Monitoring with head-mounted displays in anesthesia: Simulator and clinical evaluations

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Introduction

Head-mounted displays (HMDs) can superimpose patient vital signs over an anesthesiologist’s field of view, letting them monitor the patient no matter where they are in the operating room. HMDs are similar to the head-up displays (HUDs) commonly used in aviation, and are frequently featured in movies such as Top Gun and RoboCop.

Prior studies reported in the literature indicate that anesthesiologists using a head-mounted display can:

- Detect vital signs changes (“events”) faster than otherwise
- Reduce their need to look at the standard patient monitor
- Spend more time focused on the patient’s clinical signs
- Potentially benefit from using the HMD in the OR

Despite the apparent benefits of HMDs, no studies have investigated the cognitive and perceptual problems associated with these displays:

- Worsened inattentional blindness – pilots using head-up displays are more likely to miss salient but safety-critical events, e.g. a runway incursion on approach to land. Would the same phenomenon occur in anesthesia?
- Focal depths – many HMDs have adjustable focus settings, but there has been no research on where it should be focused for anesthesia monitoring.

We performed three experiments with anesthesiologists wearing a Microvision Nomad™ HMD under various simulated and clinical conditions to investigate the above issues.

Experiment 1: Full-scale simulator

Aims

To determine whether anesthesiologists under “naturalistic” settings would miss unexpected events (1) when monitoring with an HMD, and (2) with specific combinations of HMD focus, ongoing task location and event location.

Methods

12 anesthesiologists provided anesthesia to a METI ECS simulator during three 35 minute scenarios: standard monitoring (Control), HMD with near focus, HMD with far focus. Each scenario contained 8 events constructed from a combination of the ongoing task distance (near, far) and event location (monitor or HMD, anesthesia machine, patient, elsewhere in the OR). The scenarios were tightly scripted with actors playing the roles of nurses and surgeon.

Results

Neither HMD usage nor depth of focus affected the accuracy or speed of event detection. However, when using the HMD anesthesiologists spent more time looking towards the patient and less towards the machine.

Conclusions

There was no evidence of worsened inattentional blindness with the HMD. Furthermore, anesthesiologists did not detect events any faster when using the HMD.

Experiment 2: Part-task trainer

Aims

To determine whether an HMD can help anesthesiologists detect changes in their patient’s vital signs faster than otherwise, when they are busy or physically constrained.

Methods

12 anesthesiologists each performed two scenarios lasting 8 minutes in which they navigated a Dexter Endoscopic Dexterity Trainer maze using a fiber-optic bronchoscope. A simulated patient’s vital signs were presented on a standard monitor (Control scenario), or on the standard monitor and on the HMD (HMD scenario). Four events (unexpected vital signs changes) were presented in each scenario.

Results

Two events (light anesthesia and hypovolemia) were detected faster with the HMD, one event was detected more slowly with the HMD (excess sedation), and there was no significant difference between conditions for the fourth event.

Conclusions

HMDs help anesthesiologists detect patient events faster when they are busy or physically constrained. However, inattentional blindness or other cognitive or perceptual problems may interfere with detection of waveform changes.

Experiment 3: Clinical evaluation

Aims

To determine whether the results from simulation studies would (1) generalize to clinical practice, and (2) be any different during crisis management.

Methods

6 attending anesthesiologists each provided anesthesia to six patients undergoing rigid cystoscopy procedures. Each participant alternated between Control conditions (Philips Intellivue MP70 monitor only) and HMD conditions (MP70 plus the HMD). Participants’ monitoring behavior was analyzed from recorded video data.

Results

Participants in conditions with the HMD spent more time looking towards the patient, and less towards the monitors. While managing a regurgitation episode, a participant using the HMD (a) spent less time looking and looked less frequently towards the monitors, and (b) looked at the patient for longer periods of time, compared to their own baseline.

Conclusions

An HMD allows anesthesiologists to spend more time monitoring the patient’s clinical signs during normal anesthesia and especially during crisis management.

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