Analysis of neonatal resuscitation using eye tracking: a pilot study

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ABSTRACT

Background Visual attention (VA) is important for situation awareness and decision-making. Eye tracking can be used to analyse the VA of healthcare providers. No study has examined eye tracking during neonatal resuscitation.

Objective To test the use of eye tracking to examine VA during neonatal resuscitation.

Methods Six video recordings were obtained using eye tracking glasses worn by resuscitators during the first 5 min of neonatal resuscitation. Videos were analysed to obtain (i) areas of interest (AOIs), (ii) time spent on each AOI and (iii) frequency of saccades between AOIs.

Results Five videos were of acceptable quality and analysed. Only 35% of VA was directed at the infant, with 33% at patient monitors and gauges. There were frequent saccades (0.45/s) and most involved patient monitors.

Conclusion During neonatal resuscitation, VA is often directed away from the infant towards patient monitors. Eye tracking can be used to analyse human performance during neonatal resuscitation.

INTRODUCTION

The Joint Commission on Accreditation of Healthcare Organisations emphasised that failures in neonatal resuscitation account for more than two-thirds of cases of perinatal mortality and morbidity.[1] Therefore, international organisations have emphasised the need to study human performance during neonatal resuscitation.[2]

The performance of healthcare providers (HCPs) is a complex interplay of many factors, including perception, attention, memory, knowledge, decision-making, communication, teamwork and motor skills. The study of HCP performance requires a 'toolbox' of assessment methods. Video recordings have been used to examine team performance during neonatal resuscitation,[3] as has eye tracking, which has been used, for example, in aviation to study visual attention (VA). Eye tracking glasses video record participants' visual fixation and gaze shifts (saccades). These data are analysed to provide information such as areas of interest (AOIs), percentage of time spent on each AOI and types and frequency of saccades. Eye tracking has been used to study changes in VA with increased workload during critical medical incidents.[4 5]

Despite improvements in technology and education, neonatal resuscitation remains demanding and stressful, requiring the resuscitator's attention on many tasks (eg, mask ventilation, observing monitors, coordinating team and decisions-making). The division of this attention and its correlation with neonatal resuscitation performance is not well understood. Furthermore, practice changes, such as increasing use of ECG for heart rate monitoring, may have an unintended effect on HCPs' attention and performance.

As eye tracking has been successfully used to analyse VA in clinical practice (eg, surgery), we aimed to test its use to analyse HCPs' VA during neonatal resuscitations in the delivery room.

METHODS

As a pilot study, six specialised video recordings were obtained using head-mounted eye tracking glasses (Tobii Glasses, Tobii Technology, Inc, Falls Church, Virginia, USA). Participants were voluntary HCPs from a tertiary neonatal intensive care unit. The set-up of the resuscitation environment is presented in figure 1. Participants included neonatal fellows (n=1), respiratory therapists (n=2), neonatal nurse practitioners (n=2) and neonatal consultants (n=1). Each participant acted as airway manager and team leader and stood at the head of the resuscitation warmer. After a brief period of calibration (<30 s), eye tracking recordings were started.

Eye tracking glasses use reflected infrared light to track pupillary movement, and image processing to incorporate gaze patterns as markers into a video from a participant's viewpoint. The videos were manually coded to obtain (i) AOIs, (ii) the time spent on each AOI (indicating VA distribution), (iii) frequency of saccades during the entire resuscitation (a marker of cognitive loading, or amount of mental effort used) and (iv) frequency of the saccades between each AOI (indicating how each area contributed to cognitive loading). The first 5 min of each video, which is the most active phase of resuscitation, were analysed. The study was approved by the human research ethics board, University of Alberta. Parental written consent was obtained for use of the video recordings. HCPs agreed to participate but signed consent was not obtained.

RESULTS

All six videos were reviewed by two investigators (BHYL and GS); five videos were of acceptable quality and analysed. The sixth video had >50% data loss due to poor calibration and was excluded. Results from the remaining recordings are summarised in table 1. Infants had a mean (SD) gestation and birth weight of 28[3] weeks and 1296 (402) g, respectively. The median (IQR) Apgar scores at

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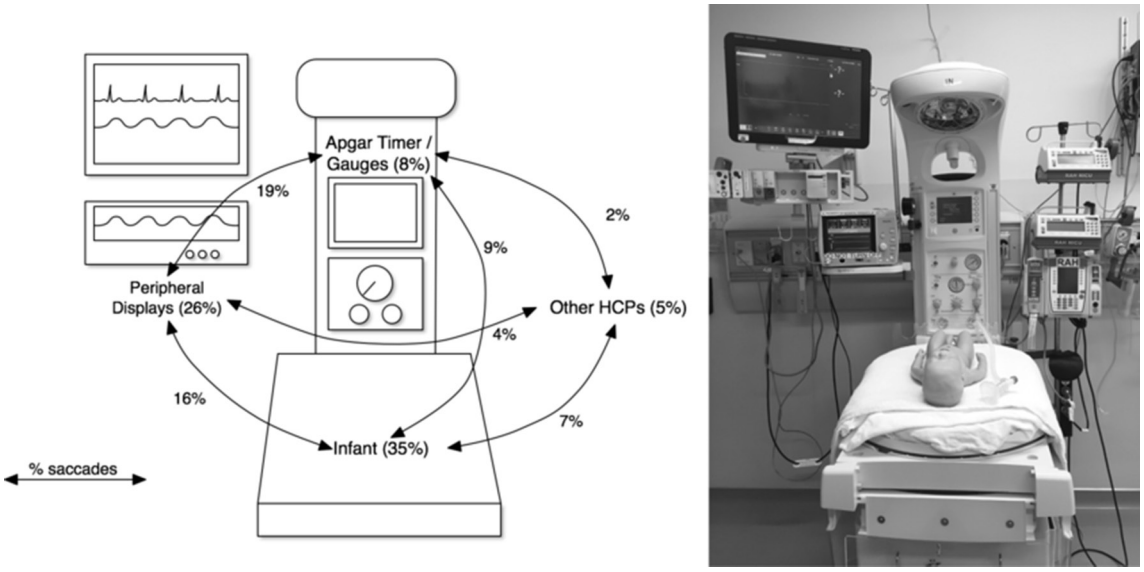

Figure 1 Diagram representing the percentage visual attention directed at different areas of interest in the resuscitation environment, and frequency of saccade types. HCPs, healthcare providers.

1 and 5 min were 5 (3–6) and 8 (7–9), respectively. Four infants received mask ventilation and one infant underwent endotracheal intubation and emergency umbilical venous catheter placement. During the first 5 min of resuscitation, an average of 35% of VA was directed at the infant, with 33% focused on displays and gauges. Only 5% of time was directed towards other HCPs. When displays and gauges integrated on the radiant warmer (including Apgar timer and T-piece pressure gauges) were separated from peripheral displays (including vitals signs monitors and flow sensors), HCPs were found to focus more on peripheral displays (26%). In the infant requiring intubation, 44% of VA was directed at the infant, with 21% of the time directed at the displays and gauges.

There were frequent saccades (mean 0.45 saccades/s) in all cases, or approximately one every 2 s. With endotracheal intubation, saccades were less frequent (0.33 saccades/s). Analysis of saccades with respect to AOIs showed that 53% were to or from peripheral displays (pulse oximetry, ECG and respiratory flow sensors). The percentage of time devoted to each AOI and the percentage of saccades are represented graphically in figure 1. Participants reported that the eye tracking glasses had not interfered with their clinical work.

DISCUSSION

In this pilot study, we successfully used eye tracking to examine VA in the first 5 min of neonatal resuscitation. To the best of our knowledge, this has not been previously studied. We observed that HCPs directed only 35% of VA towards the infant. As in the report by Schulz *et al*,[4] we observed that a significant amount

Table 1 Summary of results, including interventions required, percentage time spent on each area of interest during first 5 min of resuscitation and average frequency of saccades (per second)

		Recordings					Combined	
		1	2	3	4	5	Mean	SD
Interventions performed		Mask ventilation 3 min PPV	Mask ventilation 30 s PPV	Mask ventilation 1 min PPV	Mask ventilation 3 min PPV	Intubation (at 2 min), UVC insertion (at 4 min)		
% of time focused on each area of interest	Infant	29	40	26	38	44	35	8
	Displays and gauges (total)	43	24	42	33	21	33	10
	Apgar timer and gauges	9	4	12	14	3	8	5
	Peripheral monitors (vital signs and flow sensor)	34	24	30	19	22	26	6
	Other health professionals	1	6	8	3	6	5	3
	Transition/shifting gaze	25	14	20	20	13	18	5
	Other	1	2	5	7	1	3	3
	No data	0	13	1	2	16	7	7
Saccades per second		0.53	0.36	0.51	0.51	0.33	0.45	0.1

PPV, positive pressure ventilation; UVC, umbilical venous catheter.

of HCPs' VA (33%) was on patient monitors. In their anaesthesia simulation study, Schulz *et al*[4] found that VA focused on monitors increased from 20% to 30% once a critical incident occurred, suggesting that monitors are important in situation awareness. We also observed that minimal VA was directed at other HCPs. Communication was primarily verbal with little eye contact, increasing the risk for communication failures.

Overall, saccades were frequent, reflecting the high cognitive load (amount of mental effort used) and divided VA. During mask ventilation HCPs often moved their gaze to or from monitors to assess the effectiveness of their ventilation. Half of observed saccades (53%) involved peripheral displays. This cognitive demand might be related to neonatal resuscitation guidelines, which recommend continuous monitoring of a patient's condition using pulse oximetry and ECG. With more emphasis on monitoring, visual displays will be more important during neonatal resuscitation. Therefore, the impact of visual displays on HCP performance, including VA and situation awareness, requires further study.

Visual attention of HCPs during neonatal resuscitation might be further affected by mental workload and task performance. In this study, VA directed at the infant differed during resuscitation with endotracheal intubation compared with resuscitation with mask ventilation alone. Saccades were also less frequent as the HCP was focused on establishing an airway. More data is required to elucidate the impact of different resuscitation tasks on VA and situation awareness.

This is a pilot study of only five analysed recordings. One recording was excluded because of poor quality, which is similar to the proportion of unusable data previously reported.[4 5] Furthermore, visual fixation analysis alone does not take account of the phenomenon of inattentional blindness. To assess a HCP's perception and comprehension of the clinical information, situation awareness measures are required. Finally, there is high variability between the observations, as VA, in general, is highly variable depending on workload, environment, tasks, training, interpersonal differences and other factors. Larger studies under specific resuscitation conditions are needed.

CONCLUSION

Eye tracking can be used to examine visual attention of HCPs during neonatal resuscitation. In this pilot study, a significant proportion of VA was directed away from the infant towards peripheral patient monitors. Future studies using eye tracking with other tools should be performed to examine factors affecting human performance during neonatal resuscitation.

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Contributors GS, BHYL: Conception and design. GS, SvO, BHYL, P-YC, BZ, MW: Collection and assembly of data; analysis and interpretation of the data; drafting of the article; critical revision of the article for important intellectual content; final approval of the article.

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Competing interests None declared.

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Data sharing statement Abstracted and anonymised eye tracking data are available upon request.

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Notes