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Real-World Timing of Critical Resuscitation Interventions in Delivery-Room Cardiac Arrest: Significant Deviations from NRP Guidelines

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Abstract

To outline when key resuscitative actions occur in the delivery room. We performed a retrospective review of newborns delivered at a level III centre who required chest compressions. The timing of major steps—intubation, UVC placement, endotracheal (ETT) epinephrine, and intravenous (IV) epinephrine—was recorded. Event timing was also compared between births with and without a neonatology team present. A total of 51 infants met the inclusion criteria. The primary endpoint was noted in 28 cases (65%). An alternate airway was obtained at 4.24 ± 5.9 minutes. Endotracheal epinephrine was given at 3.98 ± 3 minutes, and IV epinephrine at 10.87 ± 5.18 minutes after chest compressions began. Real-world observations indicate that several resuscitative steps recommended by the Neonatal Resuscitation Program often occur later than intended.

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

Introduction

In 2019, deaths during the neonatal period represented roughly 47% of global mortality in children under 5 [1]. About 25% of these deaths are attributed to birth asphyxia [2]. Although most term infants (around 85%) adapt with little or no support, 5% need positive pressure ventilation (PPV), 2% require an advanced airway, and approximately 1–3 per 1000 live births receive chest compressions (CC) and emergency drugs [3]. This underscores the necessity for trained clinicians at all deliveries, especially those considered high-risk.

The Neonatal Resuscitation Program (NRP) outlines sequential actions for newborn stabilization, including when to begin PPV and when medication should be introduced. In contrast to adult and pediatric guidance, NRP highlights ventilation as the dominant intervention in neonatal resuscitation [4, 5].

NRP recommendations [4, 5] call for PPV to begin within 1 minute of birth, securing an alternative airway before CC, performing CC for 60 seconds if the infant does not respond after 30 seconds of effective PPV, and giving epinephrine following 60 seconds of coordinated CC and ventilation.

NRP further advises that if epinephrine administration is likely, a team member should initiate preparation for Umbilical Venous Catheter (UVC) placement while others continue PPV and CC [5]. Because these actions are time-critical, deviations may influence both immediate and long-term outcomes. The program also recommends at least one trained individual solely responsible for newborn care at every delivery, and a minimum of two such individuals when risk factors are present. Proper preparation, communication, and teamwork support adherence.

Existing studies [6-9] suggest adherence varies depending on setting, staffing, and skill level. Only a small number have examined real-time delivery room intervals for resuscitation steps [10], and there is limited evidence

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from U.S. centres. To address this gap and evaluate care quality at our institution, we reviewed the actual timing of major resuscitation events in the delivery room.

Material and Methods

We performed a retrospective review that examined medical charts and code documentation for all eligible newborns delivered between January 2015 and May 2022. The study took place at Hutzel Women's Hospital in Detroit, Michigan, USA, a tertiary centre with roughly 4000 births annually and an associated level III Neonatal Intensive Care Unit (NICU). Institutional Review Board approval was obtained from Central Michigan University (2021–1173). For high-risk births, our institution assigns a team consisting of a neonatologist, neonatal fellow, pediatric resident, registered nurse, and respiratory therapist, all certified in the NRP. During major resuscitations, a designated team member—typically a NICU nurse—records event times on a standardized code sheet that is later added to the infant's record.

Infants who received at least chest compressions in the delivery room were included. Newborns with "do not resuscitate/comfort care" directives, or those with major congenital anomalies or dysmorphic features, were excluded.

Event timing was captured for intubation, UVC placement, endotracheal (ETT) epinephrine, and intravenous (IV) epinephrine. Although all time points were logged in seconds, PPV was documented only as occurring within the first 60 seconds or not.

We compared event timing between cases where a neonatology provider (fellow, attending, or nurse practitioner) was already at the bedside before birth and those in which they arrived after delivery.

Statistical analysis was completed using Stata17 (College Station, TX: StataCorp LLC). Continuous variables are presented as mean ± standard deviation (SD) and median with interquartile range (IQR). For group comparisons, we used Kruskal–Wallis, t-tests, Mann–Whitney U tests, and Fisher's exact tests. A p-value < 0.05 was considered statistically significant.

Results

A total of 51 infants fulfilled the eligibility criteria. Baseline demographics are summarized in **Table 1**. The average gestational age was 30.2 ± 6.6 weeks. The neonatal team was already present for 38 deliveries (74.5%), whereas in 25.5% of cases they arrived after the infant was born. The schedule of key interventions is shown in **Table 2**. Positive-pressure ventilation (PPV) began within the first 60 seconds in 66.7% (n = 34), though 19.6% had missing data. Placement of an alternate airway occurred at a median of 2.5 minutes (IQR 1–5). Umbilical venous catheter (UVC) insertion took place a median of 14 minutes after resuscitation began (IQR 9–20). Endotracheal epinephrine was given a median of 2.5 minutes after chest compressions (CC) were initiated (IQR 2–5), and IV epinephrine at a median of 10 minutes (IQR 7–16) following the start of CC.

Table 1. Baseline characteristics

Characteristic	Median (IQR)	Mean (±SD) or %	n
Gestational age, weeks	28 (24–37)	30.2 (±6.6)	50
Birth weight, grams	1380 (640–2930)	1743 (±1226)	49
Maternal age, years	30 (25–34)	29.2 (±6.1)	51
Apgar score at 1 minute	1 (1–2)	1.63 (±1.73)	49
Apgar score at 5 minutes	2 (1–4)	2.5 (±2.3)	49
Apgar score at 10 minutes	3 (1–6)	3.9 (±3.1)	45
Male gender	—	50%	25
Black/African-American race	—	80.4%	41
Primigravida mother	—	27.5%	14
Multiple gestation	—	11.8%	6
Clinical chorioamnionitis	—	6%	3
Histological chorioamnionitis	—	51%	26
Vaginal delivery	—	33%	17
Neonatology team present before delivery	—	74.5%	38

Table 2. Timing of resuscitation events

Key Resuscitation Event	Median (IQR), minutes
Time from birth to intubation	2.5 (1–5)
Time from start of chest compressions to endotracheal epinephrine	2.5 (2–5)
Time from start of chest compressions to intravenous epinephrine	10 (7–16)
Time from birth to successful umbilical venous catheter placement	14 (9–20)

No significant differences were identified in major procedural timings (intubation, IV epinephrine, or UVC insertion) when comparing cases with and without neonatal team arrival before birth. However, administration of endotracheal (ETT) epinephrine occurred earlier when the team was present prior to delivery (2.3 (2–5) minutes vs 8 (5–11) minutes, p = 0.01), as shown in **Table 3**.

Table 3. Comparison of mean timing of events relative to neonatal team presence before delivery

Resuscitation intervention timing (minutes)	p-value	Neonatal team called after delivery (n=13)	Neonatal team present prior to delivery (n=38)
Time from birth to intubation	0.21	3.9 (2–6)	2 (1–5)
Time from chest compressions to endotracheal epinephrine	0.01	8 (5–11)	2.3 (2–5)
Time from chest compressions to intravenous epinephrine	0.63	12 (8–19)	9.1 (6.5–16)
Time from birth to successful UVC placement	0.31	17 (13–25)	14 (9–18.8)

Among all infants, 25 (49%) died, including 13 who died in the delivery room. Return of spontaneous circulation (ROSC)—defined as a sustained heart rate greater than 100 beats/min—was reached in 37 infants (72.6%). For those achieving ROSC, the average time to ROSC was 11.15 minutes (SD = 10; median 7; IQR 4.5–15).

Discussion

Maintaining strict adherence to NRP recommendations can be difficult, and both clinical and simulation-based research have highlighted deviations. Although many reports evaluate compliance with individual NRP steps, relatively few focus specifically on the timing of key interventions. Our study adds to this limited body of data by documenting real-world timelines for major resuscitation actions. To our knowledge, there are no comparable reports from U.S. centres examining the actual timing of such events.

Consensus guidelines on neonatal resuscitation are published by the American Academy of Pediatrics, the American Heart Association, and international resuscitation organizations. In the United States, the NRP Steering Committee develops training materials designed to ensure providers acquire the necessary procedural competence, clinical knowledge, communication, and teamwork skills essential for optimizing outcomes in high-risk neonatal resuscitation.

Real world resuscitation data

A retrospective assessment using video recordings of resuscitations in preterm infants born at < 32 weeks showed multiple timing-related deviations, with overall protocol adherence in 80.9% of cases, and only 12.5% of intubations completed within the recommended 30-second window [6]. Heathcote *et al.*, in a 2018 U.K. review of 27 newborns who underwent full resuscitation including chest compressions, likewise reported delayed UVC placement (median 9.0 minutes, CI 7.0–14.0) and delayed first epinephrine dosing (median 10.0 minutes, CI 8.0–14.0). In that cohort, a neonatal team was present at delivery in 30%, called in after delivery in 48%, and undocumented in 22% of cases [10]. In comparison, the present study had neonatal personnel present before birth in 74.5% of resuscitations. A related study of 23 complex cases by Yamada *et al.* found frequent NRP deviations, with 72% classified as errors of commission involving PPV, intubation, chest compressions, or coordination between these steps [7].

Simulation studies

Multiple simulation-based investigations examining compliance with neonatal resuscitation recommendations have shown similar variability in performance and knowledge [8, 11-13]. Foglia *et al.*, using an in-situ manikin scenario with 50 NRP-trained providers, documented inconsistent adherence to coordinated CC and ventilation instructions [11]. Evidence suggests that adherence is influenced by the environment, staffing, and provider competency, all of which can meaningfully influence outcomes. In a prospective trial, Bender *et al.* reported that a booster simulation at 7–10 months post-NRP training, with reassessment at 15–18 months, enhanced procedural ability and teamwork [12]. Another simulation project by Rubio-Gurung *et al.* showed that providers who received in-situ simulation training demonstrated significantly better performance than those who did not [13].

Medicolegal claims related to neonatal resuscitation

Delivery room resuscitation represents a frequent source of malpractice claims. Berglund *et al.* evaluated 177 Swedish cases involving compensation claims related to childbirth and identified delayed initiation of ventilation in 7 cases (4.2%). The median time to endotracheal intubation was 6 minutes (range 0–180) [14]. A systematic review by Aiyengar *et al.* found that delayed initiation of resuscitation—particularly lags in emergency drug administration—was mentioned in 5 of 12 included studies [15]. The present study also noted delays in several

steps. More research is required to determine which delayed events are most strongly tied to measurable clinical consequences.

How long should resuscitation continue?

The 7th edition of the NRP guidelines suggested considering cessation of efforts after 10 minutes of ongoing asystole [16]. The most recent NRP update extends this consideration period to 20 minutes, though individualized decision-making is emphasized [5]. In the current cohort, IV epinephrine was administered at a median of 10 minutes following the onset of chest compressions. Decisions regarding termination of resuscitation should take into account the timing of airway placement and IV epinephrine delivery.

The strengths of the study include its single-centre design in a level III NICU with a stable team of providers and 7 years of data, highlighting a persistent pattern in practice. These findings reinforce the need for continuous quality-improvement efforts to maintain skills that degrade over time. The documented intervals for airway placement, epinephrine use, and UVC insertion help address gaps in existing literature.

As a retrospective review, the study is subject to limitations such as uncertainty in event sequencing and reasons for procedural delays. Times were recorded from code sheets completed by clinical staff rather than research personnel, leaving open the possibility that actual intervention times were later than recorded. Trevisanuto *et al.* reported that providers tend to underestimate elapsed time during neonatal resuscitation [17], suggesting true delays may be greater than documented.

Conclusions

This study identified delays in several delivery-room resuscitation steps. Early presence of a trained neonatal team was associated with improved timing of key interventions. Institution-specific quality-improvement efforts aimed at strengthening adherence to NRP guidelines are needed and may involve ensuring the availability of experienced staff and having epinephrine and UVC equipment immediately accessible for anticipated high-risk births. Additional research is required to define which delayed actions correlate with significant clinical outcomes.

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