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Learning through simulated independent practice leads to better future performance in a simulated crisis than learning through simulated supervised practice

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Editor's key points

- Medical simulation offers learning opportunities without risk to patient care.
- Simulation scenarios reproduce physiological pertubations and critical incidents.
- Premature or simplistic resolution of a critical incident may limit solid learning.
- Failure, if coupled with supportive teaching, can impact positively on learning.

Background. Anaesthetists may fail to recognize and manage certain rare intraoperative events. Simulation has been shown to be an effective educational adjunct to typical operating room-based education to train for these events. It is yet unclear, however, why simulation has any benefit. We hypothesize that learners who are allowed to manage a scenario independently and allowed to fail, thus causing simulated morbidity, will consequently perform better when re-exposed to a similar scenario.

Methods. Using a randomized, controlled, observer-blinded design, 24 first-year residents were exposed to an oxygen pipeline contamination scenario, either where patient harm occurred (independent group, $n=12$) or where a simulated attending anaesthetist intervened to prevent harm (supervised group, $n=12$). Residents were brought back 6 months later and exposed to a different scenario (pipeline contamination) with the same end point. Participants' proper treatment, time to diagnosis, and non-technical skills (measured using the Anaesthetists' Non-Technical Skills Checklist, ANTS) were measured.

Results. No participants provided proper treatment in the initial exposure. In the repeat encounter 6 months later, 67% in the independent group *vs* 17% in the supervised group resumed adequate oxygen delivery ($P=0.013$). The independent group also had better ANTS scores [median (interquartile range): 42.3 (31.5–53.1) *vs* 31.3 (21.6–41), $P=0.015$]. There was no difference in time to treatment if proper management was provided [602 (490–820) *vs* 610 (420–800) s, $P=0.79$].

Conclusions. Allowing residents to practise independently in the simulation laboratory, and subsequently, allowing them to fail, can be an important part of simulation-based learning. This is not feasible in real clinical practice but appears to have improved resident performance in this study. The purposeful use of independent practice and its potentially negative outcomes thus sets simulation-based learning apart from traditional operating room learning.

Keywords: high-fidelity simulation; independent practice; medical education; medical error

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The classic resident training paradigm of apprentice-based learning and traditional educational adjuncts (e.g. lectures and independent study) is under scrutiny in an era of working hour restrictions and decreased numbers or diversity of patient encounters.[1 2] Simulation has emerged as an important adjunct to modern clinical training, yet the key factors that distinguish simulation-based education from traditional operating room (OR) learning have not been fully elucidated. These factors are potentially important if senior doctors are to provide targeted and meaningful postgraduate education over a relatively short period of residency training.

Errors and near misses are ubiquitous in medicine,[3–5] cost billions of dollars annually,[6] and also have negative effects on practitioners.[7–13] Anaesthetists are not immune and may fail to recognize and manage certain rare, dangerous perioperative events properly.[14 15] While devastating, these errors can be important learning opportunities, prompting detailed recall[16 17] or encouraging self-reflection and study, or both, which may improve future practice.[18–20] In real clinical training, errors are ideally not allowed to occur or develop further as residents are supervised by senior faculty. However, these represent potential missed learning opportunities which,

if engineered in the simulated environment, might lead to similar recall and self-reflection.

While some critics of simulated mortality believe it should almost never occur except in teaching specific, predefined objectives regarding the management of death (i.e. breaking bad news, terminating a resuscitative code),[21] there has been little convincing evidence that simulated mortality has a negative effect on practitioners. In the past, our group have shown that adding emotional fidelity and increasing stress during simulation improved future performance of advanced cardiovascular life support in a medical student cohort.[22] We posit that the stress of simulated mortality might act in a similar manner as a catalyst to improve learning and future performance in a cohort of anaesthesia residents.

In this study, we sought to test whether residents exposed to a simulated oxygen pipeline contamination would perform better in a second simulated exposure 6 months later, if during initial exposure, they were exposed to simulated mortality. We hypothesized that learners who were allowed to manage a scenario independently and allowed to fail, thus causing simulated morbidity, would consequently perform better when re-exposed to a similar scenario (as opposed to a group who could call an attending anaesthetist who was immediately available to assist).

Methods

Study design: phase 1

Study approval was obtained from the Mount Sinai Program for the Protection of Human Subjects. The study was given exemption from the need for written consent. The simulation curriculum is part of the integrative basic anaesthesia training programme at our institution. The experimental scenario (oxygen pipeline contamination) was otherwise hidden within the standard, identical 6 week simulation curriculum. All 24 incoming first-year anaesthesia residents were given the opportunity to opt out of the study voluntarily. All 24 residents agreed to participate in the study. The residents were informed that during the 6 weeks of simulation they would be observed for the research study, but were blinded as to which scenario was experimental.

The study was divided into two phases: the initial exposure phase (phase 1; hidden in the standard simulation curriculum); and the assessment phase (phase 2; 6 months later, not hidden). Before exposure to the scenario, every resident was given the Trait portion of the State–Trait Anxiety Inventory (STAI) to measure baseline anxiety levels.[23 24] All results were de-identified using identification numbers randomly generated for each resident. The initial exposure was given to all residents over the course of 2 days during the same week of training (week 4).

Scenario design

For the experimental scenario, participants were brought to the Mount Sinai Department of Anesthesiology Human Simulation Center for a combined 60 min simulation and debrief session. Participants were randomized, using a computer-generated binary group randomization program, to one of two groups, either the independent group or the supervised group. Both groups received the same starting scenario (see Supplementary material Appendix 1). The independent group would receive no help throughout the scenario (i.e. if they called for an attending anaesthetist, one would be 'busy' and .never arrive), whereas the supervised group would receive help from a simulated attending anesthetist when the patient's cardiopulmonary status began to deteriorate, whether or not they called for help (i.e. attending anaesthetist would state he wanted to check in and see how things were going).

The simulator used (CAE Human Patient Simulator, Saint-Laurent, Quebec, Canada) was programmed with the following baseline parameters: heart rate 121 beats min^{-1} in sinus rhythm, blood pressure 153/82 mm Hg, saturation 100% on 2 litres via nasal cannula, and respiratory rate 21 bpm. After being allowed to assess the situation, the surgeon would begin asking the team to provide anaesthesia as soon as possible because he was very busy. During the scenario, the patient proved extremely difficult to sedate for the procedure, and the surgeon insisted that the patient be given more sedation. Eventually, with escalating anaesthetic doses, the patient became apnoeic while the procedure commenced. Once apnoeic, the gas supply to the anaesthesia machine was manually switched from oxygen to nitrogen by a faculty member running the scenario remotely. Both groups were expected to diagnose and treat the apnoea using proper airway-management techniques. As the pipeline was contaminated, no intervention taken (including positive pressure ventilation with or without tracheal intubation) would improve the patient's status, and the patient monitoring would indicate oxygen desaturation. The oxygen concentration on both monitors accurately reflected the 0% oxygen that was being delivered to the patient.

The scenario then took one of two paths depending on the participant actions. In the independent group, the patient oxygen desaturation worsened and eventually progressed to cardiac arrest. Simulated patient death occurred unless one (or more) of three successful interventions was undertaken: (i) open the auxiliary oxygen tank on the anaesthesia machine and disconnect the machine from the pipeline; (ii) switch the anaesthesia machine to deliver air only; or (iii) ventilate the patient with a manual self-inflating resuscitative bag either connected to an auxiliary oxygen tank or room air. If help was called for, the participant was told their attending anaesthetist was unable to leave their other operating room because they were having 'issues'.

In the supervised group, once the patient oxygen saturation fell below 80% an attending anaesthetist entered the room (whether help was called for or not), diagnosed the pipeline contamination with the resident, and dictated an effective treatment plan (i.e. switching from the hospital supply to an auxiliary oxygen source) if the resident had no valid suggestions. The patient then demonstrated complete resolution, the oxygen saturation increased to 100%, and the patient began breathing on their own (Fig. 1).

After the simulation, and regardless of the patient outcome, both groups received identical debriefings that did not focus on