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 (1) the level of immersion, with a sense of presence in which the individual has the perception that they are engaged in a real experience 3 and (2) 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° 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° panoramic two-dimensional photographs, since research has identified that 360° 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 4.25 m wide by 3 m long and 2.25 m high room. Three of the walls are back-projection screens and the fourth wall is left open. The benefit of back-projection compared with 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.

‘Real’ environment

Two standardised 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 healthcare assistant. The scenario facilitators used a structured script to standardise each simulation.

‘Virtual’ environment

Two 360° 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, California, USA) that was linked via WIFI to an app on an iPhone (Apple, Cupertino, California, USA), which controlled the camera and also made any adjustments, such as resolution. The camera was placed in the centre of the rooms and six photographs were taken, which were then combined using the integrated software. The final 360° 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, California, USA) with a 4K resolution (4096×2160 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__Z4xas/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.

Semistructured individual interviews were performed on six anaesthetic trainee participants (four female, two male) immediately after the simulations. Qualitative thematic analysis identified five main themes and one theme for recommendations (see table 1).

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.

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