Clinical Simulation Training in Virtual Reality

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Introduction and Background

Immersive virtual reality (IVR) is an emerging technology in surgical education that provides an immersive visual and acoustic simulation. IVR is defined in this study as a fully interactive environment in which users wear a head-mounted display (HMD) in which a 3-dimensional (3D) interactive environment is projected. Due to scheduling constraints and the challenges presented by the COVID-19 pandemic, major challenges to traditional in-person surgical teaching have been brought to light. The portability and the ability to design non-proctored educational content of IVR technology is well suited to meet this need. The aim of this study was therefore to design and compare a novel pneumothorax and chest tube management simulation against current in-person educational practices.

Methods

Application Development

The IVR simulation was developed using the Unity 3D (Unity; Unity Technologies, San Francisco CA) and Blender (Blender; Blender Foundation, Amsterdam, Netherlands) applications. A 1:1 reproduction of an operating room at the Hospital of the University of Pennsylvania was designed with a full reproduction of equipment, instruments, and interactions that are present and occur in this environment. A clinically responsive mannequin was designed requiring emergent chest tube placement for a pneumothorax and in which the learner is tasked with placing and managing.

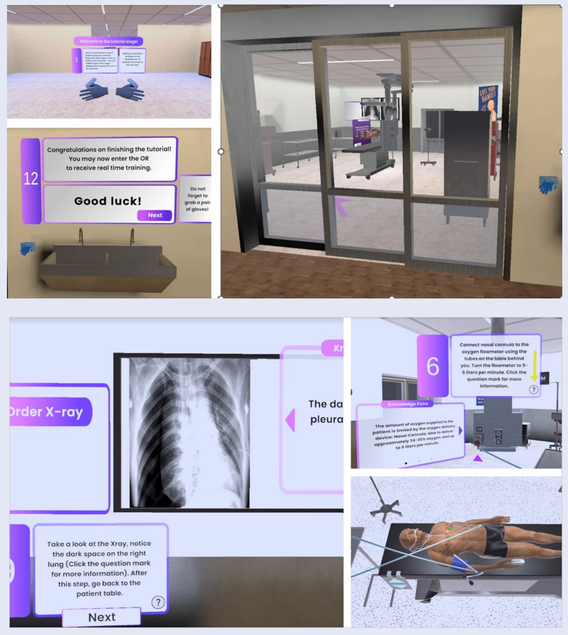
Study Design

A randomized controlled study was designed comparing the IVR simulation against conventional in-person teaching. All surgical interns without prior clinical experience were recruited into the study. Both groups took a pneumothorax and chest-tube management test prior to their respective intervention. They then were told the educational objectives of the educational experiences they were about to undergo and then underwent a respective 45-minute simulation or teaching session. Learners were retested and then took a survey on whether the educational objectives were met. IVR learners were additionally queried on motion sickness symptoms, a known issue with IVR use.

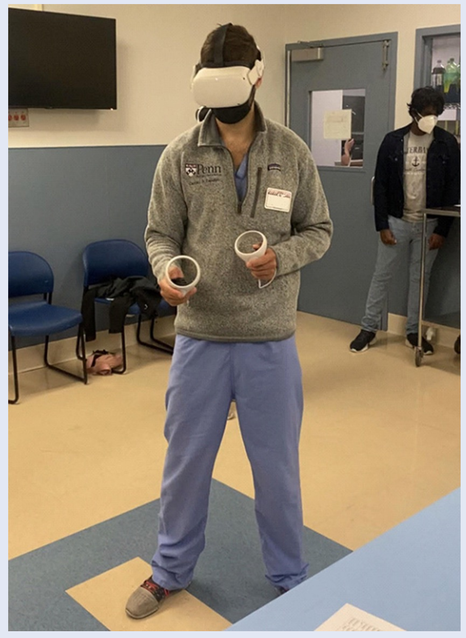
Statistical Methods

To determine whether data of continuous variables were normally distributed, the Shapiro-Wilk normality test was used. Paired *t* tests were used for variables with normal distribution of data; for variables with a skewed distribution, Mann Whitney U test was used. Cohen's d was used to calculate effect size for each intervention. Pearson's χ^2 test was utilized to determine if there was any difference in specialty composition of the two randomized groups. A two-tailed *p* value < 0.05 was considered statistically significant. Statistical analysis was performed using Stata version 17.0 (StataCorp, College Station, Texas, USA).

Photos of the IVR application

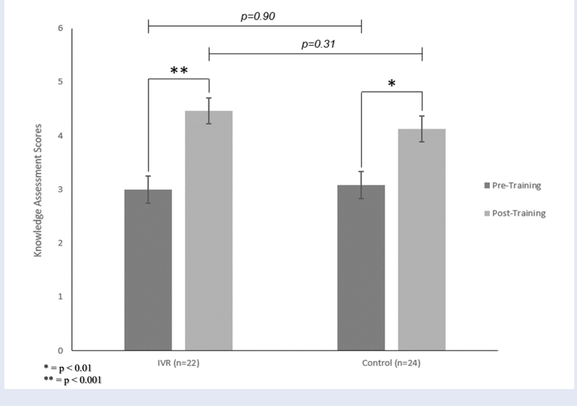


Representative images of the IVR simulation

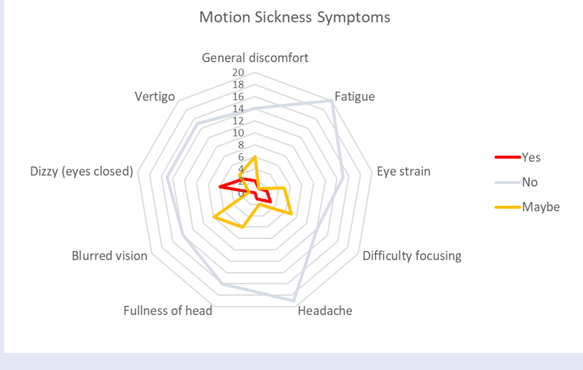


Surgical intern undergoing IVR simulation

Results



Knowledge assessment scores for IVR and control groups



Reported motion sickness symptoms with IVR

Results

A total of 30 identifying males and 16 identifying females were included in this study. Of the 48 participants who began the study, 46 completed the study as 2 participants in the IVR group requested to be excused from the learning session due to motion sickness symptoms.

Knowledge Acquisition

At baseline, there was no significant difference in knowledge test scores between IVR and control groups [3.00 ± 0.25 vs. 3.08 ± 0.25, mean difference (95% CI) 0.08 (-0.70-0.79), $p = 0.900$]. After training, no significant difference in knowledge scores was demonstrated between IVR and control groups [4.46 ± 0.24 vs. 4.13 ± 0.20, mean difference (95% CI) -0.33 (-0.95-0.32), $p = 0.308$].

Within the IVR group, however, there was a significant improvement between pre- and post-training knowledge test scores [3.00 ± 0.25 vs. 4.46 ± 0.24, mean difference (95% CI) 1.46 (0.79-2.12), $p < 0.001$]. Similarly, in the control group, a significant improvement was demonstrated between pre- and post-training knowledge scores [3.08 ± 0.25 vs. 4.13 ± 0.20, mean difference (95% CI) 1.05 (0.30-1.78), $p = 0.008$]. Although each intervention demonstrated significant improvement, a larger effect size was found with IVR ($d = 1.29$ 95% CI [0.63-1.94]) than control ($d = 0.94$, 95% CI [0.34-1.53]).

Motion Sickness

At least one motion sickness symptom was experienced by 19/22 IVR group participants (Fig 6). Dizziness with eyes closed was the most common symptom experienced by the participants, definitively occurring in 6/22 participants. Two of the participants were unable to finish the IVR didactic and simulation due to motion sickness symptoms and therefore their data was removed from inclusion in this study.

User Experience

On average, participants in both the IVR and control group indicated their respective pneumothorax and chest tube management training was efficacious based on a 5 point Likert scale (4.09 ± 0.97 vs. 3.96 ± 0.75, $p = 0.284$).

Discussion and Limitations

This study revealed that a novel IVR simulation is not only comparable to in-person teaching of pneumothorax and chest tube management, but that IVR has a larger effect on knowledge changes. The results of this study reveal that IVR technology may be an effective solution to scheduling constraints and the limitations posed by the COVID-19 pandemic to surgical education. Motion sickness was a prevalent issue with the IVR simulation and extreme enough to prevent 2 of the learners from completing the scenario. This finding is disconcerting in that unequal access to use is an unacceptable characteristic of any innovative educational technology. Research into preventing such symptoms will be necessary prior to widespread adoption of the technology.