1.5 HOURS Continuing Education

Neonatal Resuscitation Program Rolling Refresher

Maintaining Chest Compression Proficiency Through the Use of Simulation-Based Education

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ABSTRACT
Background: Structured training courses have shown to improve patient outcomes; however, guidelines are inconsistently applied in up to 50% of all neonatal resuscitations. This is partly due to the fact that psychomotor skills needed for resuscitation decay within 6 months to a year from the completion of a certification course. Currently, there are no recommendations on how often refresher training should occur to prevent skill decay.
Purpose: Improve provider proficiency and confidence in the performance of neonatal resuscitation with a focus on chest compression effectiveness.
Methods: The study recruited neonatal intensive care unit providers (n = 25). A simulation-based Neonatal Resuscitation Program (NRP) curriculum was developed and executed. Training sessions were delivered utilizing in situ simulations at varying time intervals. Pre- and postconfidence surveys and practicum skill scores were collected and evaluated by a content expert. Categorical data were summarized by frequency and percentage and tested for distributional equality via Pearson chi-square tests or Fisher exact tests depending on cell sample size distribution. All statistical tests were 2-sided with $P < .05$ considered statistically significant.
Results: Provider overall confidence and rate of chest compressions improved; however, there was no statistically significant difference between groups. Rolling refresher training at varied time intervals did not demonstrate statistically significant differences in chest compression quality among NRP providers.
Implications for Practice: Rolling refresher training more frequently than every 6 months may not provide added benefit to NRP providers.
Implications for Research: Additional research is needed to determine optimal refresher training frequency to prevent skill decay.
Key Words: advanced resuscitation, knowledge retention, neonatal resuscitation program, skill decay

It is undisputable the benefit a structured training course like the Neonatal Resuscitation Program (NRP) has had on patient outcomes all over the world.[1,2] Despite making great strides to bridge the educational gap for all providers caring for critically ill newborns, NRP guidelines are inconsistently applied in up to 50% of all resuscitations.[3,4] Furthermore, for many healthcare providers, neonatal resuscitation embodies a low-frequency, high-acuity, and high-stress clinical situation.[5]

A newborn requiring chest compressions is an even less common occurrence, required in only 0.1% of neonatal resuscitations.[6] Chest compressions in this population, therefore, are rarely performed clinically and subsequently require practice opportunities to ensure that this skill can be effectively executed when necessary. The management of patients requiring emergent resuscitation is further complicated by the fact that many of the psychomotor skills needed for good resuscitation decay within 6 months to a year from the completion of a certification course such as NRP, Advanced Cardiac Life Support (ACLS), Pediatric Advanced Life Support.[7-9]

Most of these courses require recertification every 2 to 3 years. Currently there are no standard recommendations on how often refresher training should occur to prevent skill decay in between recertification.

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This study was conducted at Akron Children's Hospital NICU at Summa.

The authors have no conflicts of interest to declare.

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Simulation-based education has been shown to be an effective tool for initial training, to increase retention and prevent skill decay.[10-12] Learning strategies that promote skill mastery, such as deliberate practice, lend themselves perfectly to be employed in a simulation-based curriculum.[13] Coupling these strategies with training conducted in the clinical area where the skills will be utilized heightens provider preparedness.[14]

A "Rolling refresher" simulation curriculum was designed by the medical simulation team of our institution for the resuscitation of an unresponsive newborn. The goal of the curriculum was to improve provider proficiency and confidence in the performance of neonatal resuscitation with a focus on chest compression effectiveness. A secondary goal was to identify the frequency of refresher sessions needed for effective chest compression.

METHODS

Participants and Inclusion Criteria

This was a single-blinded, randomized, longitudinal study. It was considered exempt by the institutional review board. All staff members from our institution's neonatal intensive care unit (NICU) were invited to participate (convenience sample). The only inclusion criterion was to be a full-time NICU employee in good standing with the institutional certification requirements. Twenty-five of 51 possible participants (49%) completed the 6-month study period. Twenty-six participants (51%) were excluded from the study because of their inability to participate in the rolling refreshers outlined for their cohorts, primarily because of participants changing jobs (9), scheduling conflict (8) (by either becoming a part-time employee or being unavailable due to clinical duties), incomplete video data (4), or an unplanned leave of absence (3). Two (2) additional staff members were not included as they were unit coordinators and not involved in day-to-day clinical duties.

Study Design

Enrollment

On the first encounter each participant enrolled by completing an informed consent form outlining the research objectives and extent of their involvement should they decide to take part in the study.

After informed consent was obtained, participants were surveyed collecting basic demographic information (age, gender), years of experience as a neonatal care provider, relevant work experience, and NRP-related Continuous Medical Education information (such as time since initial NRP certification and time since most recent NRP recertification). Also participants were surveyed on frequency of NRP skills utilization and if currently a NRP instructor (if so, how often they conducted training courses).

Participants were subjectively evaluated on their confidence level in performing the basic life support maneuvers needed for neonatal resuscitation. They were also evaluated on their confidence leading a neonatal cardiopulmonary arrest as well as how confident they felt following the NRP protocol. This survey was composed of 5 questions utilizing a 5-point Likert scale. The survey was designed by the research team for the purpose of this study only (see Tables 1 and 2).

Once enrollment was completed, participants managed an initial Simulated Neonatal Arrest (sNA), which was used to establish a performance baseline.

Participant Allocation

All enrolled participants were assigned a study code using the terminal 4 digits of their 9-digit hospital code. A de-identified list of the providers that had all the staff members organized in descending order by years of experience was provided to the research team. Participants were assigned in sequential order to 1 of the 3 cohorts, refreshers monthly (RR1), every 3 months (RR3), or one refresher over the 6-month study period (RR6).

Rolling Refreshers

At predetermined intervals, all participants (RR1, RR3, or RR6) were approached for in situ simulation sessions. Participants were grouped in pairs to manage the sNA described earlier, with minor changes in back story and situation as to help participants suspend disbelief.

All in situ simulations involved management of a neonatal resuscitation. During each refresher session, participants received corrective feedback on all the aspects of their management of the case with an emphasis on performing effective chest compressions. A summative assessment at the end of the study was performed to assess for competency progression, followed by a postintervention confidence survey. Baseline and summative assessments, as well as all refresher training, were conducted by a NRP certified medical provider (medical simulation fellow with residency training in emergency medicine).

Simulated Neonatal Arrest

Prior to every simulation, participants had a brief introduction to the capabilities of PEDI Blue Neonatal Simulator (Gaumard Scientific Company, Inc, Miami, Florida) as well as the digital display for vital signs software Laedral for SimMan (Laerdal Medical, Wappingers Falls, New York). See Figure 1 for graphic description of sNA setup.

At the beginning of the sNA scenario, participants were briefed of the imminent arrival of a complicated newborn delivery at 33 weeks' gestation. The patient presented with suspected meconium aspiration and was unresponsive. Case progression was designed in a way that every scenario ultimately

TABLE 1. Confidence Survey

Subject ______________ Date________________ Pre / Post survey

1. How comfortable do you feel with leading a cardiopulmonary arrest in a neonatal patient?
a) Very comfortable b) Comfortable c) Neutral d) Uncomfortable e) Very uncomfortable

2. How comfortable do you feel following the NRP protocol for the management of cardiopulmonary arrest in a neonatal patient?
a) Very comfortable b) Comfortable c) Neutral d) Uncomfortable e) Very uncomfortable

3. How comfortable do you feel identifying common causes of neonatal cardiopulmonary collapse?
a) Very comfortable b) Comfortable c) Neutral d) Uncomfortable e) Very uncomfortable

4. How comfortable do you feel performing bag mask ventilations on a neonatal patient?
a) Very comfortable b) Comfortable c) Neutral d) Uncomfortable e) Very uncomfortable

5. How comfortable do you feel performing chest compressions on a neonatal patient?
a) Very comfortable b) Comfortable c) Neutral d) Uncomfortable e) Very uncomfortable

required chest compressions by all of the participants on the care team during the sNA. The case ended after 5 minutes with return of spontaneous circulation.

Additional support staff (ie, neonatologists, additional nurses), if requested by the participants, were not readily available to test the participant's knowledge on the initial actions for neonatal resuscitation.

All sNAs were videotaped for subsequent grading. They were 10 minutes in duration and administered at times convenient for the staff to avoid disrupting patient care as well as the unit's workflow.

TABLE 2. Modified Scorecard

Subject ID___________	***Date _______________***	***Assessment___________***
Do you have any limitations preventing you from performing this activity? **YES / NO**		
Episode duration	**Total minutes** ______________	
Compression rate	***# chest compression*** ______________	***Rate per min*** ______________
% of Time w/inadequate rate	Total time (s) ______________	Fraction of mins not on target rate ______________
Compression fraction	***% of total time doing Compression*** ______________	***# of significant Pauses (>1.5s)*** ______________
Compression depth	***# compression correct depth (green)*** ______________	***Fraction of mins not on green range*** ______________
Incomplete recoil	***% of total # of compression*** ______________	
Compression technique	**% time correct hand placement** ______________	***Using two thumb technique*** YES - NO
Do you have any discomfort after completing this activity? **YES / NO** If so, Do you feel you need immediate medical attention? **YES / NO**		
Notes:		

FIGURE 1

Simulated neonatal arrest (sNA) setup. Providers are performing a neonatal resuscitation in our simulation in situ environment.

Measures

Goals for chest compression performance were modeled after 2011-2015 NRP guidelines that were current at the time our study was conducted.[15] Performance was reported using a modified scorecard (see Tables 1 and 2 based on the international consensus group for uniform reporting of chest compression quality).[16]

We defined effective chest compressions as chest compressions that were performed at a rate of at least 90 compressions per minute that depressed at least one-third of the anteroposterior chest wall diameter, allowing full recoil of the chest wall after each compression and without any significant interruptions (>1.5 seconds). Hands need to lay on the lower portion of the sternum and perform compressions utilizing the 2-thumb technique.

Other important measures of chest compression quality evaluated:

a. *Chest compression fraction*: Proportion of time spent performing chest compressions during cardiac arrest.[17] In our study, providers were encouraged to attain a chest compression fraction of more than 90%.
b. *Chest compression rate*: Number of chest compressions performed in 1 minute.
c. *Adjusted chest compression rate*: Number of chest compressions in 1 minute based on the chest compression fraction.

Data Analysis

Data were imported into SPSS Statistics for Windows, Version 22.0. (IBM Corp, Armonk, New York) and summarized for each of the 3 study training schedule groups. Numeric and ordinal scaled data were summarized using means (SD), medians, and minimum to maximum range. Statistical testing for rank equality was performed via Kruskal–Wallis exact tests. Categorical data were summarized by frequency and percentage and tested for distributional equality via Pearson chi-square tests or Fisher exact tests depending on cell sample size distribution. All statistical tests were two-sided with $P < .05$ considered statistically significant.

During secondary data analysis, an adjusted chest compression rate was determined for both baseline and postintervention scores based on the chest compression fraction.

RESULTS

Our study included 25 of 51 (49%) of the available providers in the institution's NICU. Table 3 demonstrates the composition of all 3 cohorts.

Sixteen of 25 participants (64%) showed improvement in chest compression rate. Five of 25 participants (25%) remained at their baseline level of proficiency (≥90 compressions per minute) and 4 of 25 (16%) scored lower on their postintervention assessment.

Eleven (11) of the 16 participants who showed improvement attained an effective chest compression rate of at least 90 compressions per minute. The other 5 participants in this group improved as compared to their baseline performance but did not attain an effective chest compression rate. Provider overall confidence and rate of chest compressions improved; however, there was no statistically significant difference between the groups.

DISCUSSION

Chest compression rate and overall confidence improved globally for providers in this study (see Figure 2); however, there was no statistically significant difference between the groups. As expected, because of the more frequent training sessions, the RR1 group had higher self-reported confidence levels in comparison to the RR3 and RR6 groups. Conversely, even though both groups (RR3 and RR6) improved, the net increase in confidence by the RR6 month group was higher than that by the RR3 in all but one section of the confidence survey, despite fewer training sessions. We believe that this is due to the fact the RR3 had a higher baseline confidence. After excluding all ineligible providers, RR3 ultimately was composed of more senior providers (14.8 vs 12.8/median 13 vs 4) and we believe this played as a significant factor in their confidence scores.

In regard to leadership confidence, all groups self-reported increased confidence, yet there was a stated undercurrent among providers that leading the team was beyond their scope of practice. Thus, many found the training sessions to be in disconnect with their usual clinical environment. During the debriefing sessions, they also stated that being in the leadership role was distracting them from performing

TABLE 3. Demographics/Subject Characteristics[a]

Variable/Statistic	Training Schedule RR1 (n = 7)	RR3 (n = 7)	RR6 (n = 11)	P
Female gender, n (%)	7 (100%)	7 (100%)	11 (100%)	NA
Experience (years)				.798
Mean (SD)	17.7 (16.98)	14.8 (11.59)	12.8 (13.73)	
Median	15	13	4	
Min-max	2-44	2-31.5	0.5-35	
Work environment, n (%)				1.000
NICU	7 (100%)	6 (85.7%)	10 (90.9%)	
NICU/pediatric inpatient unit	0	1 (14.3%)	1 (9.1%)	
Resuscitations (per year)				.917
Mean (SD)	88.9 (125.12)	39.5 (30.36)	49.0 (40.04)	
Median	30	37.5	38.5	
Min-Max	5-350	10-90	3-100	
Team leader resuscitations (per year)				0.139
Mean (SD)	25.7 (38.24)	0 (0.00)	2.6 (5.36)	
Median	0	0	0	
Min-Max	0-100	0-0	0-15	
Level of training, n (%)				.660
RN	2 (28.6%)	1 (14.3%)	3 (27.3%)	
BSN	2 (28.6%)	2 (28.6%)	2 (18.2%)	
BSN-RN	0	1 (14.3%)	4 (36.4%)	
Other	3 (42.9%)	3 (42.9%)	2 (18.2%)	
Initial NRP training, n (%)				.540
0-6 mo	0	0	1 (9.1%)	
6-12 mo	0	1 (14.3%)	2 (18.2%)	
1-2 y	1 (14.3%)	0	0	
2-5 y	2 (28.6%)	0	3 (27.3%)	
5-10 y	0	1 (14.3%)	0	
10+ y	4 (57.1%)	5 (71.4%)	5 (45.5%)	
Most recent NRP training, n (%)				.045
0-6 mo	4 (57.1%)	0	3 (27.3%)	
6-12 mo	0	5 (71.4%)	5 (45.5%)	
1-2 y	3 (42.9%)	2 (28.6%)	3 (27.3%)	
NRP refreshers, n (%)	0	0	1 (9.1%)	1.000
NRP instructor, n (%)	2 (28.6%)	0	1 (9.1%)	.431

Abbreviations: NICU, neonatal intensive care unit; NRP, Neonatal Resuscitation Program.

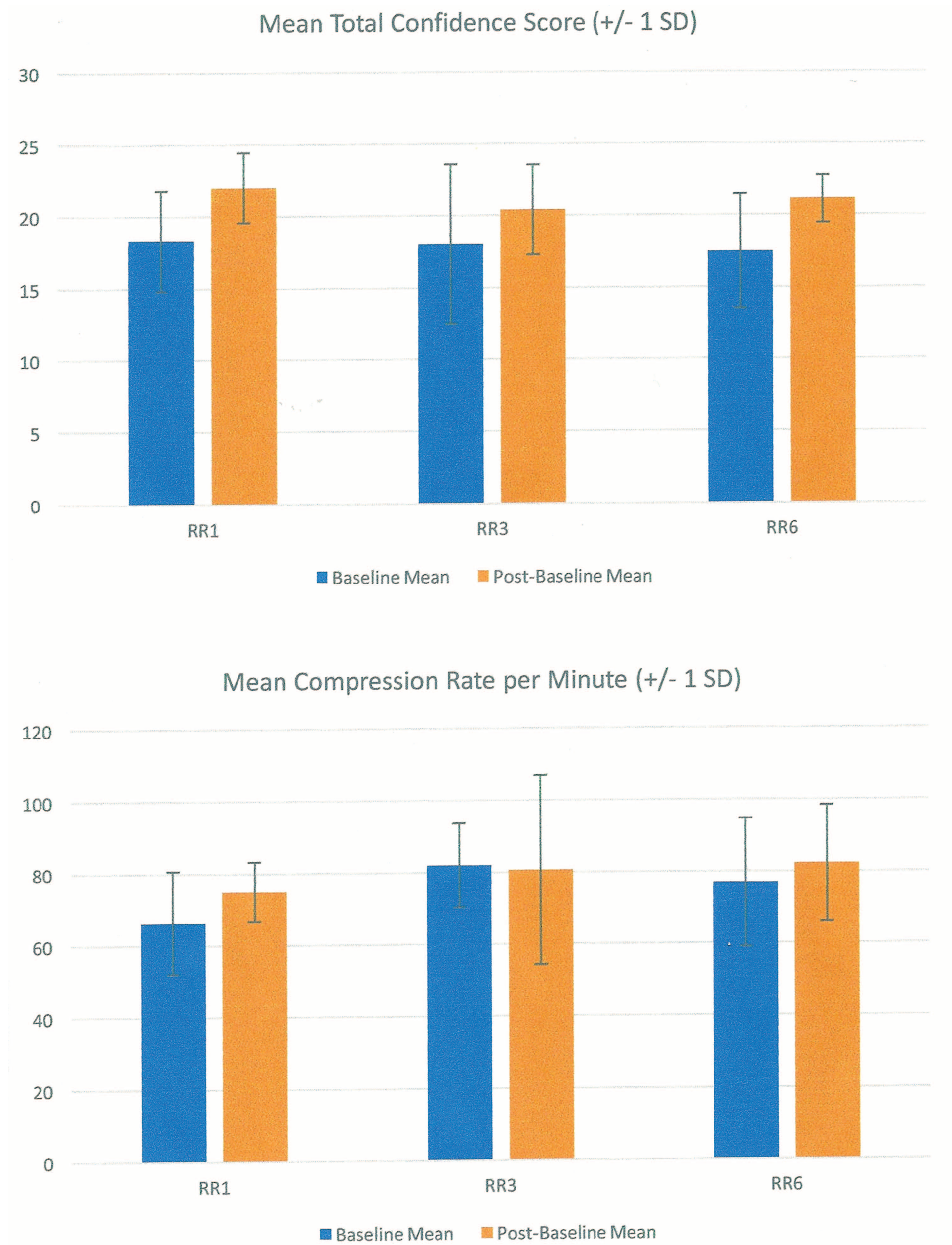
[a]P for categorical data from Pearson chi-square tests or Fisher exact tests depending on cell sample size distribution. A Bonferroni adjusted z test was performed when multiple subcategories were encountered.

P for numeric data from Kruskal–Wallis (exact) tests.

other clinical tasks. To counter this sentiment during the debriefing sessions, we emphasized that our goal was not to give them responsibilities beyond their scope of practice, but rather empower them to have the confidence of being a first responder in a situation such as the one depicted in the sNA until further help became available. All groups improved their comfort level in following the NRP algorithm, identifying causes of fetal distress leading to sNA, and performing chest compressions.

Despite the increased reported self-confidence, the providers scored poorly in several core

FIGURE 2



Pre- and postintervention confidence and chest compression rate scores. Graphic representation of the provider's confidence and chest compression rate scores with effect sizes by group.

measures of chest compression proficiency, primarily depth of compressions (most providers compressed too deeply), and allowing full recoil of the chest wall. Providers reported that they found it difficult to gauge chest compression depth and if they had achieved complete chest recoil without sacrificing hand positioning on our simulator. During debriefing, providers were able to practice chest compressions while visualizing the simulator's compression depth feedback box, indicating appropriate or inappropriate depth of compression. As part of the study design, providers did not receive any form of feedback from the simulator during the sNA. This was done in an attempt to promote mastery of this seldom used, but critical skill.

The core competency that showed most improvement was the providers' chest compression rate; however, this improvement did not reach statistical significance. More than 60% of providers showed improvement in their overall scores, but in half of the cases, providers failed to reach the ideal compression rate target of 90 per minute.

When grading the videos, we noted participants were performing chest compressions/ventilations using the NRP pneumonic "1 and 2 and 3 and breathe" that should have yielded a rate of at least 90 compressions in 1 minute, meaning their technique was adequate.

On the basis of the video data, we hypothesized then that the participants' failure to attain an effective chest compression rate was due to the number of interruptions in chest compressions during cardiopulmonary resuscitation. To test this theory, we adjusted the chest compression rate to eliminate those pauses; we noticed a majority of providers would have attained an ideal compression rate of at least 90 compressions per minute by NRP standards.

In the clinical setting, limiting interruptions in chest compressions has been shown to be associated to better cardiac and cerebral perfusion and ultimately improving outcomes.[18] This was point of emphasis during the debriefing sessions to reinforce the importance of decreasing the number of significant interruptions while performing chest compressions.

In our study, despite our best efforts, no significant change was noted on the compression fraction during the sNAs. Many providers reported that being unfamiliar with the team leader role, coupled with performing chest compressions simultaneously, affected their ability to concentrate on performing these basic resuscitative maneuvers.

Previous research on psychomotor skills for resuscitation demonstrates significant skill decay after 6 months of completing a structured certification course.[19,20] It was our hypothesis that more frequent interval training would prevent such skill decay among NRP providers in regard to chest compression quality. Despite demonstrating improvement in self-confidence and chest compression rate quality in more than 60% of providers, there was a negligible difference between cohorts. Based on our findings, it is difficult to justify interval training more frequently than every 6 months, especially in light of the fact that in situ rolling refreshers can typically be very resource intensive and can affect day-to-day workflow in the actual clinical environment.

Limitations

Limitations of our study include the small sample size and the uneven distribution in 2 of the groups after randomization as identified (see the Methods section). Another limitation is the unanticipated effect caused by the change of roles during the sNA, hindering the providers' ability to suspend disbelief and, in some cases, distracting them from performing the NRP maneuvers of bag-valve-mask ventilation and chest compressions. An additional limitation was the single evaluator of all participants pre- and poststudy performances. This evaluation was, however, limited to counting compressions over an established time period. The evaluator was able to slow down the video to ensure accuracy in the recording of chest compression rate.

CONCLUSION

Rolling refresher training at 1-month, 3-month, and 6-month intervals did not demonstrate statistically

Summary of Recommendations	
What we know:	• Structured training courses like the Neonatal Resuscitation Program (NRP) have improved patient outcomes all over the world. • Despite making great strides to bridge the educational gap, treatment guidelines are inconsistently applied in up to 50% of all neonatal resuscitations. • Poor utilization of the current guidelines is multifactorial, stemming from the low frequency in which they are needed, relative to other medical emergencies and the natural skill decay that occurs 6 months to a year after any structured training course. • In our study, frequent interruption is the primary reason why providers do not perform effective chest compressions.
What needs to be studied:	• How often refresher training should occur to prevent skill decay. • Which education modality (ie, simulation, lectures) alone or in combination could serve as an optimal delivery method to bridge this educational gap. • Cost–benefit analysis prior to standardization of any single modality to ensure sustainability for a majority of healthcare institutions.
What can we do today:	• Educate all staff members involved in neonatal resuscitation on NRP guidelines. • Have Continuous Medical Education activities to help refresh core concepts of NRP care at least once a year. • Have all staff members with direct patient care responsibilities train through simulation-based cases (drills) 1 to 2 times per year to maintain resuscitation psychomotor skills.

significant differences in confidence or chest compression quality among NRP providers. NRP rolling refresher training more frequently than every 6 months may not provide added benefit to NRP providers.

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