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Short paper

Visual attention patterns of team leaders during delivery room resuscitation

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Abstract

Aim: To assess visual attention of neonatal team leaders during delivery room resuscitation of preterm infants using eye tracking glasses.

Methods: Prospective observational eye tracking study. Gaze fixations and sequences were captured, categorized, and mapped during the first 5 min of the resuscitations. Gaze fixation metrics of total gaze duration, visit count, and visit duration were summarized and compared based on interventions performed and provider training level. Fixation sequences were compared between attending neonatologists and fellows.

Results: During 18 eye tracking recordings, practitioners focused most of their cumulative visual attention on the infant (median total gaze duration 57%, interquartile range [IQR] 38–61%), followed by monitors (24%, IQR 13–46%), clinical staff (5%, IQR 1–8%), other physical objects (4%, IQR 3–6%), T-piece resuscitator (2%, IQR 0–4%) and the Apgar timer (1%, IQR 0–2%). Visual attention parameters varied according to intervention, with higher visit counts on the infant during corrective ventilation steps than during Continuous Positive Airway Pressure (CPAP) or Positive Pressure Ventilation (PPV), and longer visit durations on monitors during PPV. Time and frequency-based measures of visual attention did not significantly differ by provider training level, but patterned fixation sequences were identified among attending neonatologists that were not observed in fellows.

Conclusion: Team leaders predominantly gazed upon the infant and monitors during resuscitation, and visual attention parameters varied depending on the respiratory interventions performed. Attending neonatologists exhibited patterned fixation sequences that were not observed in fellows. Study results may have implications for optimizing delivery room design and training novice providers.

Keywords: Neonatal resuscitation, Eye-tracking, Visual attention, Visual attention patterns, Delivery room, Continuous Positive Airway Pressure, Positive Pressure Ventilation, Neonatal intensive care unit

Introduction

Delivery room resuscitation has an important impact on perinatal morbidity and mortality.[1] The resuscitation team leader's role involves a complex interaction of situational awareness, information processing, decision making, and communication to effectively coordinate the team's performance. To date, team leaders' visual attention has not been well studied during delivery room resuscitation.

Prior methods of assessing provider visual attention include structured interviews and video analysis.[2,3] However, these methods

Abbreviations: AOI, area of interest; CPAP, Continuous Positive Airway Pressure; IQR, interquartile range; NICU, neonatal intensive care unit; PPV, Positive Pressure Ventilation; RFM, Respiratory Function Monitor; TOI, time of interest.

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used retrospective recall of experiences by the participant and/or an external reviewer to extract information. Mobile eye tracking is a novel tool to identify visual attention through gaze durations, frequencies, and sequences.[4]

Our primary objective was to characterize neonatal team leaders' visual attention during delivery room resuscitation. The secondary objectives were to determine if measures of visual attention differ based on the type of intervention performed during resuscitation or provider training level.

Methods

This was a prospective observational study of neonatal providers leading delivery room resuscitations of preterm infants (≤32 weeks gestation) in a dedicated resuscitation room at an academic level III NICU. In our hospital, team leaders do not directly provide hands-on care during resuscitation. Study participants wore eye tracking glasses (Tobii Pro Glasses 2, Tobii Technology Inc., Stockholm, Sweden), which were calibrated to the wearer prior to resuscitation [Supplemental Video].[5] Following the resuscitation, participants reviewed their video with a study team member to ascertain whether the eye tracking equipment was calibrated appropriately and accurately captured their focus.[4] Recordings with less than 70% gaze data capture were excluded. The recruitment goal was a convenience sample of 20 recordings.

All recordings were imported into Tobii Pro Lab analysis software. The first five minutes of resuscitation gaze data were manually mapped by a member of the study team to overcome the limitations of automated mapping of a dynamic clinical resuscitation. Each eye tracking gaze point was categorized and mapped onto a still photograph representing the resuscitation environment with 9 defined areas of interest (AOI) [Fig. 1]. Visual attention measures of total gaze duration, visit count per ten seconds, and median visit duration were measured for each AOI.[4] Saccades are naturally occurring transitioning eye movements which typically last 20–40 ms.[6] The Tobii Pro glasses 2 captured each gaze point in 20 ms intervals (50 Hz sampling rate); therefore, two or fewer gaze points on a single AOI were considered saccades and three or more gaze points were defined as a gaze fixation. Each resuscitation was divided into specific times of interest (TOI) based on the respiratory interventions performed: Continuous Positive Airway Pressure (CPAP), Positive Pressure Ventilation (PPV), and corrective ventilation steps (mask adjustment, repositioning, suctioning, and opening mouth).

Analyses were conducted using STATA IC 14.2 (StataCorp, College Station, TX). Visual attention measures were compared between attending neonatologists and fellows using Wilcoxon rank-sum test. AOIs with >5% total gaze duration were compared between CPAP, PPV, and corrective ventilation steps for resuscitations in which all three interventions occurred using the Friedman test and subsequently, the Wilcoxon signed rank test. P value <0.05 was considered significant.

The sequence of fixations from one AOI to the next, excluding saccades, was extracted as a collapsed string (i.e. Monitors-Infant-Infant-Apgar timer = MIA) and imported into eyePatterns Version 0.9 software[7] for pattern discovery amongst all participants and comparison between attending and fellows. Sequence patterns greater than 3 AOI fixations were empirically considered to be meaningful.

The University of Pennsylvania Institutional Review Board approved this study, and consent was obtained from all study participants. Per hospital video recording policy, parental release is required to retain video recordings beyond 28 days. Eye tracking videos without parental release were analyzed prior to 28-day deletion when possible.

Results

Of 21 eye tracking recordings captured, 3 were excluded: one had <70% gaze data capture, and two evaluable recordings were deleted before they were analyzed because parental video releases were not obtained. The 18 recordings analyzed represented resuscitations led by 12 unique participants (6 attendings and 6 fellows). Nine resuscitations were led by attendings and 9 were led by fellows. Providers had median 7 (interquartile range [IQR] 6–10) years of

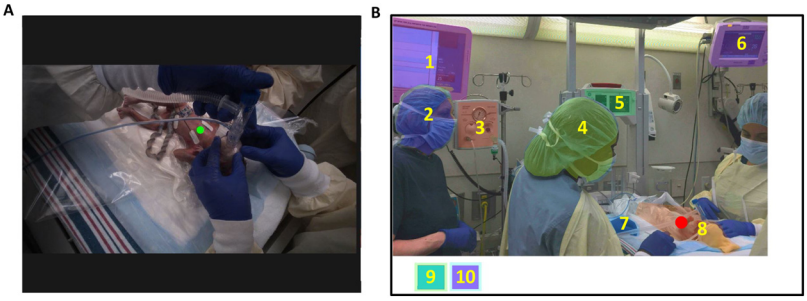

Fig. 1 – Visualization and manual mapping of neonatal resuscitation eye tracking recording.
A) Participants gaze on infant (green dot) as captured through eye tracking glasses. B) Still image with participant gaze point mapped (red dot) onto 'infant' area of interest.
Areas of interest: 1) Respiratory Function Monitor,* 2) Peripheral Staff, 3) T-piece resuscitator, 4) Team Member body, 5) Apgar Timer, 6) Vital Sign Monitor,* 7) Team Member hands, 8) Infant, 9) Other Physical Objects, 10) Saccadic Eye Movements.
***Respiratory Function Monitor and Vital Sign Monitor were combined for this analysis as "monitor", The Respiratory Function Monitor was only visible for 4 resuscitations as part of concurrent randomized clinical trial in which some infants were enrolled.**

Table 1 – Visual attention during first 5 min of resuscitation.

Area of interest	Total gaze duration (median, IQR)	Visit count per 10 s (median, IQR)	Visit duration sec (median, IQR)
Infant	57% (38%–61%)	2.4 (1.5–4.1)	2.2 (1.6–2.5)
Team Member hands	2% (1%–2%)	0.5 (0.2–0.8)	0.4 (0.3–0.5)
Team Member body	3% (1%–8%)	0.7 (0.3–1.9)	0.4 (0.3–0.5)
Peripheral Staff	0% (0%–1%)	0.1 (0.0–0.3)	0.3 (0.2–0.4)
Monitors (vitals and RFM)	24% (13%–46%)	1.4 (1.1–2.0)	1.2 (0.9- 3.1)
Apgar Timer	1% (0% -2%)	0.1 (0.1–0.3)	0.6 (0.5–0.8)
T-Piece Resuscitator	2% (0%–4%)	0.2 (0.1–0.3)	1.0 (0.5–1.4)
Other Physical Objects	4% (3%–6%)	1.0 (0.6–1.5)	0.4 (0.3–0.5)
Saccadic Eye Movements	3% (2%–3%)	4.3 (3.6–5.6)	0.06 (0.05–0.06)

IQR = interquartile range. RFM = Respiratory Function Monitor.

clinical experience, and 9 (75%) participants were female. The mean gestational age of the infants was 28.0 (SD 2.7) weeks and the mean birth weight was 1034 (SD 430) grams. CPAP was provided in 16/18 resuscitations, PPV provided in 13/18 resuscitations, and corrective ventilation steps in 15/18 resuscitations. No intubations occurred in the first 5 min of resuscitation. In all recordings, providers verified that the eye tracking recording was appropriately calibrated and accurately reflected their visual focus.

Practitioners' visual attention was primarily focused on the infant (median total gaze duration 57%, IQR 38–61%) (Table 1). Across participants, the median number of visits/10 s on the infant was 2.4 (IQR 1.5–4.1), and median visit duration on the infant was 2.2 s (IQR 1.6–2.5). Visual attention measures on the remaining AOIs are shown in Table 1.

CPAP, PPV, and corrective ventilation steps were all provided in 10 resuscitations. Providers' gaze visited the infant more frequently during corrective ventilation steps than during CPAP or PPV (Friedman test $p = 0.01$) (Table 2). Providers gazed upon the monitors for longer median durations during PPV than CPAP or corrective ventilation steps (Friedman test $p = 0.04$).

The duration and frequency of visual attention parameters on the AOIs did not significantly differ between attending neonatologists and fellows [Supplemental Table 1]. Attendings as a group exhibited patterned fixation sequences 4, 5, and 6 fixations long [Supplemental Table 2]. The most frequent fixation pattern seen among attending neonatologists was a 4-fixation sequence between infant and monitors, which occurred 70 times among all 9 attending-led resuscitations. No identifiable sequences >3 fixations were identified among fellow providers.

Discussion

This study used mobile eye tracking glasses to characterize team leaders' visual attention during delivery room resuscitation of preterm infants. Visual attention was predominantly spent on the infant and monitors, with differential allocation of visual attention based on the clinical intervention performed. While the duration and frequency of visual attention parameters were similar between attending and fellows, specific fixation patterns identified among attending-led resuscitations were not observed in fellow-led resuscitations.

Table 2 – Comparison of visual attention parameters based on respiratory intervention performed.

	CPAP	PPV	Corrective ventilation steps	Friedman test p-value	CPAP v PPV p-value	CPAP v corrective ventilation steps p-value	PPV v corrective ventilation steps p-value
Total Gaze Duration: Infant, Median (IQR)	51% (41%–61%)	51% (39%–64%)	55% (30%–74%)	0.74	–	–	–
Visit Count Per 10 s: Infant, Median (IQR)	2.6 (1.9–3.9)	2.5 (1.4–3.5)	3.1 (2.3 -5.3)	**0.01**	0.20	**0.04**	**0.01**
Visit Duration: Infant, Median (IQR)	1.8 (1.5–3.6)	2.6 (1.7–3.0)	1.4 (1.0–3.0)	0.50	–	–	–
Total Gaze Duration: Monitors, Median (IQR)	28% (5%–51%)	28% (12%–45%)	13% (8%–35%)	0.10	–	–	–
Visit Count Per 10 s: Monitors, Median (IQR)	1.9 (1.2–2.2)	1.5 (1.2–1.8)	1.4 (1.1–2.3)	0.45	–	–	–
Visit Duration: Monitors, Median (IQR)	1.5 (0.9–2.6)	2.1 (1.0–3.4)	1.0 (0.4–2.4)	**0.04**	0.07	0.21	0.09

This analysis includes only recordings where Continuous Positive Airway Pressure, Positive Pressure Ventilation, and Corrective Ventilation Steps were all performed (N = 10).
CPAP = Continuous Positive Airway Pressure. PPV = Positive Pressure Ventilation. IQR = interquartile range.
Bold values indicate statistical significance with $p < 0.05$.

Most eye tracking resuscitation studies were performed in simulation[4,8,9,10] or focused on feasibility of eye tracking to enhance learning. We were able to expand beyond this prior work to identify visual attention patterns amongst and between neonatal providers during clinical delivery room resuscitation of preterm infants. Our results are similar to a small pilot study (n = 6) of neonatal resuscitation in which providers spent the greatest proportion of their visual attention on the infant, followed by peripheral monitors.[11] Further, we identified differences in visual attention based on the types of intervention performed. These preliminary results could be used to optimize the delivery room environment and resuscitation equipment.

Time and frequency based measures of visual attention were similar between attending and fellow providers. We did not consider the 2% difference between groups in total gaze duration on "other physical objects" to be clinically important, particularly in light of multiple comparisons. However, all attendings demonstrated patterned fixation sequences that were not observed in the fellow group. Similarly, in a study of anesthesia providers, experienced physicians more frequently performed stereotyped scan paths compared with less experienced providers and only the experienced providers exhibited a clinically relevant scan path.[12] These results suggest that assessment of gaze sequence is an important component of eye tracking studies and may provide additional information that is not appreciated when only time and frequency based parameters of visual attention are measured.

The fact that the fellows did not display stereotyped gaze patterns may reflect less familiarity with the specific resuscitation environment or could reflect the fellows' relative cognitive inexperience leading resuscitations. The most recurrent gaze pattern among attendings was a repeated sequence up to 6 fixations long alternating between the monitors and infant. White et al. reported that resuscitation experts fixated on the monitor as a technique to maintain situational awareness after brief moments of focus on specific tasks or resuscitation.[13] We speculate that attendings in our study fixated on the infant and monitor AOIs as reference points to evaluate the infant's status and to assess for expected physiologic responses to resuscitative interventions. These results may have future implications for training novice leaders to perform stereotyped gaze sequences or scan paths during resuscitation. Future studies are needed to determine the impact of eye tracking patterns on clinical outcomes.

We acknowledge several study limitations. Our sample size was small, and this was a single site setting with a unique "hands-off" role of the resuscitation leader. Study strengths include manually mapping the recordings to overcome the limitations of automated mapping for clinical resuscitation and review of recordings with participants for quality assurance of video calibration and gaze capture.

Conclusion

Team leaders predominantly gazed upon the infant and monitors during delivery room resuscitation, and time and frequency measures of visual attention varied depending on the respiratory interventions performed. Attending neonatologists exhibited patterned fixation sequences that were not observed in fellows. These findings may have implications for optimizing delivery room design and training novice providers.

Author contributor

Ms. Weinberg wrote the first draft of this manuscript. All authors included in this manuscript have made significant contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

Conflicts of interest

There are no conflicts of interest to disclose.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.12.008.

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