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Resuscitator's perceptions and time for corrective ventilation steps during neonatal resuscitation☆

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Abstract

Background—The 2010 neonatal resuscitation program (NRP) guidelines incorporate ventilation corrective steps (using the mnemonic – MRSOPA) into the resuscitation algorithm. The perception of neonatal providers, time taken to perform these maneuvers or the effectiveness of these additional steps has not been evaluated.

Methods—Using two simulated clinical scenarios of varying degrees of cardiovascular compromise –perinatal asphyxia with (i) bradycardia (heart rate – 40 min^{-1}) and (ii) cardiac arrest, 35 NRP certified providers were evaluated for preference to performing these corrective measures, the time taken for performing these steps and time to onset of chest compressions.

Results—The average time taken to perform ventilation corrective steps (MRSOPA) was 48.9 ± 21.4 s. Providers were less likely to perform corrective steps and proceed directly to endotracheal intubation in the scenario of cardiac arrest as compared to a state of bradycardia. Cardiac compressions were initiated significantly sooner in the scenario of cardiac arrest 89 ± 24 s as compared to severe bradycardia 122 ± 23 s, $p < 0.0001$. There were no differences in the time taken to initiation of chest compressions between physicians or mid-level care providers or with the level of experience of the provider.

Conclusions—Effective ventilation of the lungs with corrective steps using a mask is important in most cases of neonatal resuscitation. Neonatal resuscitators prefer early endotracheal intubation and initiation of chest compressions in the presence of asystolic cardiac arrest. Corrective ventilation steps can potentially postpone initiation of chest compressions and may delay return of spontaneous circulation in the presence of severe cardiovascular compromise.

Keywords

Newborn; Cardiopulmonary resuscitation; Ventilation correction steps; MRSOPA

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Conflict of interest statement
No conflicts of interest to declare.

Effective ventilation of the lungs remains the cornerstone of neonatal resuscitation. Approximately 10% of newborns require assistance to establish effective ventilation and less than 1% need more extensive resuscitation with chest compressions and/or medications.[1] In the neonatal resuscitation program (NRP) algorithm in the 2005 AAP/NRP guidelines initiation of circulatory support (chest compressions) was indicated if the heart rate remained below 60 beats per minute (bpm) following 30 s of positive pressure ventilation (PPV).[2] The timeframe for initiation of chest compressions as per the 2005 guidelines was 90 s following delivery of the infant.[2] In the current neonatal resuscitation guidelines published in 2010, if the heart rate remained less than 60 bpm following 30 s of PPV then additional corrective ventilation steps have been incorporated, (abbreviated as MRSOPA) prior to initiation of chest compressions. These steps include **M**ask adjustment, **R**epositioning of the airway, **S**uctioning the mouth and nares, **O**pening mouth, increasing **P**ressure and placing **A**lternate airway such as laryngeal mask airway or endotracheal tube These steps have been added with the belief that providers may be progressing to circulatory support without providing adequate ventilation.[1] Ventilation alone is sufficient to effectively resuscitate greater than 99% of newborn infants and performing chest compressions without providing adequate ventilation may compromise successful resuscitation.

Circulatory support with chest compressions is important to maintain pulmonary circulation and gas exchange in the presence of severe bradycardia.[3,4] Delay in initiation of circulatory support may be detrimental in infants with asystole or severe cardiorespiratory compromise. Chest compressions are associated with increased risk of pneumothorax, rib fractures and trauma to the viscera.[5,6]

In a simulation based study of change of practice in adult resuscitation with the 2010 basic life support guidelines by eliminating the step of positive pressure ventilation prior to initiation of chest compressions shortened the time of initiation of chest compressions by approximately 20 s.[7] The time taken for or the effectiveness of the corrective ventilation steps has not been evaluated in the neonate. This study was undertaken to estimate the time taken in performing the corrective ventilatory steps and to evaluate the provider preference in performing the steps at varying degrees of cardiorespiratory compromise.

Based on NRP guidelines, initial steps of resuscitation (providing warmth, clearing airway if necessary, drying and stimulating) require 30 s. If the heart rate is <60 bpm in spite of PPV for 30 s, chest compressions are indicated. Dannevig et al. showed that in newborn piglets, initiation of chest compression after 90 s of cardiac arrest led to increased mortality and increased time to return of spontaneous circulation (ROSC). So, if corrective steps for ventilation require more than 30 s (60 + 30 = 90 s), infants in cardiac arrest at birth may have a lesser chance of survival.

1. Hypothesis

We hypothesize that the time to initiate chest compressions will not be different to be of clinical significance between resuscitation with ventilation corrective steps (MRSOPA) and direct intubation without these corrective steps. We defined as clinically significant any greater than 30 s difference in the time taken for performing all of the steps of MRSOPA vs. intubation alone.

2. Methods

2.1. Study site and equipment

The study was approved by the institutional review board of the Women and Children's Hospital of Buffalo. The Women and Children's Hospital of Buffalo is the regional perinatal center for western New York. The study was performed in the simulation lab using SimNewB® (Laerdal Inc., Wappingers Falls, NY, USA), an advanced simulator for neonatal resuscitation. SimNewB® is equipped with touchscreen monitors which provide concise clinical feedback of physiological parameters and is capable of capturing and saving videos.

2.2. Participants

Informed consent was obtained from all participants who were then briefly evaluated for their understanding of the 2010 neonatal resuscitation guidelines. All of the study participants were NRP certified providers with three or more years since first certification and with current valid NRP provider/instructor status. All of the participants had recertified in NRP or provided instruction at one or more sessions after the 2010 recommendations were published. A brief refresher of the 2010 resuscitation guidelines were provided to each of the participants.

2.3. Study design

Participants were instructed to provide resuscitation as they would do in a clinical situation. The case study included a depressed term newborn delivered by cesarean section for fetal distress with clear amniotic fluid, either with a heart rate of 40 bpm or 0 bpm (asystole). The scenarios were identical except for the initial heart rate and were presented in random order. Randomization to the order of the scenarios presented was performed by opening a sealed envelope following informed consent. One of the research personnel played the role of the assistant to the resuscitator (participant). All of the resuscitation scenarios were videotaped and later viewed for data extraction. The simulations were analyzed by a single interpreter (VS). Debriefing mode was used to extract data with 1 s precision.

At initial assessment the heart rate of the manikin was set at the pre-randomized rate of zero or 40 bpm. As the participant progressed through the initial steps of resuscitation any or all attempts at ventilation were deemed to be ineffective at improving the heart rate and the heart rate remained at or below 40 bpm throughout the course of simulated resuscitation. Participants were evaluated (a) if they initiated the ventilation corrective steps and (b) if all the steps were performed in the order recommended by the NRP. Following these ventilation correction steps, the heart rate remained below 40 bpm and the subject progressed to perform chest compressions. At this time the participant was instructed that the case study was complete and advised to prepare for the second scenario. In the second scenario the participant was presented with the identical case except for the alternate pre randomized heart rate (either 0 bpm or 40 bpm). As in the first scenario all of the efforts at resuscitation were deemed ineffective and resuscitation was continued to the point when chest compressions were initiated. Following this event, the research personnel reviewed the recording specifically for the steps of MRSOPA. Participants who failed to initiate or performed incomplete MRSOPA in both scenarios, were given a demonstration of ventilation corrective steps and given one of the scenarios at random to repeat and this attempt was video recorded. The different possible combination and sequence of scenarios based on participants' performance is shown in Table 1. The study protocol was designed to make sure that every participant performed the following two sequences of resuscitation: (i) resuscitation with all steps of MRSOPA for corrective ventilation and (ii) resuscitation with immediate intubation without any corrective steps (Table 1). The time taken for the individual steps of resuscitation was evaluated from the video recordings. The time taken for the ventilation corrective steps was calculated as the time taken to arrive at chest compressions with MRSOPA minus time taken with intubation without MRSOPA.

2.4. Sample size and statistical methods

A sample size of 35 subjects was needed to reject the null hypothesis and observe a difference of 30 s in the time to initiate chest compressions between the two groups.[8] We used Student's '*t*'-test to analyze continuous data and Chi square and Bhapkar test for categorical data.

3. Results

3.1. Background and experience of study participants

Thirty five providers participated in the study. There were 11 physicians, 20 neonatal nurse practitioners and 4 physician assistants. The physicians consisted of attending neonatologists and fellows in neonatal perinatal medicine. The average experience of the participants (years after first NRP certification), was 17.5 years (range 4–27 years). All participants demonstrated adequate knowledge of the corrective steps for ventilation (MRSOPA) on initial assessment.

3.2. Time taken to initiate chest compressions

The time taken to initiate chest compressions with corrective ventilation steps (MRSOPA) was 131 ± 24 s as compared to 82 ± 16 s when intubation was performed without MRSOPA ($p < 0.01$). The average time taken to perform MRSOPA was 48.9 ± 21.4 s. In the scenario with the infant in asystole, only 2/35 (5.7%) participants performed all of the steps of MRSOPA while 26/35 (74.3%) performed MRSOPA when the initial heart rate was 40 min^{-1} ($p < 0.01$ by Bhapkar test) (Fig. 1). In the scenario where the initial heart rate was 40, the time taken to initiate chest compressions was 122 ± 23 s compared to 89 ± 24 s in scenario of asystole ($p < 0.0001$). The time taken to perform MRSOPA was not different between participants with greater than or equal to 10 years experience (51.5 ± 23.7 s) following initial NRP certification and ones with less than 10 years of experience (46.1 ± 14.9 s). The average time taken to perform MRSOPA by physicians was 49.5 ± 10.5 s as compared to 48.7 ± 24 s by neonatal nurse practitioners and physician assistants. There was no difference in the time taken to perform MRSOPA between the nine participants who needed demonstration of the ventilation corrective steps (42.5 ± 10.5 s) as compared to the 26 that performed the steps (51 ± 24 s) correctly in the first/second scenario without demonstration. The time taken to perform individual steps of neonatal resuscitation and corrective steps for ventilation are shown in Fig. 2.

4. Discussion

Ventilation of the newborn lungs is the key to neonatal resuscitation. Premature initiation of chest compressions prior to establishment of effective ventilation of the lungs is unlikely to be effective during neonatal resuscitation. The 2010 AAP/NRP resuscitation guidelines incorporated the additional step of ventilation correction measures following 30 s of positive pressure ventilation if the heart rate remains below 100 bpm. However, delayed initiation of circulatory support may increase the risk of morbidity and mortality.

There have been two recent studies evaluating the actual time taken to perform various steps of neonatal resuscitation and comparing them to the time recommended by the NRP algorithm. McCarthy et al. timed delivery room resuscitation/stabilization from two tertiary level neonatal units in Ireland and Australia. These authors showed that the time taken for initial evaluation during neonatal resuscitation was found to be in excess of 70 s as compared to the 30 s allocated in the NRP algorithm.[9] Similarly, based on the NRP algorithm, neonates with asystolic arrest should receive epinephrine by approximately 3 min of age. Wyckoff et al. demonstrated that the first dose of intravenous epinephrine during neonatal resuscitation is administered at 5.2 ± 3.1 min by highly experienced neonatal resuscitation team.[10] A more recent study by the same group showed that intravenous epinephrine is administered by 6 ± 3 min.[11] Neonatal resuscitation is a time-sensitive critical intervention that has significant impact on mortality and life-long neurological morbidity. Time periods for performing various steps of neonatal resuscitation recommended by NRP may be difficult to achieve in real-life resuscitation due to anxiety, stress, communication issues and lack of availability of trained personnel.

Ineffective ventilation is common during resuscitation and is likely cause for poor response to resuscitation.[12,13] However the small percent of infants in severe cardiovascular compromise require immediate circulatory support without delay. Neonatal myocardium is sensitive to ischemia. Studies by Parrish et al.[14] in newborn rabbits showed greater vulnerability of the newborn heart to global ischemic injury as compared to juvenile or adult heart. Dannevig et al. evaluated the impact of time of initiation of chest compressions following cardiac arrest on rate of return of spontaneous circulation (ROSC) in neonatal piglets. Delaying the onset of chest compressions up to 60 s did not prolong time to ROSC. However, delaying chest compressions past 90 s, significantly decreased the rate of and prolonged the time to successful ROSC.[15,16] In our study performing MRSOPA prolonged the time to initiation of chest compression past this critical threshold (131 ± 24 s).

All but two of the participants skipped the ventilation correction measures during resuscitation in the scenario of asystolic cardiac arrest. It is clear that this was not due to lack of knowledge of the steps involved in the ventilation correction steps as 74% of the participants performed these steps proficiently at one of the scenarios without having the need for demonstration by the investigator. Although the NRP algorithm does not make a distinction between asystole and heart rate below 60 bpm, it is possible that resuscitators attribute a greater degree of urgency for need for advanced airway and initiation of circulatory support in an infant in asystole as compared to an infant with severe bradycardia. It is also possible that many of the resuscitators performed parts of MRSOPA prior to and during the initial 30 s of positive pressure ventilation and felt that repeating these steps may not be helpful. However, there were also providers who had performed emergent intubation immediately upon appreciation of asystole. Studies in adult resuscitation and neonatal animal models have shown that the outcome following resuscitation is dependent on the duration of asystole prior to initiation of resuscitation. The Canadian NRP 2011 guidelines state "The choice of alternate airway will depend on the experience of the provider, and should not unduly delay the institution of chest compressions". In adult and pediatric CPR greater emphasis is being placed on chest compressions during resuscitation while deemphasizing ventilation.

Early initiation of chest compressions without establishing adequate ventilation may decrease chances of successful resuscitation in the newborn. The addition of the ventilation correction steps into the resuscitation algorithm is likely to decrease the number of infants who will require chest compressions. However, these corrective steps may delay chest compressions in the most severely depressed infants whose outcome depends on timely initiation of circulatory support.[17,18] The NRP resuscitation algorithm allows for establishment of alternate airway at multiple steps prior to ventilation corrective steps if the resuscitator decides to pursue alternate airway. It is evident from our study that many experienced neonatal resuscitators determine the appropriate time for an alternate airway based on the severity of circulatory compromise.

In the neonatal resuscitation program provider course, performing all of the steps MRSOPA in order is a criterion for successful completion of the megacode part of the course. It is likely that for many providers the NRP course may be the only formal resuscitation training prior to encountering a delivery room resuscitation. Performing all of the ventilation correction steps for successful completion of megacode may be a source of confusion when dealing with a real life scenario with cardiac arrest and severe cardiovascular compromise.

There are several limitations to our study. It was not possible from this study to evaluate the effectiveness of this intervention nor was it our intention to do so in this study. An important limitation of our study is that in simulated scenarios the provider's performance may be different from a real time delivery room setting. The best estimate of the time taken to perform ventilation correction steps should be made from video recordings of delivery room resuscitation of newborn infants.[19,20] However, individual providers may choose not to perform all of the steps of MRSOPA in every clinical scenario. For these reasons most studies of neonatal resuscitation have been simulation based.[21,22] The average time taken for initial assessment in our study was approximately 24 s. This is much shorter than that was seen in the study by McCarthy et al. The time in our study began at the point of initiation of resuscitation by the subject. Finally, in both our resuscitation scenarios, heart rate did not change with ventilation. This is an unlikely situation during resuscitation of an asphyxiated neonate.

Effective ventilation of the lungs and prompt circulatory support are key to achieving ROSC and reducing neurological morbidity following birth asphyxia. The NRP guidelines provide considerable flexibility regarding the optimal time of endotracheal intubation. Experienced resuscitators resort to early intubation and circumvent corrective ventilation steps (MRSOPA) in the presence of severe cardiovascular compromise. We recommend that in cases of asphyxial arrest with no improvement in heart rate with 30 s of ventilation, an option to immediately establish alternate airway (LMA or intubation) without corrective steps be considered to avoid delay in providing circulatory support during neonatal resuscitation.

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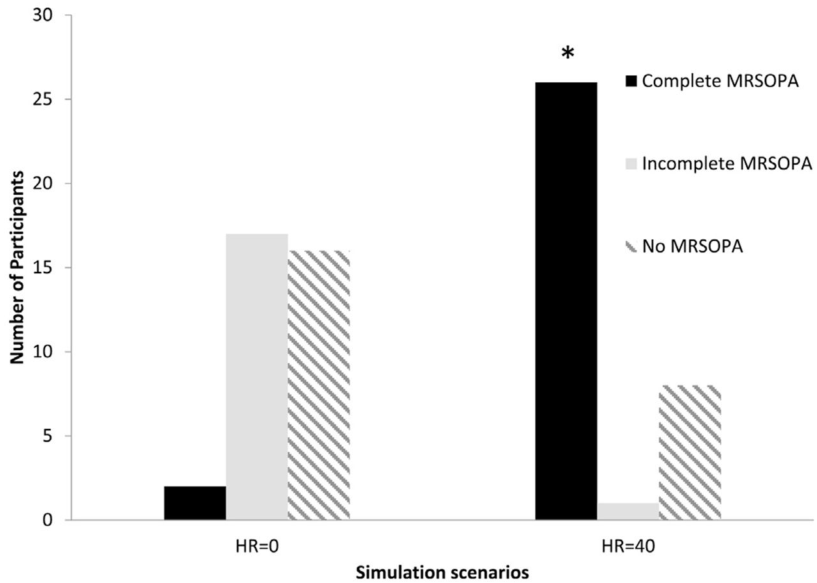

Fig. 1.

Participant's preference for performing ventilation corrective steps (MRSOPA) at the two different heart rate scenarios (*$p < 0.05$ compared to HR = 0 scenario).

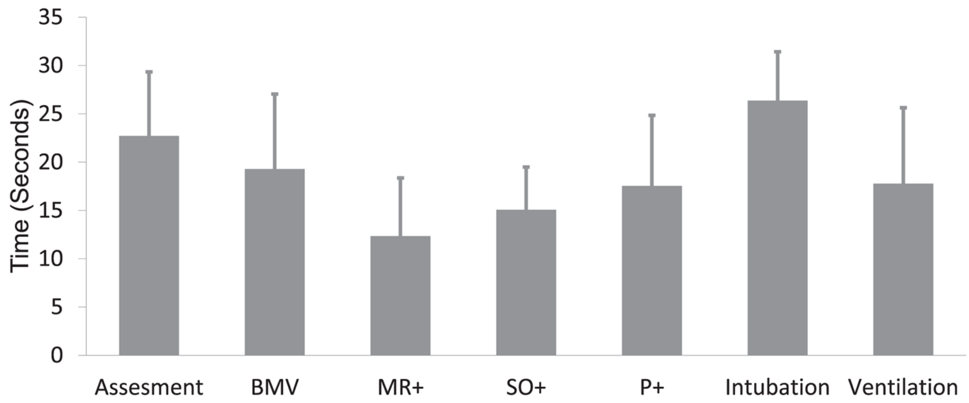

Fig. 2.

Average time taken (in seconds) ± standard deviation for performing individual steps of resuscitation (BMV – bag mask ventilation; MR+ – mask adjustment and reposition; SO – suctioning and opening the mouth; P – increasing pressure).

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Table 1

Flow diagram of possible pathways individual participants can take during simulated resuscitation scenarios. Time taken for ventilation correction steps = time taken with complete MRSOPA - time taken with endotracheal intubation without MRSOPA. e.g. Time taken for MRSOPA by provider C is column 3 minus column 1. For provider I – column 3 minus column 4.

Scenarios	HR = 0	HR = 40	Repeat after demonstration	
A (n = 1)	Intubation	Intubation	MRSOPA	
B (n = 11)	Intubation	MRSOPA		
C (n = 5)	Intubation	Inc MRSOPA	MRSOPA	
D (n = 0)	MRSOPA	Intubation		
E (n = 2)	MRSOPA	MRSOPA	Intubation	
F (n = 0)	MRSOPA	Inc MRSOPA	Intubation	
G (n = 0)	Inc MRSOPA	Intubation	MRSOPA	
H (n = 13)	Inc MRSOPA	MRSOPA	Intubation	
I (n = 3)	Inc MRSOPA	Inc MRSOPA	MRSOPA	Intubation

Inc MRSOPA – incomplete MRSOPA.