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Simulation and education

Standardising communication to improve in-hospital cardiopulmonary resuscitation

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Abstract

Aim: Recommendations for standardised communication to reduce chest compression (CC) pauses are lacking. We aimed to achieve consensus and evaluate feasibility and efficacy using standardised communication during cardiopulmonary resuscitation (CPR) events.

Methods: Modified Delphi consensus process to design standardised communication elements. Feasibility was pilot tested in 16 simulated CPR scenarios (8 scenarios with physician team leaders and 8 with chest compressors) randomized (1:1) to standardised [INTERVENTION] vs. closed-loop communication [CONTROL]. Adherence and efficacy (duration of CC pauses for defibrillation, intubation, rhythm check) was assessed by audiovisual recording. Mental demand and frustration were assessed by NASA task load index subscales.

Results: Consensus elements for standardised communication included: 1) team preparation 15–30 s before CC interruption, 2) pre-interruption countdown synchronized with last 5 CCs, 3) specific action words for defibrillation, intubation, and interrupting/resuming CCs. Median (Q1,Q3) adherence to standardised phrases was 98% (80%,100%). Efficacy analysis showed a median [Q1,Q3] peri-shock pause of 5.1 s. [4.4; 5.8] vs. 7.5 s. [6.3; 8.8] seconds, $p < 0.001$, intubation pause of 3.8 s. [3.6; 5.0] vs. 6.9 s. [4.8; 10.1] seconds, $p = 0.03$, rhythm check pause of 4.2 [3.2,5.7] vs. 8.6 [5.0,10.5] seconds, $p < 0.001$, median frustration index of 10/100 [5,20] vs. 35/100 [25,50], $p < 0.001$, and median mental demand load of 55/100 [30,70] vs. 65/100 [50,85], $p = 0.41$ for standardised vs. closed loop communication.

Conclusion: This pilot study demonstrated feasibility of using consensus-based standardised communication that was associated with shorter CC pauses for defibrillation, intubation, and rhythm checks without increasing frustration index or mental demand compared to current best practice, closed loop communication.

Keywords: In-hospital cardiac arrest, Advanced life support, Nontechnical skills, Communication, Delphi technique, Simulation

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Introduction

More than 500,000 people suffer from a cardiac arrest each year in the United States.[1] Overall survival rates remain poor for both out-of-hospital and in-hospital cardiac arrest with major variance between hospitals.[1–3] Chest compression pauses including pre-shock- and post-shock pauses[4–7] are important predictors of successful resuscitation. International resuscitation guidelines therefore emphasize minimisation of chest compression pauses in order to improve survival following cardiac arrest.[8,9]

The length of chest compression pauses is highly variable among hospitals.[10] Factors for variation in length of chest compression pauses may include having a shared mental model on the cardiac arrest team and displaying good leadership skills.[11,12] Accordingly, international guidelines emphasize the importance of teaching teamwork and communication with the use of closed-loop communication to optimize cardiopulmonary resuscitation (CPR) and minimise chest compression pauses.[13,14] Chest compression pauses are often too long, even when using closed-loop communication, and current guidelines don't recommend any specific strategies to optimise communication during CPR.[13,15]

Use of standardised communication with specific terms with universal meaning have successfully been implemented and improved safety in the aviation industry.[16] Accordingly, standardised communication has the potential to improve patient care during advanced life support (ALS) performed by trained healthcare providers. Recent studies have proposed using standardised communication in neonatal resuscitation to improve communication and chest compression fraction,[16,17] and standardised "action-linked phrases" in basic life support has been associated with shorter time to start of chest compressions.[18] It is unclear how to standardise communication to facilitate planning ahead and creating a shared mental model to ensure that chest compression pauses are kept as short as possible. We aimed to develop standardised communication for in-hospital advanced life support by identifying optimal phrases to reduce chest compression pauses and errors and to validate the use of standardised communication for in-hospital ALS.

Methods

This study consists of two parts: 1) development of novel, standardised communication for in-hospital ALS using a modified Delphi approach, and 2) refinement and feasibility testing in simulated cardiac arrest (Fig. 1). The study was conducted and reported in accordance with international reporting guidelines for simulation-based research[19] and was approved by the Institutional Review Board at the Children's Hospital of Philadelphia. All participants provided informed consent for survey participation and simulations.

Development of standardised communication

The standardised communication for in-hospital ALS was built using three steps: A) an international survey aiming to identify which communication components that resuscitation experts would

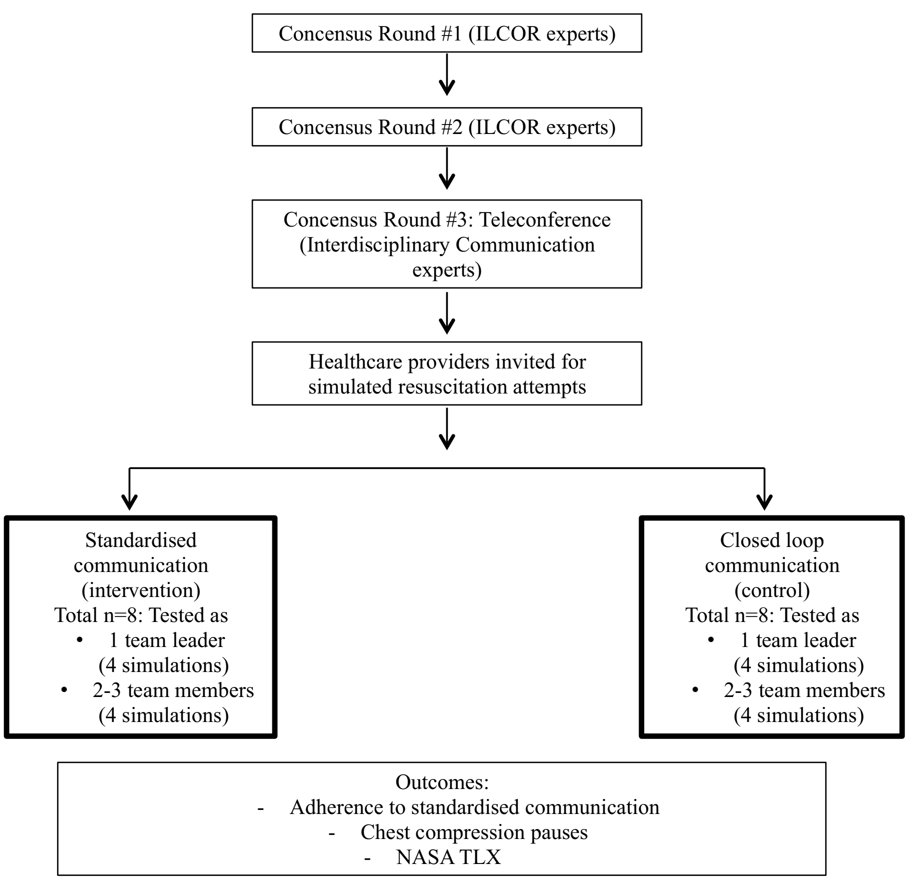

Fig. 1 – Study design and main outcomes. NASA TLX: National Aeronautics and Space Administration Task Load Index.

useduring in-hospital ALS, B) a survey aiming to identify which communication components that experts in team resuscitation would recommend to use for standardised communication aiming to minimise chest compression pauses, C) A teleconference with an interdisciplinary panel of experts in communication, human factors, and resuscitation to reach consensus on standardised communication.

For the first round, we built a structured questionnaire focusing on planning ahead, creating a shared mental model, and action-linked phrases as these factors have been found to be important for team dynamics and team performance.[11,20–22] This questionnaire focused on what resuscitation experts would say as team leaders when preparing the team before pausing chest compressions, how they would make a countdown, and which action-phrases they would use for pausing and resuming compressions. We focused on the most common causes for chest compression pauses in resuscitation: Rhythm check, intubation, and defibrillation.[11] It was possible to provide free text comments on the reasoning behind the wording for each phrase.

The questionnaire was drafted online using REDCap.[23] The questionnaire was reviewed by the research group and subsequently by 5 resuscitation experts to ensure that questions were correctly understood.

The questionnaire was sent to task force members in the International Liaison Committee on Resuscitation (ILCOR) from the subgroups of Basic-, Advanced-, and Paediatric Life Support and Education, Implementation, and Teams (n = 73) to target a wide range of internationally recognized resuscitation experts.

Before the second round, we made a content analysis of all answers. We surveyed ILCOR task force members in Education, Implementation, and Teams (n = 18) as the most prominent experts within the scope of this study. We sent a questionnaire including the four most frequently used content structures for each phrase from the first round. Respondents were asked which content they would recommend to use for each of the standardised phrases in order to specifically minimise chest compression pauses.

For the third round, a group of 10 interdisciplinary experts were invited for a teleconference to reach final consensus on standardised communication. We selected experts having expertise within aviation, space, athletics, human factors, dispatcher assisted CPR, and clinical resuscitation. Experts were provided with anonymized results of the three most popular content structures for each phrase from round two before the teleconference.

Evaluating feasibility

To evaluate feasibility, we conducted 16 simulated cardiac arrest scenarios with paediatric ALS providers randomized to standardised- or closed loop communication (Fig. 1). All providers were previously familiar with closed loop communication from their ALS training. The scenarios were conducted as team leader simulations (n = 8) with physician team leaders (fellow- or attending physicians, 4 using standardised- and 4 using closed loop communication) and a team of actors (simulated participants) to study adherence to standardised phrases and performance when using the standardised phrases. The remaining 8 were conducted as team member simulations with teams of 2–3 nurses and/or respiratory therapists (4 following standardised- and 4 following closed loop communication) and actors functioning as team leader, airway manager, nurse, and a person managing a defibrillator to study team members' ability to follow the phrases. Participants were recruited from the paediatric intensive care unit or emergency department at the Children's Hospital of Philadelphia, Pennsylvania, USA and chosen to reflect typical team members or team leaders at this hospital.[24,25] Actors were physicians and nurses working with simulation and were instructed to follow team leader commands when pausing- and resuming compressions and to read back to the team leader when getting orders using the same phrases for defibrillation, intubation, and rhythm checks when applicable. The actors rehearsed these scripted responses in 3 pilot actor training simulations and then rehearsed the scripted phrases again just prior to each simulation. The actor functioning as team leader was instructed to use standardised communication in the intervention arm, and was instructed to use closed loop communication in the control arm.

Randomization and blinding

Each simulation was randomized in a 1:1 ratio to standardised- or closed-loop communication using blocks with random sizes of 1 or 2. A randomized allocation list was created using Stata version 13.0 (StatsCorp LP, College Station, TX, USA).[23] Due to the nature of the study, actors and assessors were not blinded to the study intervention as they participated in pre-briefings and simulations for both groups. Participants were unaware of the study design and outcome measures.

Simulation testing

Participants received an email with a brief online questionnaire inquiring on participant demographics and a 3-minute video on either standardised- or closed-loop communication before the session. The standardised communication video included information about the rationale for the phrases and how to use it for defibrillation, intubation, and rhythm check. The video on closed loop communication included information on the rationale and how to use closed loop communication with read-back, i.e. asking for a task to be done and expect read-back of the order and confirmation when the task is done to minimise errors.[26] A scripted 10-minute pre-briefing with training on the allocated type of communication was performed immediately before the simulation.

A 6-min cardiac arrest scenario was performed with a 17-year old male having pulseless electrical activity (PEA) with no chest rise when ventilating. The airway manager, being a simulated participant capable of performing intubation, was instructed to request intubation due to lacking chest rise and fail intubation with ongoing compressions but intubate as quickly as possible when chest compressions were paused for intubation. The airways of the manikin were unblocked after intubation. After the second rhythm check, the rhythm turned into ventricular fibrillation and return of spontaneous circulation (ROSC) was obtained a minute after the first shock delivered. The scenario was terminated when the team confirmed ROSC. Immediately after the simulation, all non-actor participants completed a National Aeronautics and Space Administration Task Load Index (NASA TLX) questionnaire. This is a widely used tool for assessment of workload rating six items on a scale from 0 (lowest workload) to 100 (highest workload).[27,28] We prospectively identified two of the workload subscales, mental demand and frustration, for analysis.

Simulations were performed in a simulation laboratory with oxygen outlet, code cart, and patient monitors reflecting a realistic hospital environment. We used SimMan® (Laerdal Medical, Stavanger, Norway) and Zoll R-series defibrillator (Zoll Medical, Chelmsford, Massachusetts, USA). The simulation was video-recorded using

B-line (B-Line Medical, Washington DC, District of Columbia, USA) from three different angles in the ceiling.

Endpoints

The primary endpoint was adherence to standardised communication defined as the fraction of phrases with correct content. Secondary endpoints included A) pause length for rhythm check, B) pause length for defibrillation, C) pause length for intubation, D) mental demand, E) frustration.

Adherence to standardised communication and chest compression pauses were assessed from video recordings. Adherence was defined as the use of correct language content and calculated as the proportion of correct verbalizations divided by maximum number of correct verbalizations they ideally should have performed in the scenario. Frustration and cognitive load were extracted from the NASA TLX questionnaire.

Data analysis

Language components for communication used during CPR from the first survey were coded using grounded theory content analysis. After language categories were identified by one of the authors, two authors both coded the language components and a Cohen's kappa was calculated for interrater agreement.

No sample size calculation was performed for this pilot study. Based on a previous study on action-linked phrases, adherence of 63% was associated with significantly shorter time to start of chest compressions.[21] Accordingly, we defined adherence of 65% as successful. Adherence to standardised phrases was tested against the 65% success criteria using a one-sample t-test and difference in adherence between the two groups were evaluated using Wilcoxon rank-sum test. Data were assessed for normality using quantile −quantile plots and histogram analysis. Data are presented as median (first quartile: Q1); third quartile: Q3). Due to the limited sample size, frustration and pause durations for defibrillation, intubation, and rhythm check were compared for both team leader groups and team member groups combined using generalized linear mixed effect models with data presented as mean difference and 95% confidence intervals (95% CI). For defibrillation and intubation the models accounted for type of simulation (i.e., team leader simulation vs. team member simulation). For assessments with multiple measures within each simulation (i.e. rhythm checks, frustration, and mental demand), the models accounted for both type of simulation and clustering by team. All tests were two-sided and a p-value of <0.05 was considered as statistically significant. No adjustment for multiple comparisons was performed. Data were analysed using Stata version 13.0 (StatsCorp LP, College Station, TX, USA).

Results

Consensus on standardised communication

For the first round of the consensus process on standardised communication, 60 ILCOR task force members responded (response rate: 82%). Using qualitative analysis, we identified different content used for each message that experts would communicate before, during or after pausing chest compressions (Supplementary Fig. 1). Interrater agreement of language coding was 0.84. For the second round, 15 out of 17 responded (response rate: 88%). Overall, experts disagreed on which content and wording to use for standardised communication except from most experts preferring using "action-word" plus "compressions" when pausing- or resuming compressions (e.g. "pause compressions" and "resume compressions" (Supplementary Fig. 2).

For the third round, 10 interdisciplinary experts were invited for a teleconference to reach final consensus and all participated. The panel considered it important to keep phrases as short as possible, yet including sufficient content. The panel reached unanimous agreement on standardised phrases for preparation, countdowns, pausing, and resuming compressions (Table 1).

Simulation testing

We conducted 16 simulated resuscitation attempts using standardised communication or closed-loop communication from February 7th 2019 through April 15th 2019. Due to the small sample size, baseline demographics were not completely balanced between groups (Table 2). Overall median (Q1; Q3) adherence to standardised phrases was 98% (80%; 100%) in the standardised communication group which was significantly higher than the predefined level of success ($p = 0.005$) and significantly higher than the control group (median 20% (16%; 25%), $p < 0.001$). Median adherence for team leaders in the standardised group was 80% (64%; 84%).

Chest compression pauses were in general shorter and frustration level was lower in the standardised communication group compared with the closed loop communication group (Fig. 1). Median (Q1; Q3) total pause duration for defibrillation, intubation, and rhythm check combined was 21.9 s (18.5; 27.1) vs. 41.2 s (31.0; 47.0) for standardised vs. closed loop communication respectively, difference: −16.3 (95 % CI: −24.2, −8.4), $p < 0.001$ (Fig. 2). Median peri-shock pause

Table 1 – Standardised phrases for cardiopulmonary resuscitation.

Time point	Phrase
15−30 s before rhythm analysis	Rhythm check, pulse check and change of compressors in 15. On my count
5 s before ANY pause in chest compressions	Team ready! 5, 4, 3, 2, 1
Anytime when pausing compressions	PAUSE COMPRESSIONS
Anytime when resuming compressions	RESUME COMPRESSIONS
Before intubation with ongoing compressions	Prepare for intubation. Continue compressions during attempt
15−30 s before intubation WITH pause in compressions	Prepare to intubate with maximum 10 s pause in compressions. Tell me when you see the vocal chords
When charging defibrillator	VF, continue compressions while charging
When shocking patient	CLEAR − SHOCK

Table 2 – Participant demographics.

	Standardised communication	Closed loop communication
Team leaders (n)	4	4
Sex (% female)	50%	75%
Age (years)	42 (36; 46)	34.5 (33; 40)
Clinical experience in years	13 (6; 21)	7 (5; 13)
PALS certification	100%	100%
ACLS certification	100%	100%
BLS certification	100%	100%
Team members[a]	7	9
Sex (% female)	57%	67%
Age (years)	27 (26; 32)	39 (29; 52)
Clinical experience in years	5 (4; 9)	9.5 (3; 29)
PALS certification	100%	89%
ACLS certification	86%	44%
BLS certification	100%	100%

Continuous data are presented as median (quartile 1; quartile 3). PALS: paediatric advanced life support. ACLS: advanced cardiac life support. BLS: basic life support.
[a] Demographic data are missing for two team members in the standardised communication group.

was 5.1 s. (4.4; 5.8) vs. 7.5 s. (6.3; 8.8) for standardised vs. closed loop communication, difference: −2.6 s. (95% CI: −4.0, −1.2), p = 0.001. Median pause for intubation was 3.8 s. (3.6; 5.0) vs. 6.9 s. (4.8; 10.1), difference: −2.6 s. (95% CI: −5.0, −0.2), p = 0.03 and median pause for rhythm check was 4.2 s. (3.2; 5.7) vs. 8.6 s. (5.0; 10.5), difference −3.9 s. (95% CI: −6.0, −1.8), $p < 0.001$ for standardised vs. closed loop communication. Frustration was median 15 (5; 30) vs. 30 (20; 50), difference: -14 (95% CI: −31 to 3), p = 0.12 and mental demand was median 55 (30; 70) vs. 65 (50; 85), (95% CI: −20 to 24), p = 0.88, for standardised vs. closed loop communication. Similar trends were seen for both the team leader groups and the team member groups (Suppl. Fig. 3).

Discussion

We reached consensus on standardised communication for in-hospital CPR with preparation of the team 15−30 s before pausing compressions, a countdown, and action-words for pausing and resuming compressions. We showed good adherence to the usage of standardised phrases and shorter chest compression pauses.

In contrast to previous studies investigating the effect of general aspects of crisis resource management and leadership skills,[29−32] we provide the first study on scripted phrases tailored to minimise chest compression pauses. Closed loop communication was not emphasized in the training of standardised communication. While closed loop communication may be efficient when ensuring that e.g. drawing-up of medication is completed, it remains unknown if closed loops prolong the pauses due to read-back of all actions. As such, the use of standardised communication can be considered a further advance in communication using approaches from aviation and sports where standardised phrases are used to coordinate actions on high-performing teams.

Only a few studies have been conducted using scripted phrases during simulations of acute medical conditions.[17,21] Hunt et al. developed “action-linked” phrases for in-hospital CPR courses (e.g. “there is no pulse, start compressions”). Implementation of six different ALS phrases was although poor when assessed after training being used in only 43% of cases.[21] One possible factor explaining why we found a higher adherence compared to Hunt et al. could be that they taught the phrases during an ALS course curriculum where learners had to comprehend a lot of new information meanwhile learning the phrases. Learners in our study were practicing the standardised phrases as a sole intervention immediately before the simulation. It should be investigated whether the standardised phrases could be learned during ALS courses.

Yamada et al. were unable to show a significant reduction in time to initiation of positive pressure ventilations and -chest compressions when using a standardised communication lexicon for simulated neonatal resuscitation.[17] They achieved a lower adherence to the implemented standardised phrases compared to the present study possibly due to a more comprehensive lexicon of standardised phrases. In contrast, we used simplified, identical phrases for countdowns, pausing- and resuming compressions. Moreover, they did not tailor the standardised communication to reduce chest compression pauses but used general principles of effective communication from the aviation industry.

We found a significant reduction in pause length for rhythm check with pulse check, intubation, and defibrillation which may affect survival outcomes following cardiac arrest.[4,5] This may be due to the preparation of the team before pausing compressions as Kessler et al. found that achieving a shared mental model is associated with shorter pauses during simulated CPR.[11] Moreover, the use of a CPR coach to coordinate tasks before pausing compressions (i.e. sharing a mental model 15−30 s. prior to pausing compressions and providing countdowns) have been shown to reduce peri-shock pauses from 9.4 s to 5.5 s which is comparable to our pause length for both rhythm checks and defibrillations.[33] Importantly, standardised phrases were used by the team leader in our study, but these phrases may be used by a CPR coach instead.

Other factors possibly affecting pause length include training of team members to act according to specific phrases (linking phrases with actions)[21] and ensuring brevity of communication when pausing. Given the limited sample size of this feasibility study, we are unable to infer on how the amount of words and specific wording affect pause length. However, we notice that the teams having a simulated team leader in the intervention group tended to have slightly shorter pauses for defibrillation and rhythm checks compared to the team leaders

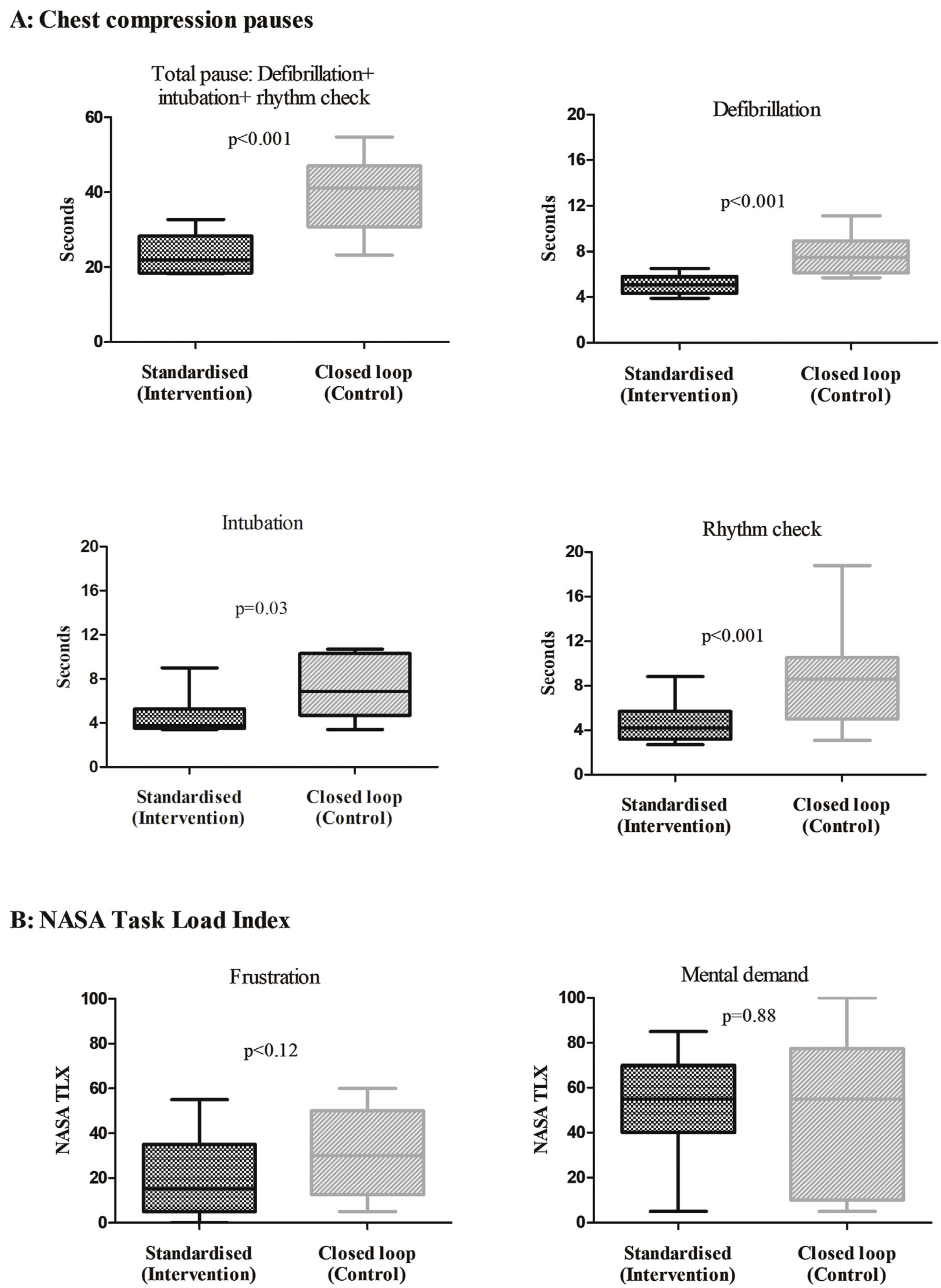

Fig. 2 – Comparison of chest compression pauses (A) and frustration and mental demand (B) for the standardised communication (intervention group) and closed loop communication (control group) respectively. Boxes are reported as median with quartiles and maximum range. Frustration and mental demand is measured using National Aeronautics and Space Administration Task Load Index (NASA TLX) on a scale from 0 (lowest) to 100 (highest).

being tested (Suppl. Fig. 3) while having a higher adherence to standardised phrases, possibly explaining the difference.

The tendency towards a lower frustration index in the intervention group may likewise be explained by the fact that participants using standardised communication were prepared on both what to say and how to respond to the wording. Importantly, we included fellows and attending physicians having experience as team leaders. Mental demand may be higher for residents compared to fellows and attendings used in our study. Less experienced team leaders could potentially experience greater reduction of cognitive load when using standardised communication or they could simply be cognitively overloaded by learning new phrases. Further research is needed to investigate how standardised communication would affect performance and cognitive load for resident level team leaders.

Limitations

This is a simulation study. The sample size was small and not powered to show a difference in chest compression pauses or to adjust for imbalances in baseline provider characteristics and as such the results should be interpreted with caution. We tested team leaders' ability to use the phrases and chest compressors' ability to follow the phrases separately. Ideally, standardised communication should be tested using both participant team leader and participant chest compressors in the same scenario. The simulations were conducted at a tertiary academic children's hospital with strong interests and efforts in resuscitation. Therefore the standardised communication should be evaluated in a multi-center setting for external validity. For this reason, we cannot infer on feasibility and effect of using standardised communication in adult hospitals or the pre-hospital setting. We tested team leaders' ability immediately after a brief training for standardised phrases and retention of skills in using standardised phrases was not evaluated.

Conclusions

This pilot study demonstrated feasibility of using consensus-based standardised communication that was associated with shorter CC pauses for defibrillation, intubation, and rhythm checks without increasing frustration index or mental demand compared to current best practice, closed loop communication.

Conflicts of interest

None.

CRediT authorship contribution statement

Kasper Glerup Lauridsen: Conceptualization, Methodology, Investigation, Formal analysis, Project administration, Writing - original draft, Writing - review & editing. **Ichiro Watanabe:** Formal analysis, Investigation, Writing - review & editing. **Bo Løfgren:** Conceptualization, Funding acquisition, Supervision, Writing - review & editing. **Adam Cheng:** Conceptualization, Investigation, Supervision, Writing - review & editing. **Jordan Duval-Arnould:** Conceptualization, Investigation, Supervision, Writing - review & editing. **Elizabeth A. Hunt:** Conceptualization, Investigation, Supervision, Writing - review & editing. **Grace L. Good:** Investigation, Methodology, Writing - review & editing. **Dana Niles:** Resources, Supervision, Writing - review & editing. **Robert A. Berg:** Resources, Funding acquisition, Supervision, Writing - review & editing. **Akira Nishisaki:** Conceptualization, Methodology, Supervision, Visualization, Writing - original draft, Writing - review & editing. **Vinay M. Nadkarni:** Conceptualization, Methodology, Investigation, Supervision, Visualization, Funding acquisition, Project administration, Writing - original draft, Writing - review & editing.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.12.013.

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