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Provider Visual Attention on a Respiratory Function Monitor during Neonatal Resuscitation

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Abstract

Background: A respiratory function monitor (RFM) provides real time positive pressure ventilation feedback. Whether providers use RFM during neonatal resuscitation is unknown.

Methods: Ancillary study to the MONITOR (NCT03256578) randomized controlled trial. Neonatal resuscitation leaders at two centers wore eye-tracking glasses, and visual attention (VA) patterns were compared between RFM-visible and RFM-masked groups.

Results: There were 14 resuscitations (6 RFM-visible, 8 RFM-masked) analyzed. The median total gaze duration on the RFM was significantly higher with a visible RFM (29% vs 1%, $p<0.01$), while median total gaze duration on other physical objects was significantly lower with a visible RFM (3% vs 8%, $p=0.02$). Median total gaze duration on the infant was lower with RFM visible, although not statistically significantly (29% vs 46%, $p=0.05$).

Conclusion: Providers' VA patterns differed during neonatal resuscitation when the RFM was visible, emphasizing the importance of studying the impact of additional delivery room technology on providers' behavior.

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Competing Interest:
None declared.

Introduction:

Positive pressure ventilation (PPV) is the cornerstone of neonatal resuscitation but is a technically challenging skill to master. The respiratory function monitor (RFM) is a novel tool that may improve safety and efficacy of PPV by providing real time information about the quality of PPV. The RFM uses an in-line flow transducer between the gas flow and facemask to calculate and display data on delivered inflations during PPV. While using a RFM to guide PPV improves the quality of PPV performed in a simulated environment, little is known about how providers used the RFM to guide clinical resuscitation.¹ In an audit of clinical resuscitations with a visible RFM, the majority of providers reported that they did not use RFM data to inform resuscitative efforts.² Conversely, introducing a novel tool such as a RFM may distract providers from attending to key auditory and visual cues.³ Whether and how providers use the RFM during clinical resuscitation has not been well described.

Wearable eye-tracking glasses identify and classify the wearer's focus of visual attention (VA) and have been used in simulation and clinical environments.⁴ Eye tracking offers a method to identify how providers visually access RFM data during resuscitations. The objective of this study is to compare providers' VA patterns during delivery room (DR) resuscitation with and without a visible RFM with the primary outcome of total gaze duration on the infant.

Methods:

This was an ancillary study to the MONITOR ([NCT03256578](#)) randomized controlled trial, which compared a visible vs masked RFM on the primary outcome of exhaled tidal volume during DR PPV for infants 24.0-27.6 weeks gestation. Neonatal resuscitation leaders at two academic delivery hospitals, the Hospital of the University of Pennsylvania (HUP) and Leiden University Medical Center (LUMC), wore mobile eye-tracking glasses (Tobii Pro Glasses 2, Tobii Technology Inc., Stockholm, Sweden) during DR resuscitation of neonates enrolled in the MONITOR trial. We enrolled a convenience sample of providers for whom eye-tracking recordings were captured. At both hospitals, resuscitations of high-risk infants are performed with a dedicated leader. Eye-tracking glasses were calibrated to the wearer prior to resuscitation. To account for the possibility of a systematic offset between measured and actual gaze location,⁵ reviewed their video with a study team member to determine whether the eye-tracking glasses correctly captured their focus.⁶ Recordings with >30% gaze capture data loss were excluded, consistent with a prior study.⁷ Data loss is determined through gaze sample percentage, which is the number of eye-tracking gaze points recorded divided by the theoretical maximum (50 sample points per second with a 50Hz sampling rate). Blinking and fixations to the periphery are common causes of data loss.

All processing was conducted with Tobii Pro Lab analysis software. The first five minutes of resuscitation gaze data were manually mapped by a study team member. Five minutes was chosen to capture the most active part of the resuscitations, consistent with other DR eye-tracking studies.^{7,8} Each gaze point was categorized as a fixation or saccade. Saccades are 20-40ms transitioning eye movements. Given Tobii Pro Glasses 2 capture gaze points in 20ms intervals, 2 or less gaze points on a single AOI were considered a saccade and 3 or

more were considered a fixation. Fixations were mapped to a photograph representing the resuscitation environment with nine defined areas of interest (AOI). AOIs were infant, vitals monitor, RFM, T-piece resuscitator, team member body, team member hands, Apgar timer, peripheral staff, and other physical objects (Supplemental Figure 1). Total gaze duration, visit count per ten seconds, and visit duration for each AOI and saccades were calculated, as previously described.⁶ The primary outcome was total gaze duration on the infant. Analyses were conducted using STATA IC 14.2 (StataCorp, College Station, TX). VA measures were compared between RFM-visible and RFM-masked recordings using Wilcoxon rank-sum test. P value of <0.05 was considered statistically significant. Local institutional review boards approved this study at both study sites, and consent was obtained from study participants.

Results:

Eye-tracking data from 11 providers representing 14 resuscitations were analyzed and included (Table 1). One recording was excluded due to >30% gaze data loss. Six resuscitations were randomized to RFM-visible and eight to RFM-masked. With a visible RFM, providers distributed their VA evenly between the RFM, vitals sign monitor, and infant, with total gaze duration of 29%, 27%, and 29% respectively (Table 2). With a masked RFM, providers primarily distributed their VA on the infant (46%) and vital sign monitor (35%) with 8% VA on other physical objects. With a visible RFM, median total gaze duration on the RFM was significantly increased (29% vs 1%, $p<0.01$) and median total gaze duration on other physical objects was significantly decreased (3% vs 8%, $p=0.02$). Median total gaze duration on the infant was lower with RFM-visible compared with masked, although not statistically significantly (29% vs 46%, $p=0.05$). A visible RFM was also associated with lower frequency of visits to the vitals monitor, other physical objects, and saccadic eye movements. The median visit duration on the visible RFM was 2.6 seconds (IQR 1.9–4.0).

Discussion:

To our knowledge, this is the first study to quantitatively measure providers' VA during a clinical resuscitation with and without an additional monitor, the RFM. A visible RFM was associated with altered patterns of providers' VA, with increased total gaze duration on the RFM, decreased total gaze duration on other physical objects, and decreased frequency of visit counts to the vitals monitor, other physical objects, and saccadic eye movements. Providers directed 29% of their total gaze duration on the RFM when it was visible. The median gaze duration on the visible RFM (2.6 seconds) was similar to median visit durations on the infant and the vitals sign monitor in both groups.

These results demonstrate that providers regard the visible RFM during resuscitation. Although VA does not necessitate cognitive attention, providers allocated almost one third of their VA to the RFM. The duration and amount of VA devoted to the RFM when visible suggests that providers reviewed the RFM data during clinical resuscitation.

Notably, providers devoted less VA (46% versus 29%, $p=0.05$) to the infant with a visible RFM. We hypothesize the study may have been underpowered to detect a statistically significant difference, but this finding does raise interesting questions about the impact of new technology in the DR. If providers are facile at RFM interpretation, decreased VA on the infant may in fact improve patient outcomes given known provider inaccuracy of PPV assessment using chest rise. However, without the skills to interpret RFM data, decreased VA on the infant could potentially negatively impact patient outcomes. The changes in VA distribution with the visible RFM emphasizes the importance of studying the impact of additional technology in the DR on providers' behavior.

We acknowledge study limitations. As previously stated, we cannot draw conclusions about cognitive attention using VA alone. The two study sites were academic delivery hospitals which may limit the generalizability to community delivery hospitals. As previously stated, the small sample size provides limited power and precludes our ability to assess the association between VA and patient-level outcomes. Despite the lack of patient outcomes, the change in provider VA distribution alone demonstrates that additional technology impacts provider attention and behavior during neonatal resuscitation. Further evaluation of the impact of additional equipment on provider attention and patient outcomes is imperative.

Conclusion:

A visible RFM in the DR was associated with altered VA for providers leading neonatal resuscitation. These results emphasize the importance of studying the impact of additional technology in the DR environment.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Citations:

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What is known about this topic?

The respiratory function monitor (RFM) is a novel tool that may improve positive pressure ventilation (PPV) by providing real time information about PPV quality.

The RFM improves the quality of PPV performed in a simulated environment, but little is known about how providers use the RFM in clinical resuscitation.

Wearable eye-tracking glasses have been used effectively in both simulation and clinical environments to identify and classify the wearer's focus of visual attention.

What this study adds?

Providers regarded the RFM during neonatal resuscitation, directing 29% of their total gaze duration on the RFM when it was visible.

A visible RFM was associated with altered visual attention patterns during neonatal resuscitation.

These results emphasize the importance of studying the impact of additional delivery room technology on providers' behavior.

Table 1:**Participant and Resuscitation Characteristics**

Participants*	N=11
Male sex, n (%)	6 (55%)
Provider Role	
Attending, n (%)	3 (27%)
Fellow, n (%)	4 (36%)
Resident, n (%)	3 (27%)
Physician Assistant, n (%)	1 (9%)
Years of Clinical Experience, mean (SD)	9 (6)
Resuscitations	N=14
Hospital	
HUP, n (%)	5 (36%)
LUMC, n (%)	9 (64%)
Infant Gestational Age, mean (SD)	25.9 (1.4)
Infant Birth Weight, mean (SD)	844 (210)
PPV intervention occurrence, n (%)	11 (79%)
Intubation intervention occurrence, n (%)	1 (7%)

HUP= Hospital of the University of Pennsylvania, LUMC=Leiden University Medical Center, PPV= Positive Pressure Ventilation

* 1 participant recording was excluded for >30% data loss

Table 2:

Visual Attention of RFM Visible versus RFM Masked in first 5 Minutes of Resuscitation (Visible n=6; Masked n=8)

Area of Interest	Total Gaze Duration % ¹ (median, IQR)			Visit Count per 10 seconds ² (median, IQR)			Visit Duration ³ (seconds) (median, IQR)		
	RFM Visible	RFM Masked	P-Value	RFM Visible	RFM Masked	P-value	RFM Visible	RFM Masked	P-Value
Infant	29% (22%-35%)	46% (39%-49%)	0.05	1.1 (0.9-1.6)	1.7 (1.3-2.5)	0.12	2.21 (2.03-2.34)	2.23 (1.09-2.53)	0.90
Vitals Monitor	27% (4%-38%)	35% (27%-44%)	0.37	0.8 (0.4-1.0)	2.4 (1.8-2.9)	<0.01	3.41 (0.99-4.03)	1.34 (0.91-1.51)	0.25
Respiratory Function Monitor	29% (13%-51%)	1% (0%-1%)	<0.01	0.8 (0.6-1.9)	0.3 (0.1-0.5)	0.05	2.56 (1.89-3.95)	0.18 (0.12-0.21)	<0.01
Other Physical Objects ⁴	3% (0%-6%)	8% (6%-9%)	0.02	0.7 (0.1-1.1)	2.0 (1.1-2.4)	<0.01	0.58 (0.48-0.77)	0.30 (0.23-0.43)	0.07
T-Piece Resuscitator	2% (1%-4%)	5% (2%-6%)	0.09	0.3 (0.2-0.4)	0.4 (0.1-0.5)	0.25	0.74 (0.20-1.29)	0.75 (0.70-1.08)	0.61
Team Member body	2% (1%-6%)	1% (1%-2%)	0.25	0.6 (0.2-0.9)	0.3 (0.2-0.4)	0.37	0.41 (0.24-0.74)	0.28 (0.18-0.36)	0.25
Team Member hands	1% (0%-1%)	1% (0%-1%)	0.70	0.2 (0.2-0.4)	0.2 (0.1-0.4)	0.80	0.48 (0.25-0.55)	0.25 (0.19-0.31)	0.20
Apgar Timer	0% (0%-1%)	1% (0%-5%)	0.22	0.1 (0.1-0.1)	0.2 (0.1-0.6)	0.17	0.51 (0.31-0.69)	0.76 (0.19-1.09)	0.46
Peripheral Staff	0% (0%-1%)	1% (1%-1%)	0.16	0.1 (0.0-0.2)	0.1 (0.1-0.2)	0.24	0.42 (0.18-0.75)	0.38 (0.30-0.68)	0.80
Saccadic Eye Movements	2% (1%-2%)	4% (2%-4%)	0.05	3.1 (2.4-3.7)	5.2 (4.0-6.4)	<0.01	0.06 (0.05-0.06)	0.05 (0.05-0.05)	0.22

RFM= Respiratory Function Monitor, IQR= Interquartile Range

¹Total Gaze Duration %= Cumulative time each participant gazed on an area of interest, divided by the corrected time of interest duration. The cumulative duration of gaze samples accounts for gaze sample percentage. For example: if the recording is 100s, but the gaze sample percentage is only 90%, the cumulative duration of gaze samples is 90s.

²Visit Count= Number of visits within an area of interest per 10 seconds

³Visit Duration= Median time spent in an area of interest on a single visit

⁴Other Physical Objects= any physical object in the delivery room that was not pre-specified as an Area of Interest (e.g. IV poles, lights, wall posters).