In practice report

# Understanding the potential of Mixed Reality simulation training for the management of ‘Can’t Intubate -Can’t Oxygenate’ emergencies

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# INTRODUCTION

The management of an unanticipated difficult airway resulting in a “can’t intubate – can’t oxygenate” (CICO) emergency is a rare time-critical and life-threatening emergency that is highly stressful, and the associated stress can impair the performance of the whole multidisciplinary team.

We are interested in supporting anaesthetic trainees in managing CICO emergencies, especially by developing their non-technical skills for dealing with this situation. Simulation training supports learners to develop clinical skills in a safe learning environment that shares many features of a real environment. Our challenge was to create simulation training that had sufficient fidelity so as to evoke the stress of managing CICO emergencies.

The fidelity of a simulation is essential for evoking stress during a performance and is determined by (a) the level of immersion, with a sense of presence in which the individual has the perception that they are engaged in a real experience, [1]; and (b) the level of authenticity, which is the extent to which the learner considers the simulation represents a real environment, [2].

We describe a feasibility study to ensure that the components of an intervention are appropriate to produce the intended outcomes and to identify any changes that may be required for a future larger study. Previous studies suggest that six participants can identify the extent to which the components are appropriate, [3].

# DEVELOPING THE TRAINING SIMULATION

We developed a mixed-reality simulation that combined a CICO emergency after induction of anaesthesia within a virtual environment, which was created using high-definition 360 degree panoramic two-dimensional photographs of real clinical environments.

In our experience, the stress of performing emergency airway interventions by anaesthetic trainees was dependent on the specific environment , with an emergency department trauma bay environment being more stressful than an operating theatre for some. Providing two sequential simulations that allow development and consolidation of training across two progressively stressful simulations, can be logistically difficult in busy clinical departments.

We decided to use 360 degree panoramic two-dimensional photographs, since research has identified that 360 degree panoramic two-dimensional photographs can effectively create a high level of immersion that are comparable to more expensive and difficult to produce full virtual reality environments, [4].

# THE MIXED-REALITY SIMULATION

The simulation was held in the Computer Augmented Virtual Environment (CAVE) at Edge Hill University. This is a 4.25m wide by 3m long and 2.25m high room. Three of the walls are back-projection screens and the fourth wall is left open. The benefit of back-projection compared to front-projection is that it avoids any shadows appearing from people or objects in the simulation. The participants face the screens, with their backs to the open wall.

(a) ‘Real’ environment

Two standardized scenarios with a high fidelity manikin were designed to recreate an unexpected CICO emergency arising after induction of anaesthesia: first, in an otherwise healthy patient having elective surgery, and second, in a critically ill trauma patient requiring a rapid sequence induction of anaesthesia. The scenarios were performed with a multidisciplinary team comprising an anaesthetic trainee, an operating department practitioner and a health care assistant. The scenario facilitators used a structured script to standardise each simulation.

(b) ‘Virtual’ environment

Two 360 degree two-dimensional photographs (an operating theatre’s anaesthetic room and an accident and emergency department’s trauma bay) at Aintree University Hospital were obtained using an Insta360 Pro 8K camera (Insta360,Tustin, CA) that was linked via WIFI to an app on an iPhone (Apple, Cupertino, CA), which controlled the camera and also made any adjustments, such as resolution. The camera was placed in the centre of the rooms and 6 photographs were taken, which were then combined using the integrated software. The final 360-degree photographs were virtually projected outward from a point in the centre of the CAVE at eye height. The three projectors were high-definition Christie Mirage 304K 9 (Christie, Cypress,CA) with a 4K resolution (4096x2160 pixels), a peak brightness of 30,000 lumen, and a 2000:1 contrast.

See link to view the simulation:

<https://drive.google.com/file/d/11a6x-lS00g_6JrcPHeQsKn9R-_Z4xasd/view?usp=sharing>

# THE EVALUATION

We evaluated the extent to which immersion and authenticity were created by the mixed-reality simulation, and also to obtain user recommendations for improvement.

Semi-structured individual interviews were performed on six anaesthetic trainee participants (4 female: 2 male) immediately after the simulations. Qualitative thematic analysis identified five main themes and one theme for recommendations. See Table 1.

Table 1: Results of thematic analysis: main themes, number of participants with comments in the theme, and illustrative quotation from participants.

| Theme | Illustrative quotation from participants |
| --- | --- |
| Immediate reaction of immersion and authenticity (N=6) | Well, I think when I first saw the kind of images, I…it took me a few seconds to work out what was real, and then I realised that none of it was real. But at first, I thought, oh what’s—this can’t all be real, what’s not real? And, but then once I kind of had made that assessment, I didn’t really think about it anymore. (Participant1) |
| Continuing reinforcement of immersion and authenticity (N=4) | I found it really immersive; it adds a lot to the simulation in a way when you just look up from the model just to take in various things, it does feel like you’re more in the environment than when you just do it in a generic classroom …… out of the corner of your eye, you can see things that look real as opposed to just a blank white wall. (Participant 4) |
| Replication of realistic thought processes  (N=3) | I think it was just makes it more realistic and I think it increases the speed of thought …. I act more like I do at work rather than in a simulation. (Participant 3) |
| Importance of physical presence of equipment (N=3) | The time to get things was a bit more realistic as well ‘cause they had to actually be got, like the difficult airway trolley, and obviously it could be from further away in reality Like, the machine and the equipment were set up in the way they would normally be. (Participant 4] |
| Acceptance of picture quality  (N=3) | When I was looking at the patient and the surroundings were in my peripheral view, the resolution didn’t really matter as much, it was high enough to be convincing. [Participant 5) |
| Recommendations for additional background noise (N=2) | The lack of sound was quite striking, so there were no beeps from the monitors… I think that sort of background hubbub of A & E and that background noise that you have to compensate for …. it felt immersive, but I think that just being told there's a code red trauma next door, there would have been - that generates a lot of noise, a lot of talking, so perhaps just having something like that playing in the background as well would really just reinforce that there's something else going on, so you are kind of on your own. (Participant 5) |

# DISCUSSION

Overall, the mixed-reality CICO simulations that we developed appear to have created a simulation with an appropriate high level of fidelity, with immersion and authenticity. An important aspect of our simulations was that they also appeared to have sufficient fidelity to replicate the thought processes of real world experience.

It is interesting that three participants highlighted the importance of the physical presence of equipment for fidelity of the simulation, which is not available in full virtual reality simulations.

Some participants were aware of minor image distortion in the panoramic two-dimensional photographs, but this did not appear to reduce the immersion and authenticity. Improved image quality may not be possible with current camera technology.

The recommendation to increase auditory fidelity through the addition of background noise has the potential to increase the level of immersion and authenticity, with the creation of escalating levels of stress. The optimum level of this additional auditory fidelity to supplement the visual fidelity is uncertain.

Our findings from this feasibility study have encouraged us to continue to develop and research the use of mixed-reality simulation training for the management of CICO emergencies, with the further development of increased auditory fidelity and research on evoked stress and comparison across different scenarios. The study population was small but our findings have potential relevance to inform the development of similar future simulations in other contexts and to stimulate further research, especially since no similar studies were identified.

# ETHICAL APPROVAL

The study was approved by the Faculty Research Ethics Committee at Edge Hill University (FREC IPP5/2018) and the NHS HRA (Project 249844 19/HRA/0264).

# CONFLICTS OF INTEREST

None

# FUNDING

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# CONTRIBUTION

JS,PG,PV and JB designed the study and intervention. PV operated the CAVE virtual environment and PG, TM and TRM were scenario facilitators. JS collected the data and JS and JB analysed the data. All authors contributed to writing the draft manuscript and its critical revision, approval of the final version and are accountable for all aspects of the work.

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