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Simulation and education

Impact of a novel decision support tool on adherence to Neonatal Resuscitation Program algorithm☆

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ABSTRACT

Aim: Studies have shown that healthcare professionals (HCPs) display a 16–55% error rate in adherence to the Neonatal Resuscitation Program (NRP) algorithm. The aim of this study was to evaluate adherence to the Neonatal Resuscitation Program algorithm by subjects working from memory as compared to subjects using a decision support tool that provides auditory and visual prompts to guide implementation of the Neonatal Resuscitation Program algorithm during simulated neonatal resuscitation.
Methods: Healthcare professionals (physicians, nurse practitioners, obstetrical/neonatal nurses) with a current NRP card were randomized to the control or intervention group and performed three simulated neonatal resuscitations. The scenarios were evaluated for the initiation and cessation of positive pressure ventilation (PPV) and chest compressions (CC), as well as the frequency of FiO_2 adjustment. The Wilcoxon rank sum test was used to compare a score measuring the adherence of the control and intervention groups to the Neonatal Resuscitation Program algorithm.
Results: Sixty-five healthcare professionals were recruited and randomized to the control or intervention group. Positive pressure ventilation was performed correctly 55–80% of the time in the control group vs. 94–95% in the intervention group across all three scenarios ($p < 0.0001$). Chest compressions were performed correctly 71–81% of the time in the control group vs. 82–93% in the intervention group in the two scenarios in which they were indicated ($p < 0.0001$). FiO_2 was addressed three times more frequently in the intervention group compared to the control group ($p < 0.001$).
Conclusions: Healthcare professionals using a decision support tool exhibit significantly fewer deviations from the Neonatal Resuscitation Program algorithm compared to those working from memory alone during simulated neonatal resuscitation.

1. Introduction

In order to standardize neonatal resuscitation, the American Academy of Pediatrics and American Heart Association developed the Neonatal Resuscitation Program (NRP) in 1987. However, the ability to follow these guidelines precisely has proven difficult in actual clinical practice. Studies have shown that healthcare professionals (HCPs) display a 16–55% error rate in adherence to the NRP algorithm.[1] Examples of resuscitation errors include an inability to accurately detect heart rate, clinically significant delays in the initiation of positive pressure ventilation (PPV), initiation of chest compressions (CC) prior to or in the absence of PPV, and the provision of CC for an insufficient period of time.[2,3] When appropriate ventilation and oxygenation are delayed, neonates are more likely to develop cardiopulmonary collapse and require mechanical and pharmacologic support of cardiac output.[4] Errors are clinically significant and can be developmentally devastating. For example, extremely low birth weight infants (<1000 g) who required CC in the delivery room have increased risk of mortality, severe intraventricular hemorrhage, and poorer neurodevelopmental outcomes.[5–8] Furthermore, despite periodic training

Abbreviations: BPM, beats per minute; CC, chest compressions; HCP, healthcare professional; HR, heart rate; NICU, neonatal intensive care unit; NRP, Neonatal Resuscitation Program; PPV, positive pressure ventilation; RR, respiratory rate; SpO_2, hemoglobin oxygen saturation via pulse oximetry.

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sessions following a formal NRP course, rapid deterioration of the content knowledge integral to successful neonatal resuscitation has been documented.[9]

The causes of errors during resuscitation by HCPs have received little attention in the peer-reviewed medical literature. Research in other domains has shown that humans are limited in both input and output processing of multiple, simultaneous stimuli.[10] Both of these limitations in human performance can lead to crucial delays in either understanding or action during high-intensity activities such as resuscitation.

Given the complexity of the tasks required for neonatal resuscitation and the inherent limitations in human performance, it would seem logical that a properly designed decision support tool would reduce the potential for human error.[11,12] This study compared adherence to the NRP algorithm based on memory alone (control group) to that resulting from the use of a decision support tool (intervention group) during simulated neonatal resuscitation. We hypothesized that subjects using a decision support tool would exhibit fewer deviations from the NRP algorithm compared to those working from memory alone.

2. Methods

2.1. Selection and description of subjects

HCPs (obstetric nurses, neonatal nurses, respiratory therapists, pediatric attending physicians and residents, and neonatology attending physicians and fellows) with a current NRP card were randomized to the control or intervention group and performed three simulated neonatal resuscitations. Subjects were recruited via electronic mail from three different neonatal intensive care units (NICUs); Lucile Packard Children's Hospital Stanford (Level IV NICU), El Camino Hospital (Level III NICU) and Watsonville Community Hospital (Level II NICU). Informed written consent was obtained from all subjects. This study was reviewed by the Western Institutional Review Board (IRB) and determined to be of non-significant risk.

2.2. Technical information

Using a prospective, randomized, controlled design, each subject participated in three standardized simulated neonatal resuscitation scenarios (A, B, C) presented in random order. Primary outcomes included percent adherence to the NRP algorithm in providing PPV and CC when clinically indicated, and the frequency of fraction of inspired oxygen (FiO_2) adjustments.

The study was conducted at the Center for Advanced Pediatric and Perinatal Education (CAPE) at Lucile Packard Children's Hospital at Stanford. CAPE is a training and research center that provides a realistic simulated delivery and resuscitation room with microphones, cameras and a computerized neonatal patient simulator, separated from a control room by a one-way mirror. The simulation specialists at CAPE are skilled in creating the complex visual, auditory, and tactile cues necessary to produce a high degree of realism during scenarios, functioning as HCPs and family members and engendering behavior in subjects consistent with that seen in real life.

The SimNewB® neonatal patient simulator (Laerdal, Stavanger, Norway) was used in all scenarios. Heart rate (HR), respiratory rate (RR), and breath sounds were controlled remotely and could be assessed by auscultation of the thorax, observation of chest movement and palpation of the umbilical cord. The vital signs that are typically available in the delivery room (HR and hemoglobin oxygen saturation via pulse oximetry [SpO_2]) were set via a computerized control interface and displayed on the bedside monitor that is integrated with SimNewB® in both the control and intervention groups.

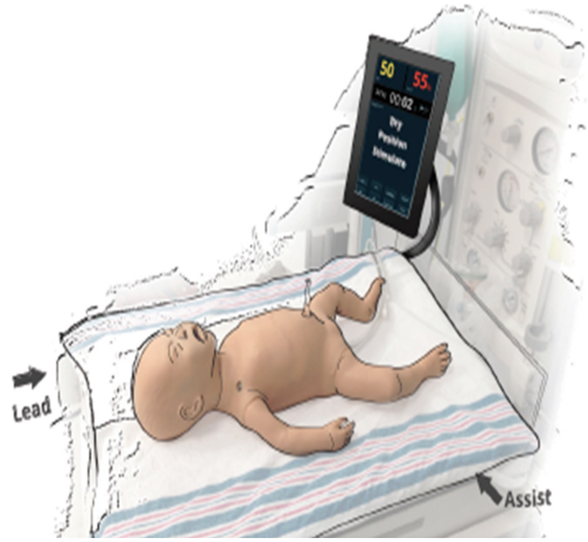

Fig. 1. NeoCue® software is loaded on a 10 × 6.6 in. tablet mounted 6 in. above the patient's left foot.

During all scenarios, starting at time zero, subjects could obtain the HR by assessing the patient (auscultation of the chest or palpation of the umbilical cord), referencing the bedside monitor, or verbally confirming HR with control room personnel. At 60 s of life, the SimNewB monitor displayed visual confirmation of the HR and SpO_2. Subjects in the intervention group could also obtain HR and SpO_2 via the decision support tool (NeoCue® device). SpO_2 was not made available in any scenario until 60 s after birth, in order to mimic the typical delay in sensing, commonly encountered when using this device in the real clinical environment.[13–19] Additionally, the SpO_2 of SimNewB® is not shown on the monitor when the HR is less than 60 beats per minute (BPM). The purpose of the study is to test decision support rather than specific device functioning.

NeoCue® (MedicalCue, Inc., Mountain View, CA) is a proprietary, integrated system that is designed to improve clinician performance during neonatal resuscitation (Fig. 1). The user interface is designed to continuously display data required to implement the NRP algorithm and provides a combination of auditory and visual prompts (Fig. 2). Examples of these auditory prompts are listed in Table 1. Numbers displayed on the tablet change color based upon the appropriateness of the value. For RR, adequate respirations are green, RR > 60 are yellow, and apnea is represented by the color red.

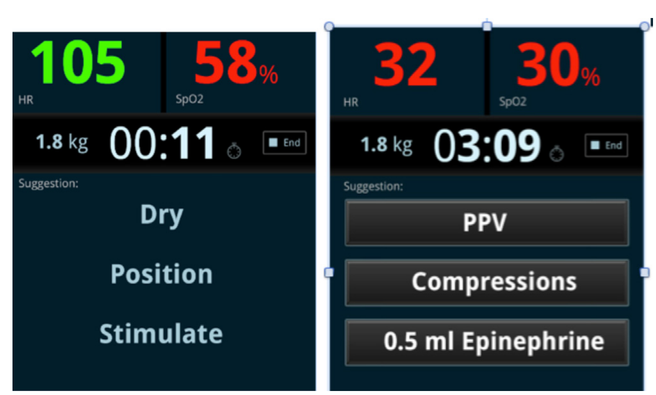

Fig. 2. The tablet displays the following information: current HR, SpO_2, time since delivery, preprogrammed neonatal weight, and prompts that are extrapolated from the NRP algorithm based on HR.