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A Pilot Project Using Eye-Tracking Technology to Design a Standardised Anaesthesia Workspace

Jaber Hanhan¹ , Roderick King² , T. Kyle Harrison³ , Alex Kou³ , Steven K. Howard³ , Lindsay K. Borg⁴ ,
Cynthia Shum⁵ , Ankeet D. Udani⁶ , Edward R. Mariano³ 

¹University of Utah School of Medicine, Salt Lake City, Utah, USA

²Stanford University School of Medicine, Stanford, CA, USA

³Department of Anaesthesiology, Perioperative and Pain Medicine, Stanford University School of Medicine, Stanford, CA, USA; Anesthesiology and Perioperative Care Service, Veterans Affairs Palo Alto Health Care System, Palo Alto, CA, USA

⁴Department of Anaesthesiology, Kaiser Permanente Northwest, Portland, OR, USA

⁵Anesthesiology and Perioperative Care Service, Veterans Affairs Palo Alto Health Care System, Palo Alto, CA, USA

⁶Department of Anaesthesiology, Duke University School of Medicine, Durham, NC, USA

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ORCID IDs of the authors: J.H. 0000-0003-1468-1946; R.K. 0000-0002-6717-5345; T.K.H. 0000-0002-2083-1472; S.K.H. 0000-0001-6475-1792; C.S. 0000-0001-6409-1659; A.D.U. 0000-0002-6195-7151; E.R.M. 0000-0003-2735-248X

Objective: Maximising safe handoff procedures ensures patient safety. Anaesthesiology practices have primarily focused on developing better communication tools. However, these tools tend to ignore the physical layout of the anaesthesia workspace itself. Standardising the anaesthesia workspace has the potential to improve patient safety. The design process should incorporate end user feedback and objective data.

Methods: This pilot project aims to design a standardised anaesthesia workspace using eye-tracking technology at a single university-affiliated Veterans Affairs hospital. Twelve practising anaesthesiologists observed a series of images representing five clinical scenarios. Each of these had a question prompting them to look for certain items commonly found in the anaesthesia workspace. Using eye-tracking technology, the gaze data of participants were recorded. These data were used to generate heat maps of the specific areas of interest in the workspace that received the most fixation counts.

Results: The laryngoscope and propofol had the highest percentages of gaze fixations on the left-hand side of the workstation, in closest proximity to the anaesthesiologist. Atropine, although the highest percentage of gaze fixations (33%) placed it on the right-hand side of the workstation, also had 25% of gaze fixations centred over the anaesthesia cart.

Conclusion: Gaze fixation analyses showed that anaesthesiologists identified locations for the laryngoscope and propofol within easy reach and emergency medications further away. Because eye tracking can provide objective data to influence the design process, it may be useful when developing standardised anaesthesia workspace templates for individual practices.

Keywords: Eye tracking, workspace, anaesthesia, design, patient safety, handoffs

Introduction

Transitions of care ('handoffs') between anaesthesiologists may occur during a single surgical case (1). These handoffs may (2, 3) or may not (4) affect patient outcomes. Maximising safe handoff procedures is a Joint Commission patient safety goal. Anaesthesiology practices have primarily focused on improving communication tools (5). While these tools can be effective (6), they tend to ignore the physical layout of the anaesthesia workspace itself.

A key aspect of the anaesthesiologist's role in perioperative care is crisis resource management (7). During an intraoperative emergency (e.g. loss of airway security, hypo- or hypertension and inadequate anaesthetic depth), an anaesthesiologist has to respond immediately. In such cases, familiarity with the environment directly influences the timeliness

of response. If an anaesthesiologist takes over a case in an unfamiliar location set up by another anaesthesiologist, delays in care as well as errors such as syringe swaps (8, 9) may occur. Standardising the anaesthesia workspace layout can effectively improve patient safety (10) and workflow efficiency, but the design process has not typically been data-driven (10, 11).

Eye tracking has been applied in the field of ultrasound-guided regional anaesthesia (12, 13) and crisis management simulation (14) but has not yet been described for workspace design in anaesthesiology. Eye tracking collects objective data within domains that have been previously limited to subjective responses. We present the results of a pilot project exploring the potential applications of eye tracking to design a standardised anaesthesia workspace.

Methods

This study was approved by the institutional review board and Veterans Affairs research committee. Participants provided written informed consent. Reporting of this educational study followed the STROBE checklist for observational studies (15).

From July to September 2017, a convenience sample of attending anaesthesiologists was recruited from a single academic institution. All the participants had active hospital privileges in good standing, state medical licences, and certification from the American Board of Anesthesiology. If calibration of the eye-tracking system (Tobii Pro Glasses 2; Karlsvåg, Sweden) was unsuccessful, recruits were excluded (12). The participants completed a short survey to record baseline characteristics.

The project was conducted in a private office using methods described previously (12). Eye-tracking technology utilises corneal reflection to determine the focus of the subject's gaze (16, 17); hence, it must be calibrated according to the individual participant before beginning the experiment (12). After successful calibration, the participants received standardised scripted instructions that they would be shown a series of PowerPoint slides (Microsoft Office, Redmond,

WA) on a 50-inch plasma, high-definition (1080p) television screen (Panasonic, Kadoma, Japan). For each of the five clinical scenarios, participants would be asked a question prompting them to look for certain items, and their eye movements would be recorded. Based on prior experiences (12, 13), a static image was used to optimise the collection of objective measures using this eye-tracking system. This static image showed an anaesthesia workstation in an operating room at the study institution. The image was taken from the vantage point of an anaesthesiologist standing at the head of the operating room table looking over his or her right shoulder (Figure 1).

The five clinical scenarios and questions were developed and iteratively tested by three investigators who were not involved in data collection. These questions were then posed to the participants in random order (www.randomizer.org): Q1) *Your patient is preoxygenated and ready for induction. Where will you find your propofol?* Q2) *Your patient is ready for endotracheal intubation. Where will you find your laryngoscope?* Q3) *Your patient suddenly becomes bradycardic. Where will you find your atropine?* Q4) *Your patient is moving during surgery, and you need to bolus rocuronium. Where will you find your rocuronium?* Q5) *Your patient has hypotension and tachycardia post-induction. Where will you find your phenylephrine?* For each scenario, the participants wore eye-tracking glasses and were instructed to look where they would expect to find each item on the image. They were instructed to inform the proctor verbally when they had completed their task by stating 'now' or 'done'.

Outcomes and analyses

Eye-tracking recordings and gaze data were continuously collected through the Tobii Pro Glasses 2. Tobii Pro Lab software (Karlsvåg, Sweden) was used to draw boundaries around each area of interest (AOI) a priori (14), calculate metrics such as time to first fixation (i.e. time to first measured gaze fixation within any AOI), record viewing time and produce image maps. Raw fixation points were tabulated for each of the 10 AOIs to extrapolate frequency of viewing. Percentage fixation count was calculated for each AOI (number of fixations within an AOI divided by the



Figure 1. Panorama image of an anaesthesia workstation in an operating room at the study institution used for subsequent eye-tracking measurements

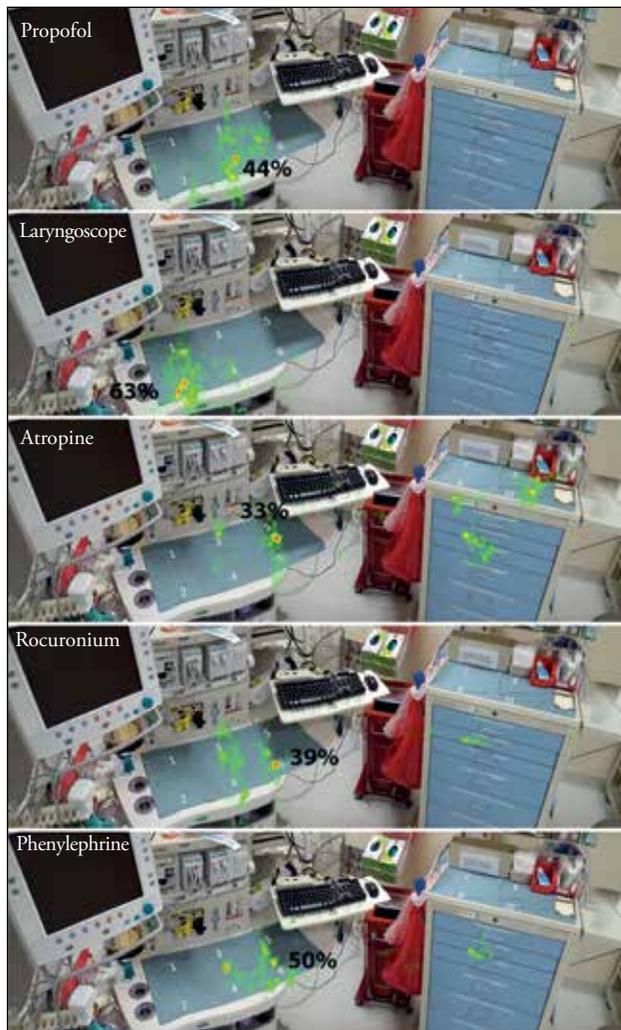


Figure 2. Heat maps generated by all participants' fixations along with the area of interest receiving the highest percentage of fixation counts for each scenario

total number of fixations for all AOIs). Normality of distribution was determined. Time to first fixation and time to complete the task were compared among participants using the Kruskal–Wallis Rank Sum Test with post-hoc multiple comparison tests (R Core Team, Vienna, Austria) (18). For all comparisons, a p -value of <0.05 was considered statistically significant.

Results

In total, 12 participants enrolled, consented and were successfully calibrated. Half of the participants were female (6/12) with 10 (3–27) years in practice [median (10th–90th percentiles)] and 6 (2–18) years at the current institution; a total of 7/12 completed anaesthesiology residency at Stanford University Medical Centre (58%).

Time taken to complete each task (median [IQR]) was as follows: Q1) 4.98 (5.45) s, Q2) 3.06 (2.13) s, Q3) 3.55 (1.43) s, Q4) 3.41 (2.38) s and Q5) 3.40 (0.83) s ($p=0.056$). Time to first fixation (median [IQR]) for each scenario was

as follows: Q1) 0.54 (0.78) s, Q2) 0.21 (0.53) s, Q3) 0.62 (0.94) s, Q4) 0.40 (0.33) s and Q5) 0.40 (1.03) s ($p=0.416$). The distributions of participants' time to first fixation were not different ($p=0.075$). Time to complete task results was non-random ($p=0.010$), but there were no pairwise differences.

Heat maps generated by all the participants' fixations along with the AOI receiving the highest percentage of fixation counts for each scenario are shown in Figure 2. The laryngoscope and propofol had the highest percentages of gaze fixations on the left-hand side of the workstation, in closest proximity to the anaesthesiologist. Atropine, although the highest percentage of gaze fixations (33%) placed it on the right-hand side of the workstation (Figure 2), also had 25% of gaze fixations centred over the anaesthesia cart.

Discussion

Using eye-tracking technology, we are able to objectively demonstrate where anaesthesiologists at a single institution fix their gaze when searching for specific items or medications in the anaesthesia workspace. In this study, anaesthesiologists indicated locations for the laryngoscope and propofol within easy reach on the workstation and emergency medications further away. These data suggest that eye-tracking technology can be useful for anaesthesia workspace design.

Grigg et al. (10) have demonstrated that implementation of a standardised anaesthesia medication template made from milled polyvinyl chloride decreases the odds of committing a medication dosing error during simulated emergencies and the monthly error rate in clinical practice. Unfortunately, their study provides a very limited description of the design process, '3-year period involving multiple test and revision cycles', with no mention of objective data (10). In contrast, the results of our project show that objective data from eye tracking can be collected in an efficient fashion and influence the design process. Further, the gaze fixations measured from our sample almost completely avoid the anaesthesia cart in the image, except for atropine, which is where Grigg and colleagues recommend placing their medication template. This likely reflects variations in practice and suggests that a standardised workspace should be specific to each institution.

The identified site for emergency medications further away from the anaesthesiologist's convenient reach is worth noting and represents an intrinsic patient safety feature. Although the highest percentages of gaze fixations placed phenylephrine and atropine on the right-hand side of the workstation, atropine also had a clinically relevant percentage of gaze fixations centred over the anaesthesia cart. This finding suggests that anaesthesiologists at the study institution prefer atropine in this location or may not routinely draw it up at all.

This pilot project has its limitations. Most importantly, these results are specific to one institution. The design of a standardised anaesthesia workspace arguably should be unique to an institution, considering anaesthesiologists' preferences, equipment models, medications and supplies available and operating room layout. Interestingly, only 58% of participants were trained at the affiliated anaesthesiology residency programme. Yet, there was general concordance of gaze fixations for nearly all items, which suggests that institutional practice has more influence than the training site. The results of our study show that objective data may be collected using eye tracking to assist in the design process. The eye-tracking results from our study cannot be extrapolated to items or medications that were not tested (e.g. other airway devices or medications) because every item should be tested individually. Other important elements of workspace design were also not included in our study (e.g. overall layout, lighting, and colour). Finally, the design of a standardised workspace cannot be assumed to result in safer patient care and must be studied in clinical practice.

Conclusion

The results of this study show that collective objective gaze fixation data using eye-tracking technology can be useful in the design of a standardised anaesthesia workspace.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Stanford University (eProtocol #32593, Approved on June 30, 2017).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

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