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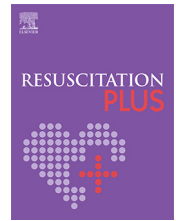
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Clinical paper

Assessment of temporal variations in adherence to NRP using video recording in the delivery room

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Abstract

Introduction: Video recording and video evaluation tools have been successfully used to evaluate neonatal resuscitation performance. The objective of our study was to evaluate differences in Neonatal Resuscitation Program (NRP) adherence at time of birth between three temporal resuscitative periods using scored video recordings.

Methods: This is a retrospective review of in-situ resuscitation video recordings from a level 3 perinatal center between 2017 and 2018. The modified Neonatal Resuscitation Assessment (mNRA) scoring tool was used as a surrogate marker to assess NRP adherence during daytime, evening, and nighttime hours.

Results: A total of 260 resuscitations, of which 258 were births via Cesarean section, were assessed. mNRA composite scores were 86.2% during daytime hours, 87% during evening hours, and 86.6% during nighttime hours. There were no significant differences in mNRA composite scores between any of the three time periods. Differences remained statistically similar after controlling for complexity of resuscitations with administration of positive pressure ventilation (PPV), intubation, or chest compressions.

Conclusion: Overall adherence to NRP, as measured by composite mNRA scores as a surrogate marker, was high across all three daily resuscitative periods without significant differences between daytime, evening, and nighttime hours.

Keywords: Delivery room, Resuscitation, NRP, Video

Introduction

It is estimated that approximately 10% of newborns require some degree of resuscitation at birth, and approximately 1% require invasive resuscitative measures such as cardiac compressions and medications^{1,2}. The interventions performed during resuscitation have a direct influence on immediate survival and also on long-term neonatal morbidity and mortality. The Neonatal Resuscitation Program (NRP) guidelines are a set of standardized instructions guiding neonatal resuscitation. However, adherence to NRP resuscitative guidelines is challenging and performance can be variable^{3,4}. This has been attributed to limited experience of practitioners, high-stress environment when a neonate is distressed, poor communica-

tion amongst team members, and decline in skills over time^{5–9}. Video recordings and video evaluation tools allow for the observation and scoring of resuscitation practices and may result in improved resuscitation outcomes by allowing for debriefing, group audit and reflection, identification of targeted areas for training debriefing, group audit and reflection, and identification of targeted areas for training^{8,10–15}. These strategies can help to detect strengths and weaknesses in the performance of neonatal resuscitation and NRP adherence, and can facilitate future targeted education and quality improvement initiatives.

Furthermore, recent literature suggests potentially worsened outcomes of neonates resuscitated at birth during evening and nighttime hours^{16–19}. Shift length, shifts scheduled outside of typical daytime

Abbreviations: NRP, Neonatal Resuscitation program, DR, delivery room, mNRA, modified Neonatal Resuscitation Assessment, NRA, neonatal resuscitation assessment, PPV, positive pressure ventilation, CPAP, continuous positive airway pressure

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hours, and physician fatigue can result in increased patient load and capacity strain on perinatal providers during nighttime hours and potentially contribute to medical errors and poor outcomes^{20–23}. The objective of our study was therefore to compare adherence to NRP in resuscitations that occurred during daytime hours, evening hours, and nighttime hours using video recordings and mNRA scores as a surrogate marker of adherence.

Methods/Study design

This study is a retrospective review of prospectively collected data from a level 3 regional perinatal center with approximately 6,100 births per year. The Institutional Review Committee at ChristianaCare approved this study. Consent for video recording of resuscitations to be utilized for quality improvement purposes is incorporated into standard hospital consent obtained by obstetricians. Video recording of birth resuscitations has occurred at our institution since 2015 as part of an ongoing quality improvement project following staff buy-in. Notable resuscitations are reviewed with staff members on a regular basis for educational purposes and without punitive consequences.

Select labor and delivery rooms and all operating rooms used for Cesarean births are outfitted with overhead video cameras above resuscitation beds and resuscitations from these deliveries are recorded in real time. The cameras are mounted above the warmer and are positioned so as to provide a field of view that includes the entire infant and the hands of the resuscitation team. The cameras are switched on by a member of the resuscitation team on arrival to the birth. The resuscitation team is comprised of at minimum two providers (“small team”), and typically includes at least one member of the neonatology team (neonatal nurse practitioner, pediatric resident, neonatology fellow, neonatology attending) and a labor and delivery nurse. Higher risk births as well as emergency deliveries are frequently attended by multiple neonatal providers (“full NICU team”) as well as neonatal nurses, neonatal respiratory therapists, and labor and delivery nurses. As part of an ongoing quality improvement initiative, recordings are deidentified and reviewed periodically by members of the neonatal resuscitation quality improvement team. Recordings are stored on secure encrypted drives until review.

Previously recorded videos of resuscitations from 01/2017 to 06/2018 were reviewed and scored using the modified neonatal resuscitation assessment (mNRA) tool. The neonatal resuscitation assessment (NRA) is a validated tool that assesses competency to NRP in seven domains: preparation and initial steps, heart rate assessment, oxygen administration, bag/mask ventilation, intubation, cardiac compressions, and medication use¹⁰. We utilized a modified version of this tool, the mNRA, in order to place additional emphasis on team function and communication, which was difficult to assess in the original tool. Sections in this tool are weighted differently, and the sum of the awarded points is divided by the total points possible for that resuscitation and multiplied by 100 to yield a percentage or composite score.

Relevant data regarding the need for and appropriate use of positive pressure ventilation (PPV), continuous positive airway pressure (CPAP), endotracheal intubation attempts and technique, chest compressions, and administration of endotracheal and intravenous medications were collected. Infants of all gestational ages were included in this study. Three temporal resuscitative periods were assessed: daytime hours (0700 – 1459), evening hours (1500–2259), and night-

time hours (2300–0659). These specific time periods were chosen because, in our institution, a decreased number of neonatal providers is present in the hospital in the late afternoon, evening, and nighttime hours as opposed to morning and early afternoon hours. Nighttime hours were specifically evaluated due to concerns for provider fatigue occurring during this time period. Additionally, change of shift and therefore transitions of care occur within these specific time periods for both nursing and medical (physician and nurse practitioners) staff. The seniority, experience and recency of NRP training of the members of the resuscitation team for all 3 time intervals occurred at random based on routine staffing and scheduling. Data regarding these factors was not collected.

After establishing interrater reliability, three independent research team members scored the resuscitations using the mNRA tool. Only resuscitations that received CPAP or higher were included in the analysis, as it was felt that those represented more complex resuscitations with higher likelihood of deviation from NRP guidelines. Data regarding timeliness of the interventions, including initial steps of drying, warming, and tactile stimulation, as defined by then-current NRP guidelines was collected and included in the scoring, with deduction of points if interventions were performed out of sequence or were too early or delayed. Interventions were clocked by an in-video timer. Resuscitations were excluded from analysis if they included fewer than two medical providers attending the birth or if video recording was initiated after resuscitation had begun. As the data were deidentified prior to review, the videos were unable to be linked to a patient’s electronic medical record and therefore demographic information, previously identified congenital anomalies, perinatal risk factors and post-delivery outcomes were not assessed in this study. We did, however, exclude resuscitations of infants with obvious congenital anomalies as well as resuscitations of multiple births. Reviewers were not blinded to the time of day that births occurred.

Statistical analysis was performed using SPSS version 25 (IBM Corporation, Armonk, NY). Data are represented with mean $\pm$ standard deviation unless otherwise noted. Comparisons between groups were performed using Student t-tests, ANOVA with post hoc pair-wise testing, or chi-squared tests, as appropriate. Interrater reliability was measured using Cronbach’s alpha. Multiple linear regression models were performed to adjust for complexity of resuscitations. The difference between the comparison groups was considered significant for $p < 0.05$.

Results

We included a total of 260 resuscitations in the study (Table 1). The majority of births occurred during daytime (40%) and evening hours (43%). Unadjusted analyses show that PPV was provided in 196/260 (75.4%) of resuscitations and chest compressions and administration of medications were performed in only 3.5% and 0.8% of resuscitations, respectively. Mean rates of NRP adherence as measured by mNRA composite scores as a surrogate marker were 86.2% during daytime hours, 87% during evening hours, and 86.6% during nighttime hours (Table 2). There were no differences in adherence to NRP during any of the three time points (daytime vs. evening $p = 0.48$; daytime vs. night $p = 0.78$; evening vs. night $p = 0.79$). Multiple linear regression analyses revealed no differences after stratifying for complexity of resuscitations, including those that included PPV, intubation, or chest compressions.

Table 1 – Characteristics of resuscitations assessed (unadjusted).

	Mode of Birth		Resuscitative Measures			
	Cesarean	Vaginal	PPV	Intubation	Chest Compressions	Medications
Daytime (n = 104)	102	2	71	15	5	1
Evening (n = 112)	112	0	90	18	3	1
Nighttime (n = 44)	44	0	35	14	1	0
Total (n = 260)	258	2	196	47	9	2

Births included in analysis involved usage of continuous positive airway pressure (CPAP) or higher during resuscitation. PPV = positive pressure ventilation.
 Daytime = 07:00–14:59.
 Evening = 15:00–22:59.
 Nighttime = 23:00–06:59.

Table 2 – mNRA scores as a surrogate marker of NRP adherence across study periods.

	Daytime Hours (0700–1459)	Evening Hours (1500–2259)	Nighttime Hours (2300–0659)	p-value
Number of Births (%)	104 (40%)	112 (43%)	44 (17%)	
mNRA scores				
Receiving CPAP or greater (n = 260)	86.2 ± 8.7	87.0 ± 8.1	86.6 ± 7.9	0.48*; 0.78°; 0.79^
Receiving PPV or greater (n = 196)	85.5 ± 8.6	87.2 ± 9	85.7 ± 8.6	0.22*; 0.92°; 0.41^
Intubation attempts (n = 47)	85.4 ± 9.6	87.3 ± 8.5	84.5 ± 9.6	0.41*; 1.00°; 0.43^
Chest compressions/ medications (n = 9)	86.7 ± 7.5	85.6 ± 9.7	79.0 ± 0	0.86*

P is significant if < 0.05. mNRA scores expressed as a percentage, with 100 being a perfect score.
 * = comparison between day and evening.
 ° = comparison between day and night.
 ^ = comparison between evening and night.

Table 3 – Characteristics of PPV and Endotracheal Intubation.

	Overall Score				PPV or greater			
	Average	Day-Evening	Day-Night	Evening-Night	Average	Day-Evening	Day-Night	Evening-Night
PPV	90.6%	0.042	0.438	0.446	90.8%	0.019	0.468	0.291
Successful Intubation	73.7%	0.276	0.346	0.200	77.8%	0.396	0.958	0.385

Successful intubation: defined as 2 attempts or less.

Table 3 demonstrates that PPV was given more appropriately during evening compared to daytime hours ($p = 0.042$), which remained significant after controlling for births that required PPV or greater ($p = 0.019$). A consistent number of successful intubations was seen at all time periods. The number of intubation attempts as well as the time to successful intubation was not different across time periods. Team function and communication was high at all time periods.

The structure of resuscitation teams attending births is demonstrated in Table 4. While there were fewer births during nighttime hours compared to daytime and evening hours, there was a trend towards significance ($p = 0.08$) in the nighttime team having a full NICU resuscitative team present. Additionally, there were no differences when comparing daytime versus evening ($p = 0.89$) or evening versus nighttime ($p = 0.1$).

There were no differences when the resuscitative periods were further divided into daytime (0700–1859) versus nighttime hours

(1900–0659) only, as well as when births were divided into daytime (0700–1559) versus “off hours” (1600–0659) when fewer staff and providers are typically available. NRP adherence also remained similar when comparing weekdays versus weekends/holidays.

Discussion

Previous literature has shown conflicting evidence in the outcomes of neonates born in the evening and nighttime hours, which may be related to the quality of resuscitation and NRP adherence during these time periods^{16–18,20–23}. In this analysis, we used video recordings scored with the mNRA tool to determine if adherence to NRP differed between resuscitations of infants born during daytime, evening, or nighttime hours. We found that in our level 3 perinatal referral center, adherence to NRP did not change in nighttime resuscitations compared to daytime or evening resuscitations.

Table 4 – Characteristics of Team Members Present at Births.

Small Team at Birth			Full NICU Team at Birth	
	Number of Births	Percent	Number of Births	Percent
Daytime	73	60%	49	40%
Evening	55	59%	39	41%
Nighttime	19	43%	25	57%
Total	147		113	
Small team at birth: 2–3 Pediatric/Neonatal members (one neonatal nurse practitioner + one pediatric resident or two pediatric residents and one neonatal fellow).				
Full NICU team at birth: 4–6 Pediatric/Neonatal members (one attending neonatologist, neonatal fellow, two NNPs or pediatric residents, neonatal nurse, and neonatal respiratory therapist).				
P-value for Day-Evening: $p = 0.89$.				
Day-Night: $p = 0.08$.				
Evening-Night: $p = 0.1$.				

Neonatal resuscitation is one of the most frequently practiced forms of acute resuscitation. Precise resuscitative steps and adherence to standard NRP guidelines are crucial in preventing neonatal morbidity and mortality. Despite this, deviations from NRP occur frequently, and reasons for this are multifactorial. Shift length, off-hours shifts, and physician fatigue have long been implicated as contributors to medical errors and poor outcomes²⁰. Several studies have identified no significant temporal variations in rates of intrapartum and neonatal morbidity and mortality^{21–23}. However, others have shown that despite higher risk births occurring during daytime hours, infants born at night and during high-volume days and weekends have an increased risk of adverse neonatal complications. These results imply poor NRP adherence during these time periods, potentially as a result of patient load and capacity strain on perinatal providers^{16–18,20}. Video recording during birth resuscitations is an effective training and quality assurance tool that has demonstrated success in identifying systematic and procedural errors, and may also allow for the recognition of increased deviations from standard guidelines during “off hours”^{8,10–12}. In our study sample, there was no difference in NRP adherence when comparing resuscitations occurring during the daytime hours to those occurring in the evening or night hours. However, other institutions may benefit from a similar review of performance across different time intervals, and if discrepancies are noted, a targeted quality improvement intervention to address these concerns can be developed.

Reif *et al.* identified that while afternoon and nighttime births were associated with an increase in adverse neonatal outcomes, births occurring in a tertiary or perinatal care center and birth attendance by a senior staff member appeared to have a protective effect in high risk births despite the higher volume of patients cared for in these institutions and the potential for reduced personnel coverage during off hours¹⁹. This was observed in our data set, as nighttime births had a trend towards significance in having a full resuscitation team ($p = 0.08$), while daytime births were more likely to have a smaller resuscitation team. This suggests that the nighttime births had a perceived acuity that required full neonatology attendance, such as extreme preterm infant birth or emergency delivery. Daytime births more frequently had a smaller team present at birth, likely as a result of the higher proportion of daily scheduled deliveries and Cesarean sections that had a perceived low acuity. The availability of dedicated resuscitation teams (with a regular presence of experienced practitioners) at all times in tertiary care centers such as ours may therefore improve the quality of care and may account for the lack of

temporal variability in adherence to NRP identified in our study. Additionally, our data show that there was no difference in adherence to NRP on weekend shifts or holidays when compared to weekdays, suggesting there is a stable infrastructure for births at our institution.

Up to 10% of neonates require resuscitative measures at birth, and the need for resuscitation cannot always be predicted based on perinatal risk factors. Resuscitation teams must therefore be well-equipped to provide appropriate resuscitation at any time. It has been repeatedly demonstrated that the key to successful management of birth emergencies is effective communication and teamwork^{24,25}. Hallmarks of successful resuscitations have been attributed to adequate anticipation, preparation, clinical evaluation, and prompt initiation of support by resuscitation teams^{26,27}. Communication is generally higher and team function is more consistent when there is prior knowledge of a high-risk birth with an anticipated need for resuscitation, but for those scenarios where emergencies are unforeseen, maintaining a “shared mental model” can help preserve team cohesiveness and improve communication and function^{28,29}. A shared mental model is generally defined as “the perception of, understanding of, or knowledge about a situation or process that is shared among team members through communication,” and instituting this framework before, during, and after a resuscitation can reinforce successful team performance²⁹. In our tertiary care center with around-the-clock availability of multidisciplinary teams, the establishment of such a shared mental model with anticipated need for resuscitations was more feasible and likely was responsible for uniform NRP adherence in off-hour resuscitations. Performance improvement initiatives focusing on enhancing teamwork and communication may therefore be of particular benefit to improving NRP adherence and performance.

Although several studies have evaluated perinatal outcomes depending on timing of birth, this is to our knowledge, the first study to evaluate temporally related NRP adherence. Our findings demonstrate a high prevalence of adherence to NRP across all three daily resuscitative periods without differences between daytime, evening, and nighttime hours. These findings may be explained by the fact that our study was performed in a high acuity perinatal center with a dedicated response team. Our findings may therefore have limited generalizability to hospitals with smaller delivery volumes and without a similarly dedicated team, particularly in lower resource settings. Furthermore, while prior studies suggest that infants born at night and during “off hours” are at an increased risk of adverse complications, such data was not

available to us specific to our institution. We did not have evidence, either before or during the study, of a difference in resuscitation outcomes or later outcomes by birth time.

A significant limitation of our study is that the majority of births in our study were via Cesarean section secondary to camera placement in all obstetric ORs (compared to camera presence in only 2 out of 16 labor and delivery rooms), which has the potential to create a selection bias in terms of potential acuity of infants that would necessitate larger team presence at birth.

The large proportion of Cesarean births may also limit the external validity, both to vaginally-born infants in the investigators' own hospital or in other birth hospitals.

Furthermore, in our sample, PPV was provided in a significantly higher proportion than the 10% of infants who, per global estimates, are generally expected to require respiratory resuscitation at birth¹, but again may create a selection bias. Only 3.5% and 0.8% of the resuscitations received chest compressions and administration of medications, respectively, a proportion which is low but consistent with national estimates¹.

Ongoing continuous monitoring of resuscitations is imperative to encourage sustained compliance to NRP guidelines. Longitudinal monitoring of individual resuscitators may also be helpful to follow performance over time and individual function at different temporal periods. Nonetheless, it should be noted that strict compliance with NRP may have both advantages and disadvantages for individual patients. Clinical expertise should also allow for deliberate deviation from the NRP algorithm for infants with atypical presentations or responses and may result in even better patient outcomes than strict protocol adherence.

Conclusion

In a level 3 perinatal referral center, there were no temporal variations noted when comparing NRP adherence across several time intervals (daytime vs evening vs nighttime hours). At an individual institution level, investigation of temporal variation in birth resuscitation performance and NRP adherence can be a useful tool to identify targeted areas for performance improvement. Further research is needed in investigating NRP adherence at non-tertiary centers or in institutions without a dedicated neonatal resuscitation team, as well as reviewing NRP adherence at resuscitations of vaginally delivered infants with known perinatal risk factors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Dr. Sloane conceptualized the study, searched literature, collected and analyzed data, drafted initial manuscript and approved the final manuscript as submitted.

Drs. Kenaley and Favara conceptualized and designed the study, analyzed data, critically reviewed and revised the manuscript and approved the final manuscript as submitted.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.resplu.2021.100162>.

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