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Evaluation of audio-voice guided application for neonatal resuscitation: a prospective, randomized, pilot study

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Abstract

Objectives: To examine whether audio-voice guidance application improves adherence to resuscitation sequence and recommended time frames during neonatal resuscitation.

Methods: A prospective, randomized, pilot study examining the use of an audio-voice application for guiding resuscitation on newborn mannequins, based on the Neonatal Resuscitation Program (NRP) algorithm. Two different scenarios, with and without voice guidance, were presented to 20 medical personnel (2 midwives, 8 nurses, and 10 physicians) in random order, and their performance videotaped.

Results: Audio-voice guided resuscitation compared with non-guided resuscitation, resulted in significantly better compliance with NRP order sequence ($p<0.01$), correct use of oxygen supplementation ($p<0.01$) and performance of MR SOPA (Mask, reposition, suction, open mouth, pressure, airway) ($p<0.01$), and shortened the time to "positive pressure ventilation" ($p<0.01$).

Conclusions: In this pilot study, audio-voice guidance application for newborn resuscitation simulation on mannequins, based on the NRP algorithm, improved adherence and performance of NRP guidelines.

Keywords: mannequins; neonatal resuscitation program; resuscitation simulation; voice guidance.

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Introduction

According to a 2014 meta-analysis, 10 million newborns require skilled medical personnel assistance each year [1]; about 10% require medical assistance to start breathing and one percent advanced resuscitation action [2, 3]. When resuscitation actions are needed, health care personnel require specific medical knowledge, leadership, accuracy regarding timing and order of actions, appropriate manual skills, and fast thinking. Resuscitation skills for dedicated medical personnel are acquired during Neonatal Resuscitation Program (NRP) course and several studies demonstrated the potential for reduced intrapartum related death after resuscitation training [4–7].

Several educational strategies such as resuscitation simulation, briefing and debriefing, use of check lists, video assisted debriefing, and rhythm guidance have been shown to improve resuscitation skills [8–13]. Nevertheless, fast, timely, and systematic decisions are needed during newborn resuscitation, and lack of adherence to NRP guidelines has been identified as problematic [14].

Various medical personnel are involved in the caring of newborn infants, some encounter resuscitation events infrequently (pediatric and neonatal ward medical and nursing teams, gynecologists, anesthesiologists, paramedics). Research shows that resuscitation skills deteriorate over time from attending an NRP course, and emphasizes the importance of maintaining resuscitation skills as a major and continuous task in health care centers [3, 9, 15].

In order to meet the requirements of newborn resuscitation, we developed an application which uses audio-voice to interactively guide resuscitation team leaders on how to perform newborn resuscitation in

accordance to NRP guidelines. During guided resuscitation, questions are asked and orders given in response to team leader answers and the NRP flow chart. We hypothesized that interactive audio-voice guidance could improve the resuscitation process performed by medical teams in the delivery room, and positively affect the outcome of the infants.

Our study aim was to examine whether audio-voice guidance application improves adherence to resuscitation sequence and recommended time frames during neonatal resuscitation simulation on mannequins.

Materials and methods

An audio-voice guided application was created, based on 2010 NRP resuscitation algorithm [16]. The application asks appropriate resuscitation questions ("is this a term gestation", "is the baby breathing or crying"….), reacts to Yes/No audio answers supplied by the team leaders, and recommends action or asks another question in adherence to NRP guidelines. In order to allow sufficient time to complete the required actions if no answer is supplied by the resuscitation team leader, the same question is repeated, every few seconds, until a Yes/No answer is given.

For this research two different scenarios were created: 1. Scenario required to assess correct performance of NRP steps during resuscitation of a term infant that ended after appropriate positive pressure ventilation, 2. Scenario required to assess correct performance of NRP steps during resuscitation of a term infant that ended after appropriate chest compressions.

Resuscitation team leaders practiced the resuscitation on newborn mannequins, with one scenario guided by the voice application, and the other performed according to the practitioners' knowledge. During guided resuscitation the audio-voice orders and questions were loudly played in the room by using voice amplifier. Resuscitation team leader started the resuscitation simulation and was joined by another medical personnel after calling for assistance.

The assignment of voice guidance, or not, in the first practiced scenario was random, and scenario type was randomly selected as well. The randomization was done for the first scenario practiced. Second scenario was correlated to differ in type and guidance accordingly. First scenario randomization for type and guidance was retrieved according to a sequential number from a preformed table, before starting resuscitation for each team leader.

The team leaders consisted of 10 registered nurses (RN), either midwives or newborn nurses, and 10 residents (9 in pediatrics and 1 in obstetrics and gynecology). All participants passed the NRP course. Research participants recruited were medical personnel who did not encounter newborn resuscitation on daily basis but were expected to be able to perform correctly when encountering such an event [16]. In every resuscitation two additional nurses were available to respond to team leader's request for assistance. They were instructed to follow team leader's orders only. Participants expertise was evaluated only by recording the time passed from their last NRP course. Information regarding last resuscitation simulation or actual resuscitation events was not retrieved.

Participants gave their oral consent to participate in this study. Our Institutional Review Board approved a waiver for written informed consent, as this research was part of our training simulation program. None of the participants was familiar with the resuscitation voice-guided application before. Prior to resuscitation sessions, participants were instructed to listen to the application guidelines and respond to questions during resuscitation only by saying "Yes" or "No". Participants were instructed to follow the audio-voice guided orders only if they believed them to be in accordance with NRP requirements. Scenario durations were 5–9 min, according to participant advancement.

Each resuscitation scenario was video recorded in order to retrieve information for appropriate time frames and resuscitation correct order. All recorded simulations were reviewed by first author (G.D.) with assistance of the third author (S.V.) watching the videos together. They discussed and agreed together on each marked mistake and time measured. Resuscitation actions were strictly compared to NRP resuscitation algorithm.

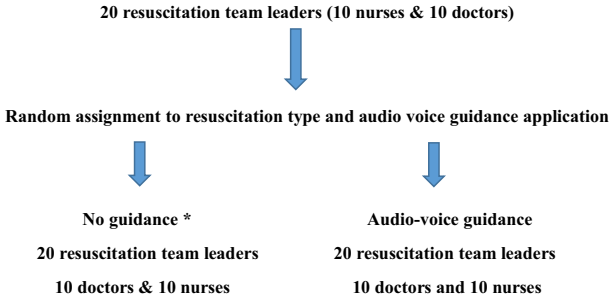
Statistics

Voice guidance sessions were compared to non-guided sessions, for correct sequence of resuscitation, timing and coordination. Scenarios order of practice, scenario type, team leaders (nurses or doctors) and time passed from the last NRP course were assessed for possible influence on results.

We used χ^2-tests or Fisher's exact test for categorical variables, and unpaired t-test or Wilcoxon Signed Ranks test for continuous variables, as appropriate, in order to compare resuscitation with and without voice guidance. Data are presented as mean ± standard deviation. p-Value of less than 0.05 was considered significant. Analysis was performed with IBM SPSS statistics for windows, Version 25.0 (IBM Corp., Armonk, NY, released 2017).

Results

Figure 1 shows medical personnel and allocation order. There was a video malfunction in one resuscitation scenario without voice guidance. Therefore, data was retrieved from 19 scenarios without and 20 scenarios with voice guidance.



*Due to technical malfunction only 19 video films of non-guidance resuscitation were available for data extraction.

Figure 1: Twenty resuscitation team leaders randomly assigned for first scenario type (two different scenarios were created) and resuscitation with or without voice guidance.

In order to assess the influence of the time passed from participants' (team leaders) NRP course on resuscitation performance, participants were divided into two groups. The first group (7 participants) had completed NRP course during the previous two years, and the second group (13 participant) more than two years prior to the study. Time elapsed from last NRP course was not associated with resuscitation performance for non-guided resuscitation (no difference between groups with recent or remote NRP course in time until "positive pressure ventilation", "chest compressions" and MRSOPA and correct sequences of resuscitation; all non-significant).

There was no difference between physicians or nurses as team leaders in resuscitation performance for non-guided resuscitation (correct sequences of resuscitation and time until "positive pressure ventilation" and "chest compressions"; all non-significant).

Research results were evaluated for possible learning effect from the first practiced scenario on second practiced scenario (non-guided resuscitation only). There was a learning effect from the first to second scenario for "time to positive pressure ventilation" (two-tailed Wilcoxon, p=0.02). There was no significant effect on correct order of resuscitation and oxygen supplementation. Evaluation of timing until "chest compression" and MRSOPA were not possible due to small sample size.

Resuscitation sequence and performance

Figure 2 shows that there was a significant difference in maintaining correct sequence of resuscitation actions between non-guided and audio-voice guided participants, favoring audio voice-guidance. All (100%) participants practicing non-guided scenario, in which chest compression was needed, had at least one mistake in correct resuscitation sequence vs. non in the guided simulation. During non-guided resuscitation, 56% of participants had at least two mistakes, 22% three mistakes, and 11% six mistakes in correct order of resuscitation sequence.

Providing 100% oxygen during chest compression in audio-voice guided resuscitation (better adherence to the NRP algorithm) was significantly better than without guidance.

Ninety-five percent of participants with audio-voice guided resuscitation performed MR SOPA (mask, reposition, suction, open mouth, pressure, airway) completely, compared to only 33% without guidance.

Chest compression and ventilation coordination, and ventilation and chest compression rates, showed a tendency for improvement under audio-voice guidance, but this did not reach statistical significance (Figure 2).

Time frame during resuscitation

Table 1 shows that the duration until "positive pressure ventilation" was significantly shorter during voice guided resuscitation and that time to "chest compression" was significantly shorter during non-guided resuscitation.

Even though a learning effect from the first to second scenario practiced was found for time to "positive pressure ventilation" in non-guided resuscitation, this time was still significantly shorter for guided resuscitation when retrieved only from the first resuscitation (two-tailed Wilcoxon, p=0.02).

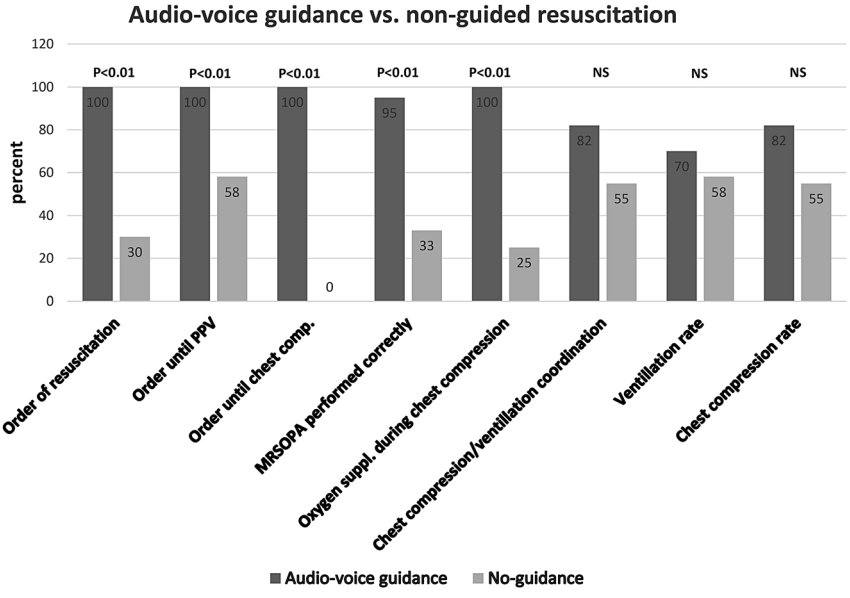


Figure 2: Correct sequence and performance of resuscitation with audio-voice guided and without guidance in accordance with scenario practiced.

Table 1: Time frames during resuscitation with/without voice guidance.

Time until	Voice guidance	Number of participants	Mean in seconds (±SD)	p-Value
Positive pressure ventilation	–	19[a]	53.4±18.9	0.01[c]
	+	20	48.5±8.5	
MRSOPA	–	6[b]	91.6±13.5	NS
	+	17	84.5±8.8	
Chest compression	–	9	93.8±33.0	0.04[c]
	+	11	135.3±10.9	

[a]Due to technical failure19 scenarios without voice guidance were included. [b]Only 6 participants in non-guided simulation performed MRSOPA. [c]Wilcoxon Exact Sig. 2-tailed.

Time until performing MR SOPA did not reach statistical difference (Table 1).

Discussion

In our pilot study, audio-voice guidance application for newborn resuscitation simulation improved adherence and performance of NRP guidelines. Correct sequence of resuscitation actions, time to "positive pressure ventilation", oxygen supplementation, and performance of MR SOPA were all significantly better when audio-voice guided.

The most striking finding was the significant number of mistakes in keeping the correct resuscitation sequence when guidance was not provided. Audio-voice guidance prevented mistakes in sequence order, permitting better adherence to NRP recommendations. Future studies in clinical practice are needed to show if this will reduce the risk of morbidity or mortality in infants who undergo neonatal resuscitation.

Furthermore, time frames of crucial significance were affected by audio guidance. Time to "positive pressure ventilation" was shorter with audio-voice guidance. As initiation of ventilation is the most important step for successful resuscitation [3], this finding could potentially affect resuscitation outcome. Time to "chest compression" was significantly shorter with no audio-voice guidance, most probably reflecting wrong order of resuscitation and faster than required performance of chest compression, before ascertaining appropriate ventilation.

Coordination between ventilation and chest compression, and ventilation and chest compression rates, all tended to improve when performed with voice guidance, but this did not reach statistical significance. This could reflect a beta error, because of the relatively small sample size in our study.

Our findings demonstrated a high number of mistakes in correct order of resuscitation, but relatively preserved manual skill (ventilation and chest compression rate and chest compression/ventilation coordination). We speculate that retention of technical skill memory is better compared to NRP algorithm memory, possibly implying the need for scheduled resuscitation algorithm memorizing practices.

Different modalities improving manual skills, coordination, and rate keeping have previously been mentioned in the literature [11]. The study group included personnel allegedly able to perform newborn resuscitation [16], but who infrequently implemented resuscitation actions. Our results showed that the participants had poor resuscitation skills. While another study group, more skilled or experienced with frequent resuscitations, could have performed better, or could be differently affected by the voice-guidance, our findings emphasize the need for simulation in a very large population of medical personnel who is not frequently exposed to resuscitation in real life.

Lack of adherence to NRP guidelines has been mentioned in several publications [8, 14, 17] which emphasize that resuscitation skills maintenance is a priority task for medical institutions [18, 19]. Resuscitation practice/simulation has to be addressed in an accurately organized, timely, dedicated manner encompassing all relevant medical staff. Optimal timing or mode of best training, in order to keep intended medical staff skilled, is not known. Nevertheless, frequent resuscitation simulation is considered the best mode of resuscitation skill maintenance [20–23]. Such training is time and personnel consuming, logistic challenging, in every hospital, especially in low income countries with remote rural communities [24].

The proposed audio-voice guidance is not intended to replace NRP course or sequential simulation, but could serve as a safety measure in stressful real-life conditions. We assume that for very skilled personnel this audio voice guidance application could serve as a "check list" to correct performance. For less experienced medical personnel, guided resuscitation could improve adherence to NRP guidelines.

Our study has some limitations. The algorithm of the voice-guided application was based on the NRP 2010 guidelines, and this was the practice during the study. Since then, multiple changes were made and the application was updated for current NRP guidelines. Our pilot study included a small sample size, that did not allow us to analyze participants with different expertise and at different levels of education and skills. Study group included medical personnel alleged to be able to apply to NRP guidelines of newborn resuscitation [16], but who had

infrequently encounter resuscitation actions, implying possibly less experienced personnel. This might pose a selection bias, that could overestimate the significance of the voice-guided application. Therefore, results pertain to this specific research group, and cannot be generalized to other very skilled, experienced medical teams. Yet, it emphasizes the potential advantages of audio-voice guidance in less experienced medical personnel with possible benefit in resource limited countries or in remote medical facilities or medical centers without neonatal dedicated personnel. We hypothesize that the success of the UN "helping baby breath" project could be enhanced by using this application for training and simulation on newborn mannequins at this stage. Resuscitation type (with or without guidance) was not blinded to video reviewers, which potentially could cause a bias. A possible learning effect between first and second scenario could be partially reduced by randomizing the different scenarios and order with or without guidance. We controlled this effect when analyzing time to "positive pressure ventilation" in non-guided first scenario and comparing it to "time to positive pressure ventilation" of guided resuscitation, confirming again faster ventilation initiation for guided resuscitation. Finally, our study was done on newborn mannequins and not in real live conditions. We can only assume same or even a more significant impact in stressful neonatal resuscitations.

Conclusions

In our pilot study, audio-voice guidance application for newborn resuscitation simulation improved adherence and performance of NRP guidelines. We hypothesize that interactive audio-voice guidance could enhance the resuscitation performed by medical teams in the delivery room, and positively affect the outcome of the infants. The audio-voice guidance application needs to be further assessed in a larger population at different levels of expertise and experience, and in real live resuscitations.

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Informed consent: Not applicable.
Ethical approval: Our Institutional Review Board approved a waiver for written informed consent, as this research was part of our training simulation program.

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