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Clinical paper

Neonatal resuscitation program (NRP) guidelines and timing of major resuscitation events in delivery rooms at a level III NICU: Understanding deviations

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Abstract

Objective: To describe the timing of major resuscitation events in the Delivery room.

Methods: A retrospective study of neonates born at a level III birthing hospital who received chest compressions in the delivery room was conducted. The timing of the resuscitation events i.e., intubation, UVC, endotracheal (ETT), epinephrine and intravenous (IV) epinephrine were described. The timing of these events were compared for deliveries with the presence of neonatology team.

Results: 51 neonates were included. The primary outcome occurred in 28 (65%) of deliveries. An alternate airway was secured at 4.24 ± 5.9 minutes. Endotracheal epinephrine and IV epinephrine were administered at a mean time of 3.98 ± 3 minutes and 10.87± 5.18 minutes after the initiation of chest compressions respectively.

Conclusion: Data from real-life cases on the timeline of events suggest that major resuscitation events as suggested by Neonatal Resuscitation Program Guidelines, are often significantly delayed.

Keywords: Neonatal Resuscitation, Neonatal Resuscitation Program, NRP, Epinephrine

Introduction

Neonatal deaths account for approximately 47% of deaths globally under 5 years in 2019.[1] Worldwide, 25% of neonatal deaths occur secondary to birth asphyxia.[2] Although most term newborns (85%) transition spontaneously to extrauterine life with no or little assistance, 5% of term infants require positive pressure ventilation (PPV), 2% need alternate airway placement, and 1–3 neonates per 1000 live births receive chest compressions (CC) and emergency medications.[3] This emphasizes the importance of the presence of appropriately trained personnel at deliveries, especially high-risk deliveries, to provide timely assistance to improve outcomes and reduce morbidities.

The Neonatal Resuscitation Program (NRP) provides step-by-step guidelines in newborn resuscitation, including the appropriate timing of initiation of PPV and medication administration. Unlike the resuscitation guidelines for adults and children, NRP guidelines emphasize providing effective ventilation as the most important and effective step for resuscitation in the delivery room for neonates.[4,5]

Specifically, the NRP guidelines[4,5] recommend initiation of positive pressure ventilation (PPV) within 1 minute of birth, securing an alternate airway before starting chest compressions, administering CC for 60 seconds if there is no response to 30 seconds of effective PPV and administering epinephrine after 60 seconds of coordinated CC and ventilation.

NRP guidelines further recommend, “If the use of epinephrine can be anticipated because the baby is not responding to PPV, one member of the resuscitation team should prepare to place an Umbilical Venous Catheter (UVC) while others continue to provide PPV and CC”.[5] Many of these events are time-sensitive, and poor

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https://doi.org/10.1016/j.resplu.2024.100571
Received 21 October 2023; Received in revised form 18 January 2024; Accepted 28 January 2024

adherence could affect the neonate's short- and long-term outcomes. Finally, the NRP recommends having at least 1 qualified individual, with the sole responsibility of newborn's care, for every birth and at least 2 individuals for infants with risk factors. Anticipation and preparation for at-risk deliveries, the presence of skilled personnel, closed-loop communication, and teamwork, all help in adherence to the guidelines.

Among the studies published,[6–9] adherence to the algorithm appears to be variable and is based on clinical setting, number of providers and their skills and knowledge. However, there are a limited number of studies looking at the real-world timing of the resuscitation[10] and to the best of our knowledge there are no or very few such reports among neonates born in the United States of America. To address this knowledge gap, and ascertain improvement in the standard of care, we conducted a retrospective study to evaluate the actual timing of major resuscitation events in the delivery room at our institution.

Material and methods

We conducted a retrospective study reviewing the medical records and code sheets of all neonates who met the inclusion criteria and were born between January 2015 and May 2022. The study was conducted at Hutzel Women's Hospital, Detroit, Michigan, USA, which is a tertiary hospital with approximately 4000 deliveries each year and with an affiliated level III Neonatal Intensive Care Units (NICU). The study was approved by the Institutional Review Board (2021–1173) at Central Michigan University. At our institution, high risk deliveries are attended by a team comprising of neonatologist, neonatal fellow, pediatric resident, registered nurse, and a respiratory therapist who all had completed NRP course. In our center, in case of a major resuscitation event, a member of the clinical team (generally NICU registered nurse) is identified to document the timing of events on a standard code sheet that is uploaded to the patient's chart.

All infants who received at least CC in the delivery room were included in the study. Neonates with "do not resuscitate orders/comfort care", with major congenital anomalies or dysmorphism were excluded from the study.

The timing of the resuscitation events i.e., intubation, UVC, endotracheal (ETT) epinephrine and intravenous (IV) epinephrine were described. While all the events are reported in seconds, the PPV timing was documented as initiated within 60 seconds or not.

The timing of these events were compared for deliveries with the presence of the neonatology team (presence of either neonatology fellow, attending or nurse practitioner) prior to delivery versus when the neonatology team arrived after the delivery of the baby.

Statistical analysis was done using Stata17 software (College Station, TX: StataCorp LLC). Continuous variables were reported as mean with standard deviation (SD) and median with interquartile ranges (IQR). For comparisons, Kruskal-Wallis test, t test, Mann-Whitney U test, and Fisher's exact test were used and a p-value of < 0.05 was considered statistically significant.

Results

A total of 51 neonates met the inclusion criteria. The baseline characteristics are presented in Table 1. The mean gestational age was 30.2 ± 6.6 weeks. The neonatal team was present prior to the delivery of the neonate in 38 (74.5%) deliveries and in 25.5% of the deliveries the neonatal team reached the delivery room after the birth of the baby. The timing of major events is presented Table 2. PPV was initiated within 60 seconds after birth in 66.7% (n = 34) of cases and data was missing in 19.6% of cases. An alternate airway was secured at a median time of 2.5 minutes (IQR 1–5 minutes). The median time from the initiation of resuscitation at which an umbilical venous catheter (UVC) was secured was 14 minutes (IQR 9–20 minutes). Endotracheal epinephrine was administered at a median time of 2.5 minutes (IQR 2–5 minutes) after the initiation of CC and IV epinephrine was administered at a median time of 10 minutes (IQR 7–16 minutes) after the initiation of CC.

The timing of major resuscitation events (Timing of intubation, Timing of IV Epinephrine and timing of UVC) was not significantly different in relation to the presence of the neonatal team before the delivery. A significant difference was found in the median timing of administration of ETT epinephrine with the presence of neonatal team prior to delivery (2.3 (2 to 5) minutes vs 8 (5 to 11) minutes, $p = 0.01$) Table 3.

Among the study subjects, 25 neonates (49%) died of which 13 neonates died in the delivery room. Return of Spontaneous Circulation (ROSC) (defined as a persistent heart rate > 100 beats/min) was achieved in 37 neonates (72.6%) in delivery room. In the neonates who achieved ROSC, the mean time of ROSC was 11.15 minutes (SD = 10; Median 7; IQR = 4.5–15).

Discussion

Adherence to the NRP recommendations could be challenging, and studies on neonates as well as mannequins have shown deviations. Although there are many studies observing deviations in the NRP recommendations, there are limited data overall focusing on the timing of various resuscitation events. Ours is one of the few studies focusing on the timing of major resuscitation events in a real-life scenario. While there are limited studies that looked at real life and simulation data, there are no studies in the USA to best of our knowledge that looked at the timing of the major resuscitation events in real life.

American Academy of Pediatrics and American Heart Association along with various Resuscitation councils across the world release consensus statements with treatment recommendations on neonatal resuscitation. In the United States, the NRP Steering Committee develops educational materials for providers to acquire the skills to perform the neonatal resuscitation. A combination of procedural skills, medical knowledge, communication skills, and effective teamwork is vital while resuscitating a high-risk newborn in achieving a best possible outcome.

Real world resuscitation data

A retrospective study of video recordings of neonatal resuscitation of preterm infants of < 32 weeks noted errors attributable to timing of events, with a global adherence to protocol in 80.9% cases, and only 12.5% of intubations were achieved within the allotted 30 seconds.[6] Heathcote et al, in a retrospective study published in 2018 from U.K analyzed 27 newborns who received full resuscitation, including CC. Similar to the current study, they also noted a delay in securing UVC (median time 9.0 minutes (CI 7.0–14.0) and administration of first

Table 1 – Baseline characteristics.

Variable	n	Mean (SD) or %	Median (IQR)
Gestational age (weeks) Mean (SD) Median (IQR)	50	30.2 (±6.6)	28 (24–37)
Birth weight (grams) Mean (SD)	49	1743 (±1226)	1380 (640–2930)
Maternal age(years) Mean (SD) Median (IQR)	51	29.2 (±6.1)	30 (25–34)
1 minute Apgar	49	1.63 (1.73)	1 (1–2)
5-minute Apgar	49	2.5 (2.3)	2 (1–4)
10-minute Apgar	45	3.9 (3.1)	3 (1–6)
Male sex	25	50%	
Black race	41	80.4%	
Primigravida	14	27.5%	
Multiple gestations	6	11.8%	
Clinical chorioamnionitis	3	6%	
Histological chorioamnionitis	26	51%	
Vaginal delivery	17	33%	
Neonatal team present prior to birth	38	74.5%	

Table 2 – Timing of resuscitation events.

Key Resuscitation Event	Median (IQR)
Timing of intubation since birth (min)	2.5 (1–5)
Timing of ETT epinephrine from chest compressions (min)	2.5 (2–5)
Timing of IV epinephrine from chest compressions (min)	10 (7–16)
Timing of securing UVC	14 (9–20)

dose of epinephrine was (median time 10.0 minutes (CI 8.0–14.0). Neonatal team was present at the time of delivery in only 30% of cases and in 48% of cases the neonatal team was summoned after delivery and undocumented in 22%.[10] In the current study, neonatal team was present before the delivery in 74.5% of the resuscitations. In a similar study analyzing 23 complex resuscitations, Yamada et al, noted deviations from NRP algorithm with 72% of the errors were classified as errors of commission (errors in administration of PPV, intubation, CC, coordination between PPV and CC).[7]

Simulation studies

Various simulation studies done on adherence to neonatal resuscitation guidelines also noted similar findings of variability in knowledge and adherence to resuscitation guidelines.[8,11–13] Foglia et al, in an in-situ study on manikin by 50 NRP providers demonstrated nonadherence to NRP algorithm while performing coordinated CC and ventilations.[11] As evidence shows, adherence to the algorithm is variable and is based on the clinical setting, number of providers and their skills and knowledge, which can significantly impact the outcomes. Bender et al in a prospective study have observed a simulation booster given 7–10 months after NRP training and reassessing at 15–18 months, showed improvement in both procedural skills and teamwork behaviors.[12] In another simulation study, RubioGurung et al, analyzing the effectiveness of simulation training on neonatal resuscitation performance, noted a significant improvement in

Table 3 – Comparison of mean timing of events in relation to the neonatal present before delivery team.

Variable	Neonatal team present before delivery	Neonatal team present after delivery	p
Timing of intubation	2 (1 to 5)	3.9 (2 to 6)	0.21
Timing of ETT epinephrine after chest compressions	2.3 (2 to 5)	8 (5 to 11)	0.01
Timing of IV epinephrine after chest compressions	9.1 (6.5 to 16)	12 (8 to 19)	0.63
Timing of UVC	14 (9 to 18.8)	17 (13 to 25)	0.31

performance among the providers who received in situ simulation training when compared to who did not receive.[13]

Medicolegal claims related to neonatal resuscitation

Neonatal resuscitation and delivery room management is a common area for malpractice suits in clinical neonatology. Berglund et al reviewed details of neonatal resuscitation for 177 claims for financial compensation related to medical malpractice in conjunction to childbirth in Sweden. They noted a delay in initiation of artificial ventilation when indicated in 7 (4.2%) cases. The median time for endotracheal intubation was 6 minutes (range 0 to 180 minutes).[14] A systematic review of medico-legal claims and complaints in neonates by Aiyengar A et al found that delay in the initiation of resuscitation, including delay in the administration of emergency drugs, was reported in 5 of the 12 studies.[15] The current study also noted delay in timing of some resuscitation events. Further studies are needed to identify the criteria for delayed resuscitation events that are associated with clinically significant outcomes.

How long should resuscitation continue?

The NRP 7th edition[16] suggested that it may be reasonable to stop resuscitation after 10 minutes of resuscitation if asystole persisted. Per the latest NRP guidelines, a reasonable timeframe for considering cessation of resuscitation efforts has been revised to 20 minutes, with consideration of individual circumstances.[5] In the current study, IV epinephrine was administered at a median time of 10 minutes after chest compressions. The decision to discontinue resuscitation efforts should be individualized considering the timing of endotracheal intubation, and IV epinephrine.

The strength of this study includes, a single center study, from a level III NICU, with a consistent group of providers attending deliveries and data from 7 years making the study observations real and a persistent problem. Our study emphasizes the importance of ongoing quality improvement projects to keep up with the skills and knowledge which tend to lose over time. The data regarding timing of events such as alternate airway, epinephrine administration and securing a UVC described in the study bridges the gap in the available literature.

Being a retrospective study, we acknowledge the inherent limitation regarding sequence of events and reasons for delays in certain procedures. The timing of events is collected based on the documentation of code sheets during the resuscitation, completed by member of the clinical team and not dedicated research personnel. There is a possibility of actual timing of interventions being later than documented. Trevisanuto D et al. noted that the health care providers often underestimate the passage during neonatal resuscitation.[17] This suggests that the timing of major resuscitation events may actually be later than documented.

Conclusions

In the current study, we observed delay in some resuscitation events for neonates in the delivery room. The presence of a skilled neonatal team prior to delivery was associated with better timing for resuscitation events. Quality improvement projects to identify key factors for improvement in adherence to NRP guidelines would be needed tailored to each institution's unique situation. These may include presence of more skilled personnel, keeping epinephrine and umbilical venous catheter readily available for high risk deliveries with anticipation of resuscitation. Further studies are needed to identify the criteria for delayed resuscitation events that are associated with clinically significant outcomes.

CRediT authorship contribution statement

Praveen Kumar Boddu: Conceptualization, Data curation, Writing – original draft, Investigation, Methodology. **Pradeep Kumar Velumula:** Methodology, Writing – reviewing & editing. **Sanket Jani:** Methodology, Writing – reviewing & editing. **Nithi Fernandes:** Methodology, Writing – reviewing & editing. **Jorge Lua:** Methodology, Writing – reviewing & editing. **Girija Natarajan:** Methodology, Writing – reviewing & editing. **Monika Bajaj:** Methodology, Writing – reviewing & editing, Formal Analysis. **Ronald Thomas:** Formal Analysis, Data curation. **Sanjay Chawla:** Conceptualization, Methodology, Supervision.

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.

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