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Simulation and education

The accuracy of human senses in the detection of neonatal heart rate during standardized simulated resuscitation: Implications for delivery of care, training and technology design☆

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ABSTRACT

Aim: Auscultation and palpation are recommended methods of determining heart rate (HR) during neonatal resuscitation. We hypothesized that: (a) detection of HR by auscultation or palpation will vary by more than ±15 BPM from actual HR; and (b) the inability to accurately determine HR will be associated with errors in management of the neonate during simulated resuscitation.
Subjects and methods: Using a prospective, randomized, controlled study design, 64 subjects participated in three simulated neonatal resuscitation scenarios. Subjects were randomized to technique used to determine HR (auscultation or palpation) and scenario order. Subjects verbalized their numeric assessment of HR at the onset of the scenario and after any intervention. Accuracy of HR determination and errors in resuscitation were recorded. Errors were classified as errors of omission (lack of appropriate interventions) or errors of commission (inappropriate interventions). Cochran's *Q* and chi square test were used to compare HR detection by method and across scenarios.
Results: Errors in HR determination occurred in 26–48% of initial assessments and 26–52% of subsequent assessments overall. There were neither statistically significant differences in accuracy between the two techniques of HR assessment (auscultation vs palpation) nor across the three scenarios. Of the 90 errors in resuscitation, 43 (48%) occurred in association with errors in HR determination.
Conclusions: Determination of heart rate via auscultation and palpation by experienced healthcare professionals in a neonatal patient simulator with standardized cues is not reliable. Inaccuracy in HR determination is associated with errors of omission and commission. More reliable methods for HR assessment during neonatal resuscitation are required.

1. Introduction

According to the current guidelines of the Neonatal Resuscitation Program (NRP) based on the consensus on science published by the International Liaison Committee on Resuscitation, a newborn's heart rate (HR) may be determined by either listening to the precordium with a stethoscope or feeling pulsations at the base of the umbilical cord.[1–3] Interventions are either administered or withheld based upon the numeric HR value determined by the healthcare professionals (HCPs) at the bedside. There exist defined HR cut-offs (100 beats per minute [BPM], 60 BPM) below which certain interventions (positive pressure ventilation [PPV], chest compressions [CC], epinephrine administration) are recommended; failure to do so may result in cardiac arrest and death. Similarly, underestimation of the true HR and inappropriately applied interventions may also result in harm. Thus if HR is not accurately determined, certain therapeutic interventions may be inappropriately withheld or administered, potentially resulting in serious injury or death.

This study sought to determine the accuracy of auscultation of the precordium (with a stethoscope) and palpation of the umbilical cord in the detection of HR during simulated neonatal resuscitation. To provide appropriate clinical context, the frequency of errors of omission (failure to perform appropriate interventions) and errors of commission (performance of inappropriate interventions) was also assessed. Using a neonatal patient simulator capable of generating a HR that is fixed in rate, volume, tone and location, and umbilical cord pulsations that are fixed in frequency, amplitude and location, we hypothesized that: (1) the detection of HR by auscultation or palpation will vary by more than ±15 BPM from actual HR, and (2) the inability to accurately determine HR will be associated with errors of omission and/or commission.

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2. Subjects and methods

2.1. Study population

Residents in general pediatrics, fellows in neonatal–perinatal medicine, attending physicians in neonatology, hospitalists, neonatal nurse practitioners and neonatal nurses (all of whom attend deliveries at Lucile Packard Children's Hospital and hold current NRP Provider status) were recruited via electronic mail and asked to participate in a study of techniques in neonatal resuscitation. Informed written consent was obtained from all subjects. This study was approved by the Institutional Review Board of Stanford University.

2.2. Study design

Using a prospective, randomized, controlled design, each subject participated in three standardized simulated neonatal resuscitation scenarios (A–C) presented in random order. SimNewB® (Laerdal Inc., Stavangar, Norway), a neonatal patient simulator capable of generating heart tones and umbilical artery pulsations, was used in all scenarios. HR was set using a computerized control interface. The simulator's HR can be assessed by auscultation of the precordium as well as palpation of the umbilical cord. Subjects were randomized to determine HR by either auscultation of the precordium or palpation of the umbilical cord and used this technique in all three scenarios. Subjects were familiarized to the simulator prior to study participation and were informed during the familiarization that they were to determine HR and verbalize their numeric HR assessment before and after any intervention.

In each scenario, subjects were asked to lead the resuscitation with the help of two assistants (both of whom were simulation specialists at the Center for Advanced Pediatric and Perinatal Education [CAPE] and skilled at role-playing during scenarios), one functioning as a bedside nurse and the other as a respiratory therapist. Scenario A incorporated a vigorous term infant (39 weeks gestation) with spontaneous respiratory effort and an initial HR set at 130 BPM. In this scenario (vigorous/term/HR = 130) the appropriate intervention was to warm, dry and stimulate (W/D/S) the infant. Scenario B involved a non-vigorous, post-term infant (41+ weeks gestation) with minimal respiratory effort and an initial HR set at 90 BPM. W/D/S followed by PPV was the proper response to this scenario (non-vigorous/post-term/HR = 90). Scenario C presented a non-vigorous, apneic, term infant (40 weeks) born after acute blood loss due to placental abruption with initial HR set at 50 BPM. In this scenario blood substitute was applied to the simulator and the surrounding environment to provide visual cues indicating blood loss. The appropriate interventions during this scenario (abruption/non-vigorous/term/HR = 50) were to first W/D/S the infant, then deliver PPV and finally, CC. If all of the indicated interventions were performed in each scenario, the HR was increased to 130 BPM (or kept at 130 BPM in the case of the vigorous/term/HR = 130 scenario) (Table 1).

All scenarios were conducted and videotaped at CAPE. Recordings of each scenario were reviewed and data collected. The stated HR before and after all interventions for each scenario were recorded and the number and type of errors of omission and commission were noted.

A 2×6 randomized block design was used to balance the assignment (auscultation vs palpation) for each of the subgroups (residents, fellows, attending neonatologists, hospitalists, nurse practitioners, and nurses) within each scenario. Each set of two subjects within the six subgroups had balanced assignments between auscultation and palpation. The order of presentation of the testing scenarios for each subgroup pair was taken from the next available choice on a randomized table of the six possible scenario orders.

Table 1
Scenario details including the initial set HR, appropriate/expected interventions, and the final HR if the appropriate interventions are carried out.

Scenario	Initial HR	Appropriate intervention(s)	Final HR
A. Vigorous/term (39 weeks)	130	Warm, dry, stimulate (W/D/S)	130
B. Non-vigorous/post-term (41+ weeks)	90	W/D/S, positive pressure ventilation (PPV)	130
C. Abruption/non-vigorous/term (40 weeks)	50	W/D/S, PPV, chest compressions (CC)	130

2.3. Data analysis

The frequency of errors made during determination of the initial HR (pre-intervention) and subsequent HR (post-intervention) was recorded based on technique (auscultation or palpation) and scenario (A–C). An error in HR assessment was defined as a HR that differed by at least 15 BPM from the actual HR set on the simulator. Cochran's Q and chi square tests were used to compare the accuracy of HR detection according to method, scenario, and other groupings. Errors of omission and commission during the simulated resuscitations were also categorized by technique and scenario.

3. Results

A total of 64 subjects were recruited for participation in the study: 22 residents, 7 fellows, 9 attending physicians, 9 hospitalists, 7 nurse practitioners, and 10 nurses. Thirty-three subjects were randomized to auscultation and 31 to palpation. Errors in HR determination were frequent, ranging from 26% to 52% (Table 2). There was no statistically significant difference in accuracy between the pre- and post-intervention assessments of HR when compared by technique (auscultation, palpation) or scenario (A–C); this indicates that there was no learning effect, i.e., enhancement in skill level as the scenario progressed. Similarly there was no statistically significant difference in the accuracy of HR assessment overall whether compared between the two techniques or across the three scenarios.

Errors in the conduct of resuscitation were recorded and categorized as errors of omission or commission (Table 3). In scenarios A and C there were more errors of commission than omission; the opposite was true for scenario B. Across all three scenarios there

Table 2
Frequency of errors in HR determination during initial (pre-intervention) and subsequent (post-intervention) assessment.

Scenario	Pre – n (%)	Post – n (%)
A. Error frequency: auscultation (n = 33 subjects)		
A	16 (48%)	14 (42%)
B	11 (33%)	15 (45%)
C	11 (33%)	15 (45%)
B. Error frequency: palpation (n = 31 subjects)		
A	14 (45%)	8 (26%)
B	12 (39%)	16 (52%)
C	8 (26%)	13 (42%)
C. Error frequency: overall = auscultation + palpation (n = 64)		
A	30 (47%)	22 (34%)
B	23 (36%)	31 (48%)
C	19 (30%)	28 (44%)