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Original Research

CRITICAL CARE

The Emotional and Cognitive Impact of Unexpected Simulated Patient Death

A Randomized Controlled Trial

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Background: **Observational studies suggest that emotions experienced during simulation training may affect cognitive load and learning outcomes. The objective of this study was to manipulate emotions during simulation training and assess the impact on cognitive load and learning.**

Methods: **In this prospective randomized trial, 116 final-year medical students received training in a simulated scenario of a 70-year-old woman presenting with reduced consciousness due to aminosalicylic acid ingestion. Training groups were randomly allocated to one of two endings for the scenario: The patient was transferred to another service, or she experienced a cardiorespiratory arrest and died. Participants rated their emotions and cognitive load after training. Three months later, we evaluated their performance on a simulation Objective Structured Clinical Examination station of a 60-year-old man presenting with reduced consciousness due to ethylene glycol ingestion.**

Results: **Emotions tended to be more negative for students in training groups where the simulated patient died. These students also reported a higher cognitive load (mean ± SD, 7.63 ± 0.97 vs 7.25 ± 0.84; *P* = .03; *d* = 0.42) and were less likely to be rated as competent to diagnose and manage a patient with reduced consciousness due to toxin ingestion (OR, 0.37; 95% CI, 0.14-0.95; *P* = 0.04) 3 months later.**

Conclusions: **Students exposed to unexpected simulated patient death reported increased cognitive load and had poorer learning outcomes. Educators need to expose learners to negative experiences; therefore, further studies are needed on how best to use negative emotional experiences during simulation training.**

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Abbreviations: MPL = minimum pass level; OSCE = Objective Structured Clinical Examination

Training medical students and residents on high-fidelity simulators is an effective complement to their clinical training.[1,2] The simulation environment may be more learner centered than the clinical environment because students can practice in a setting where errors do not have clinical consequences and in which they can have direct supervision with immediate feedback.[3-5] They can also encounter abnormal clinical findings that are not readily available on clinical rotations and can train on these whenever and as often as they like. Despite its pedagogic appeal, however, in practice, a learning gap is associated with simulation training whereby up to 25% of students fail to improve their performance after training.[6,7] Several possible explanations account for failure to improve following simulation training, including inappropriate content, ineffective delivery, and cognitive overload due to the highly interactive nature of the simulation learning environment.[8,9]

Cognitive load theory provides a convenient framework for exploring the relationship between the design of simulation training sessions and learning outcomes.[9] This theory is based on the assumption that working memory has limited capacity and that learning is impaired when aspects of instructional design overload this capacity.[9-11] Cognitive load comprises three components. Intrinsic load reflects both the inherent difficulty of a given task and the learner's prior experience with this task. Extraneous load, a superfluous

For editorial comment see page 932

load that is potentially detrimental to learning, is imposed on learners by their interaction with the instructional material (including teachers). Germane load refers to the amount of working memory dedicated to learning the new task. According to cognitive load theory, these components are additive, and learning is reduced when the total cognitive load exceeds the capacity of working memory. Thus, the optimal instructional design is one that avoids cognitive overload, minimizes extraneous load, and maximizes germane load.[9,11]

Thus far, exploration of variables that influence cognitive load during simulation training and of the effect of cognitive load on learning outcomes has been limited. We reported that emotions experienced during simulation training are associated with subjective cognitive load ratings and that learning outcomes are poorer for students with higher cognitive load.[12] Although these findings are consistent with the psychology literature on the effects of emotion on performance, the observational design of our previous study only allows us to generate a hypothesis on the relationship among emotions, cognitive load, and learning outcomes.[13-16] To test this hypothesis, we need to manipulate the emotions of learners during simulation training and then study the impact of this manipulation on cognitive load and learning outcomes.

Perhaps the simplest and most realistic way to influence emotions during a learning experience is to provide feedback to learners on their performance. The perception of failure predictably results in negative emotions, although the relationship between failure and subsequent performance is less predictable.[17-20] During simulation training, the use of definitive outcomes, such as patient death or survival, provides learners with unambiguous feedback on performance. The utility of exposing learners to patient death during simulation training is, however, a highly contentious issue.[21] Three learning scenarios in which simulated patients are allowed to die partly explain this discord. The first is expected death where both teachers and students know in advance that the simulated patient will die during the learning experience and that dealing with death is one of the stated learning objectives. In this setting, it seems intuitive that patient death would enhance learning. The second scenario is where teachers but not students know that the patient will die (unexpected death), and the third is where death is conditional on learner performance, in which case neither teachers nor students can predict death in advance (death resulting from action or inaction). There is uncertainty regarding the effect of unexpected death on learning outcomes because of a lack of empirical data and because strong arguments can be made for and against exposure to patient death. For example, advocates of learner exposure to patient death draw from literature suggesting that errors during learning result in better long-term performance,[22] whereas opponents counter with data suggesting that the emotional impact of patient death may result in cognitive overload and reduced learning.[12,20,23]

Given the equipoise regarding the utility of unexpected patient death, we chose this exposure to manipulate the emotions of learners during simulation training and to then study the impact of emotion on cognitive load and learning outcomes. The setting for the study was a simulation training session for which the learning objectives were diagnosis and management of a patient with an altered level of consciousness due to toxin ingestion. We randomly allocated participants to simulation training scenarios that ended with survival or unexpected death of the simulated patient and assessed the impact of patient death on emotions and cognitive load during the training session. To assess the impact on learning outcomes, we evaluated performance on diagnosis and management in a similar simulation scenario of altered level of consciousness due to toxin ingestion 3 months later. We predicted that the unexpected death of a simulated patient would result in a negative emotional response, increased cognitive load, and poorer learning outcomes from the simulation training session.

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Materials and Methods

Participants

Participants were 116 final-year medical students at the University of Calgary (graduating class of 2011). We have a 3-year undergraduate curriculum of which the first 2 years comprise integrated systems courses and the final year is a clinical clerkship. This study took place during a simulation training session that was part of the clinical skills in clerkship curriculum, which runs throughout the clerkship year. The Conjoint Health Research Ethics Board at the University of Calgary approved the study (ethics ID# E-22899), and we obtained written informed consent from all participants prior to entry into the study. During the consent process, we told the participants that the goal was to study the impact of emotions on cognitive load and learning outcomes, but we did not inform them of our intention to manipulate the ending of their training session. The decision to withhold this information was made in consultation with the chair of the Conjoint Health Research Ethics Board and was justified by the fact that uncertainty surrounds the impact of unexpected patient death on learning outcomes, that students were already exposed (in an uncontrolled way) to unexpected patient death, and that providing this information could introduce a performance bias in the training session.

Materials

For each training session, we used the same human patient simulator (SimMan 3G; Laerdal Medical) and training scenario: a 70-year-old woman presenting to the ED with an altered level of consciousness in which the underlying diagnosis was aminosalicylic acid ingestion. The patient had previously completed an advanced care plan, stating that she did not wish to be resuscitated in the event of cardiorespiratory arrest.

We piloted and revised all aspects of the scenario prior to the study, including the script for historical data, relevant physical examination findings, and additional data from investigations (eg, ECG, radiographs, arterial blood gas results, other laboratory test results) that supported the underlying diagnosis. We created two endings for the scenario: patient survival, in which the patient was transferred to the ICU for urgent hemodialysis, and unexpected patient death, in which the patient experienced a cardiorespiratory arrest and died.

To assess emotion during simulation training, we used an eight-item scale containing bipolar-opposite descriptors of emotion based on the semantic structure of emotion proposed by Feldman Barrett and Russell.[24] These descriptors were tense/calm, nervous/relaxed, stressed/serene, upset/contented, sad/happy, depressed/elated, lethargic/excited, and bored/alert. Because emotions typically are dichotomized into positive or negative, we asked participants to rate their emotions according to each descriptor on a five-point Likert scale, with anchors at −2 and 2 representing the bipolar opposites.[25,26] For each choice of descriptor, we assigned a positive value to the one that was rated more pleasant in the original Circumplex Model. For example, on the tense/calm scale, tense was given a score of −2 and calm a score of +2.

To assess cognitive load, we used the subjective rating tool validated by Paas and Van Merriënboer.[27] With this tool, we asked participants to rate the amount of mental effort required to complete the simulation scenario on a nine-point scale, with anchors at 1 and 9 representing very, very small and very, very high, respectively.

Procedure

Prior to this study, as part of their formal undergraduate curriculum, participants had not encountered a simulation scenario in which the simulated patient died. Figure 1 shows an overview of the study design. At the beginning of the clinical skills in clerkship curriculum, students were randomly allocated to training groups. With the use of computer-generated numbers, we then randomly allocated training groups to one of two scenarios that differed only in the ending of the training session (unexpected patient death vs patient survival). Preceptors were informed of the assigned ending for the training session immediately before the session.

Each group comprised four or five participants, and during the training scenario, they worked together to gather historical data, examine the simulated patient, and order and interpret the results of investigations. Each training session, including a debriefing, lasted for 1 h, during which time students worked through the scenario assisted by two experienced facilitators, one of whom portrayed an ED nurse and the other providing the voice and

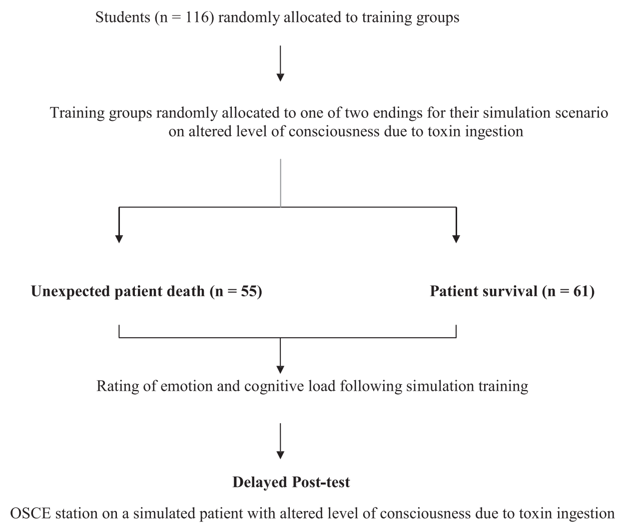

FIGURE 1. Study design. OSCE = Objective Structured Clinical Examination.

manipulating the physical status of the manikin. The simulation facilitators receive a 2-day workshop in simulation education, which includes training on how to debrief following simulation training. The structured format for debriefing is a three-step process (reaction, explanation and analysis, and summary), which begins with acknowledging and addressing the emotional reaction of learners to the simulation training scenario.[28,29]

Five minutes from the scheduled end of the simulation scenario, the ED nurse prompted students to request the assistance of either nephrology or ICU staff if they had not already requested it. The training scenario for the two groups deviated only in the final 3 minutes. In training groups randomized to patient survival, the nephrology or ICU team arrived to assume care of the patient and arranged for transfer to the ICU. In groups randomized to unexpected patient death, a nurse called to say that the nephrology or ICU team was currently busy looking after a critically ill patient and would call back as soon as possible. After this call, the patient who had a clear advanced directive for no CPR became progressively hypotensive and hypoxic. The patient then died of cardiorespiratory arrest.

We began the debriefing with an open-ended question about the simulation experience. If students were focused on the patient's death, the preceptors were instructed to validate emotions expressed by the students and to explain that a patient presenting with an altered level of consciousness requires rapid and thorough assessment because of the potentially life-threatening underlying problem. Thereafter, the debriefing focused on the learning objectives, including rapid assessment of a critically ill patient, differential diagnosis, interpretation of laboratory investigations, and management of the patient with an altered level of consciousness due to toxin ingestion. Immediately after the debriefing, participants rated their subjective emotional state and cognitive load.

Evaluation of Diagnostic Performance

Approximately 3 months after this simulation training session, all students had a summative clerkship Objective Structured Clinical Examination (OSCE), which included a formative simulation station. In the simulation OSCE station, we used SimMan 3G and a scenario of a 60-year-old man presenting to the ED with an altered level of consciousness where the underlying diagnosis was ethylene glycol ingestion. Students were expected to gather data from history and physical examination, order and interpret appropriate laboratory investigations, and suggest appropriate management. Each station had a single rater who rated performance for diagnosis and treatment on a 17-item checklist. Each item had three possible scores: 0 = task not performed; 1 = task performed, but with deficiencies or prompting; and 2 = task performed. The raters for the simulation OSCE station were not involved in teaching the simulation training scenario and were blinded to the intervention. As for all other OSCE stations, the minimum pass level (MPL) for the station was set by an independent board of examiners using the modified Nedelsky method.[30] Participants were considered to be competent in diagnosis and management of a patient with an altered level of consciousness if they matched or exceeded the MPL for the simulation OSCE station.

Statistical Analysis

To study the effect of death of the simulated patient on emotion, we used a two-sample *t* test where the components of emotion were the outcome variables, and the simulation scenario (unexpected patient death vs patient survival) was the explanatory variable. We used Cohen *d* to measure effect size. Similar analyses were used to study the effect of death of the simulated patient on cognitive load. We used logistic regression to evaluate the effect of death of the simulated patient on learning outcomes, and in this analysis, the outcome variable was whether the participant achieved the MPL on the simulation OSCE station. Stata 11 (StataCorp LP) software was used for the analyses.

Results

Effect of Unexpected Patient Death on Emotions and Cognitive Load

After debriefing on the simulation scenario, the mean subjective ratings for items assessing emotion tended to be lower (ie, more negative) for the training groups where the simulated patient died (Fig 2). The difference was significant for four of the eight items: nervous/relaxed ($P = .04$, $d = 0.38$), upset/contented ($P < .001$, $d = 0.69$), sad/happy ($P < .001$, $d = 0.72$), and depressed/elated ($P = .008$, $d = 0.51$). Participants in the training groups where the simulated patient died also reported higher mean ± SD cognitive load than those in the groups where the patient survived (7.63 ± 0.97 vs 7.25 ± 0.84, respectively; $P = .03$; $d = 0.42$).

Effect of Unexpected Patient Death on Learning Outcomes

Three months after the simulation training session, fewer participants in the group where the simulated patient died were rated at or above the MPL on the OSCE simulation station where the objective was to diagnose and manage a patient with an altered level of consciousness due to toxin ingestion (70.9% vs 86.9% of students in the group where the simulated patient survived). This finding corresponds to an OR of 0.37 (95% CI, 0.14-0.95; $P = .04$) of being rated as competent on the OSCE station for students exposed to unexpected simulated patient death. The probability of being rated as competent on the OSCE station for the two training scenarios is shown in Figure 3.

Discussion

The setting for this study was a simulation training scenario in which the learning objective was for final-year medical students to diagnose and manage a patient with an altered level of consciousness due to toxin ingestion. The study objective was, however, quite different from the learning objective. Instead, the research focus was on the impact of a negative emotional experience in the form of unexpected patient death on learning outcomes from a simulation training

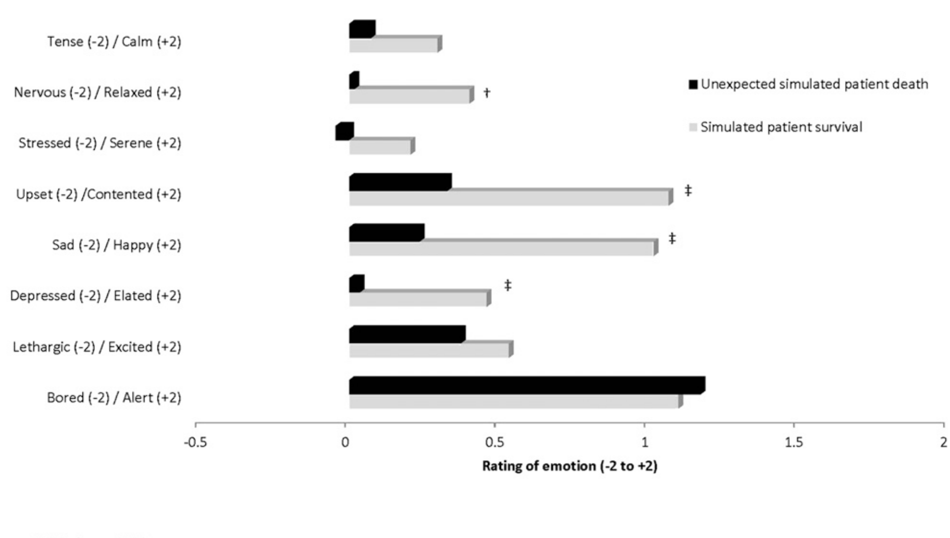

Figure 2. The effect of exposure to unexpected simulated patient death on learners' subjective ratings of emotion.

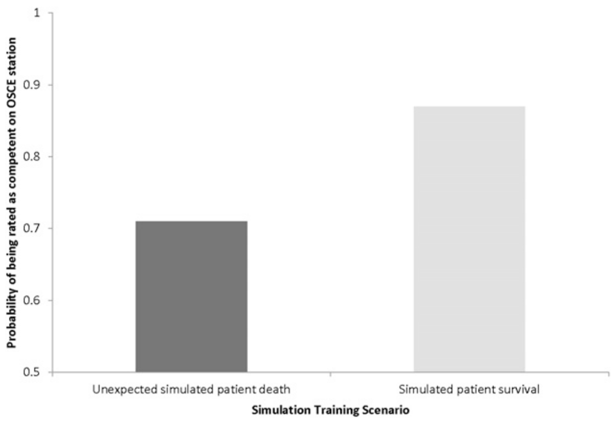

FIGURE 3. The effect of exposure to unexpected simulated patient death on the probability of learners being rated as competent on the simulation OSCE station 3 mo posttraining. See Figure 1 legend for expansion of abbreviation.

session. Although no adverse events or complaints were reported by participating students, we found that students exposed to a training scenario where the patient died not only reported more negative emotions but also were less likely to achieve the learning objectives for the simulation training session, suggesting that unexpected patient death impaired learning.

Prior to this study, we predicted that unexpected patient death would result in a negative emotional reaction and increased cognitive load, and the analyses of the subjective ratings of emotion and cognitive load at the end of the training session support these predictions. Because there were no differences between groups in either the content or the roles of the facilitators until the final 3 minutes of the scenario, the most likely explanation for the relationship between emotional and cognitive load is that negative emotions resulting from exposure to the unexpected patient death resulted in an extraneous cognitive load.[9,11,23] Because this load was encountered immediately before the debriefing session, the extraneous load associated with exposure to unexpected patient death would be expected to reduce the capacity of working memory to process and consolidate new information during the debriefing session, thus impairing learning.

Study Limitations

The present study has some important limitations. It was a single-center study of one group of learners during a single simulation training scenario, which limits the generalizability of the findings. The fact that the facilitators (although not the participants) were aware of the planned ending for the session may have introduced a performance bias into the training sessions. We only assessed emotions and cognitive load at the end of the simulation training session and do not know how well these single measures represent emotions and cognitive load throughout the training session. Although this was the first time that these learners were intentionally exposed to unexpected simulated patient death in the curriculum, we do not have data on their prior exposure to patient death and how it might have affected the impact of experiencing the simulation. From discussions with simulation facilitators, we know that some facilitators had periodically introduced simulated patient death (either unexpected or resulting from action or inaction) in a nonsystematic fashion, and participants would likely have encountered death of a real patient during their clerkship rotations. Thus, we can only comment on the emotional and cognitive impact of the first planned encounter with unexpected simulated patient death, and we have no data on whether this changes with increasing experience of patient death. Similarly, we have no data on exposure to patient death or patients with an altered level of consciousness between training and evaluation and how these may have affected participants' performance on the evaluation. Finally, between training and evaluation, the participants had no further exposure to a simulated patient with an altered level of consciousness or to simulated patient death, so we have no data on whether further learning opportunities can mitigate or reverse the effects of patient death on learning outcomes.

Implications for Simulation Training

We found that when medical students are exposed to unexpected simulated patient death for the first time, they have a negative emotional response, increased cognitive load, and reduced learning outcomes. These findings, however, should not be interpreted as suggesting that we must avoid negative emotional experiences during simulation training. Simulation training allows learners to encounter realistic scenarios in a safe environment; thus, this setting may be ideal for learners to encounter negative emotional experiences, such as patient death, as long as this is the objective of the learning experience. If, on the other hand, the objective is to diagnose and manage a patient with an altered level of consciousness, encountering unexpected patient death may detract from the learning experience. The difference in the emotional response of learners exposed to unexpected patient death compared with spared patient death speaks to the realism of death during simulation and highlights the need to consider the impact of instructional design on emotions and cognitive load during simulation training. Educators need to expose learners to negative emotional experiences but in a way that enhances learning. Thus, further studies are needed on how to maximize the utility of unexpected patient death and other negative emotional experiences during simulation training.

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Dr Fraser: contributed to the study design, data collection, and approval of the final version of the manuscript.
Dr Huffman: contributed to the study design, data collection, and approval of the final version of the manuscript.
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Mr Sobczak: contributed to the data collection and approval of the final version of the manuscript.
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Dr Wright: contributed to the study design and approval of the final version of the manuscript.
Dr McLaughlin: contributed to the study design, data collection, manuscript preparation, and approval of the final version of the manuscript.
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