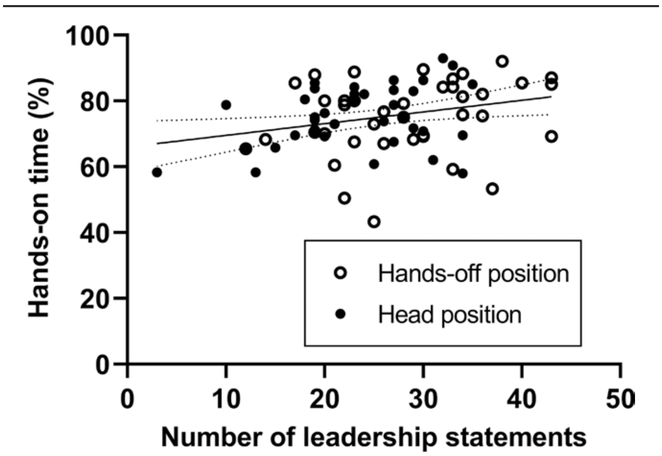

Figure 3. Increase in hands-on time with increasing number of leadership statements.

than elaborated measures.[32] Together with these limitations come the advantages of identical conditions in simulated scenarios, which allow for reproducibility and within study liability. However, simulation also implies limited generalizability.[39] Furthermore, the scenario's duration of 4 minutes is a limitation and might be too short or a wrong time frame to show how team leaders being hands-off the patient could lead their teams more effectively when more complex decision making comes into place.

Further limitation include the single center design, a heterogeneous group of physicians in different stages of their education, and the scarce demographic data. Thus, our findings may not be applicable to more experienced rescuers. However, it is often inexperienced rescuers who are the first to witness cardiac arrest situations, including in-house cardiac arrests.[40,41] This underlines the importance of the assessment and training of this specific group.

Strengths of this study are the prospective, 2 stage randomization to wash out bias for gender differences and learning effects along the scenario sequence.

5. Conclusion

In this randomized simulation-based trial team leaders in hands-off position made more leadership statement and contributed more to their teams' leadership statements than team leaders positioned at patients' head. However, team leaders' position had no effect on their teams' CPR performance.

Author contributions

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