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Simulated Death: The Perceived Stress And Its Impact On Undergraduate Medical Education

Benjamin Zabar

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Benjamin Zabar

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Simulated Death: The Perceived Stress And Its Impact On Undergraduate Medical Education

Benjamin Zabar, Kelly L Dodge, Basmah Safdar, Sanziana Roman, John Sather, Christopher Moore, Brian Biroscak, & Leigh V Evans. Yale Department of Emergency Medicine, Yale University School Of Medicine, New Haven CT.

Objectives: To determine perceived stress of medical students during simulated patient death, the impact of assigned role, and the effects on learning.

Methods: This was a prospective, single blinded, randomized cross over study of third year medical students who participated in a 12 week simulation course using a high fidelity mannequin (Laerdal SimMan®) during a required surgical clerkship. All students completed a standardized multiple choice question examination (MCQE) with nine questions each on acute myocardial infarction (AMI) and pulmonary embolism (PE). Students were initially randomized to two groups: Group PE/AMI and Group AMI/PE. During weekly one hour simulation sessions, each group had five student participants and an assigned team leader in a clinical scenario, while another six students observed; the students switched roles for a second related scenario and were then debriefed. During the second scenario, the simulated patient suffered cardiac arrest. At week 6, all students were exposed to a cardiac arrest scenario for which the patient was successfully resuscitated, while at week 10 the simulated patient expired. After simulation sessions at weeks 6 and 10, the students were debriefed and rated their stress during the arrest scenario on a 0-10 semantic differential scale. All students took the same MCQE at week 12.

Results: We enrolled 163 medical students from 09/07-06/08, 79 in Group PE/AMI and 84 in Group AMI/PE. The mean pretest score for Group PE/AMI and Group AMI/PE were comparable for AMI (4.8 v 5.0; $P = 0.30$) and PE (4.2 v 4.2; $P = 0.86$). Students did not report significantly different stress for both successful resuscitation and patient death. (4.8 v 4.9; $P=0.88$) Team leaders reported the most stress followed by participants and then observers for both the successful resuscitation (6.7 v 5.5 v 3.9; $P<0.01$) and patient death (7.3 v 5.2 v 4.1; $P<0.01$). Score improvement out of nine possible points was similar between patient survival and death [AMI: 1.3 v 1.7 ($P = 0.10$); PE: 0.42 v 0.38 ($P = 0.50$)]. Post-test knowledge scores showed significant improvement for team leaders compared to non leaders for both AMI (2.6 v 1.3; 14% difference, $P<0.01$) and PE scenarios (1.4 v 0.23; 13% difference, $P< 0.01$).

Conclusions: Medical students did not find simulated death to be more stressful than successful resuscitation. The role of team leader was more stressful than participating or observing cardiac arrest scenarios. No evidence was found that simulated death impairs medical student learning, therefore it may be an appropriate scenario outcome. Assigned team leaders demonstrated the greatest improvement in knowledge.

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Introduction

Mr. Thomas does not feel well. He came to the hospital today complaining of chest pain and difficulty breathing. He is examined by the third year medical student in the emergency department. The student directs her team to put the patient on the monitor while she takes a history and administers medications to stabilize the patient. Suddenly the patient says that he doesn't feel well, and stops talking. The monitor alarms; the patient is in respiratory arrest. She checks for a pulse but none is found. CPR begins. Another student struggles to intubate the patient, sweat dripping down his nose. Orders are shouted.

This is a simulation. The patient is a mannequin being controlled by an attending physician in another room behind a one way mirror. The attending stopped this patient's heart, stopped his breathing. The question is what to do now. Is this the first time the medical students have seen a patient die or performed CPR? Should the mannequin regain a pulse and "survive?" Or should the patient be allowed to "die"? Is this an acceptable option for third year medical students? How will simulated death affect the students emotionally and educationally?

Currently there is little guidance for educators in this scenario. Simulated death is rarely explicitly studied, especially in the medical student population. Some educators express concern about the stress felt by students managing a resuscitation or having their patient die. Conversely, this stress may be beneficial to the learning process. One could argue that "the stress caused by emergencies is unavoidable and inevitable: life sometimes does hang in the balance."[1] Therefore, the challenge is how to train medical students to deal with these situations which they will surely experience as physicians, preparing them for the next level of responsibility without creating a learning environment that is too stressful.

This thesis explores the topic of simulated death as it pertains to medical students. Specifically it addresses perceived stress during simulated patient death and the impact of this stress on the learning and retention of the proper treatment of certain medical emergencies.

Chapter 1 Overview of Medical Simulation

Medical simulation is a growing field in our educational system. One database lists 813 medical simulation centers in the United States as of the fall of 2009.[2] Simulation can be used to teach and practice psychomotor skills, decision making, and team dynamics. One type of simulator is a physical representation of a patient or part of a patient. At the lowest end of complexity are the isolated task trainers such as IV insertion arms. At the highest end are the "high-fidelity human patient simulators," these are computer controlled mannequins.[3] Other types of simulation include standardized patients (SPs) who are actors trained to provide medical history or certain physical findings. These SPs are often included in the simulation literature as they allow the simulation of interactions between patients and caregivers. There are also computer based simulators which are computer programs that the learner uses to navigate through a patient care scenario. Other modalities include laparoscopic surgery simulators, cardiology simulators, and virtual reality projections. [4,5,6]

High-fidelity simulators are computer controlled mannequins that breathe, speak (via a microphone in the mouth), have palpable pulses, exhibit tongue swelling and multiple other physical findings. With removable parts that appear as burns, fractures, and post-surgical sites, a wide variety of patient scenarios can be simulated using the same mannequin. The mannequins also permit a variety of procedures to be performed by learners such as intubation, CPR, chest tubes, and foley catheter insertion.

The SimMan (Laerdal) which was used in this study is classified by some authors as a "moderate-fidelity simulator,"[3] and by others as a high fidelity simulator.[7] While the SimMan has many of the same basic features as some of the more expensive simulators, it does not have certain capabilities such as sensing anesthesia gas administration. The SimMan costs approximately $27,000.[7]

The variety of simulators described above are used to train learners at all levels of experience, from pre clinical medical students to faculty, as well as non physician healthcare providers including paramedics and nurses. With the new generation of portable mannequins, simulation is moving outside standard simulation centers. These mannequins have been used to test the functionality of a new emergency department[8] and to orient rapid response teams to a new hospital. [9]

In Israel standardized patients are used as part of the medical school admission process to test applicants' abilities to interact with patients.[10] A novel use of simulation is to improve teaching skills. Krautscheid et al. used simulation to observe how nurse educators gave feedback to their trainees. The simulation gave these educators the opportunity to practice teaching in a mentored environment.[11]

An innovative use of simulation is as a teaching tool for preclinical medical students in a small group setting. Similar to traditional clinical simulations, with the objectives focused on the first and second year curriculum, the scenarios focus on illustrating physiology, pathology or pharmacology rather than clinical critical actions.[12]

Some educators use simulation in the preclinical setting of the large class lecture hall. Dr. Fitch reported using a simulator to each first and second year medical students about basic neuroscience. The classes were taught to students in groups of 50 using physician actors as care providers. He reports that the sessions were interactive for students, as they were able to direct the actions of the actors. He also reports that the students enjoyed the sessions.[13] Gordon et al. reports using simulation to teach first year students about myocardial infarctions.[14] While further work is needed to determine how such sessions compare to traditional lectures, these innovative uses of preclinical simulation offer exciting possibilities.

Typically, undergraduate clinical simulations have focused on third and fourth year medical students during their clinical rotations. These scenarios present students with a patient that need to interview, examine, diagnosis and treat. Other interactions that may be included are discussion with consultants, family members and EMS personnel. Practice interpreting data such as electrocardiograms and X-rays are often incorporated. The main focus of clinical teaching is often to replicate scenarios that the students will encounter in the hospital and teach the proper steps in diagnosis and treatment. To ensure that the proper teaching points are covered, there is typically a debriefing session afterward where mistakes can be corrected and the key steps in diagnosis and management reviewed. [15,16,17,18,19]

While simulation cannot replace contact with real patients, there are some possible advantages of simulation. These include protecting patients from harm at the hands of novice learners and reducing the use of learning procedures on living animals.[5] Another potential advantage is that patients may be more comfortable with students performing procedures if they know the students have mastered the skill on a simulator. [20]

One of the biggest advantages of simulation is that it allows for the practice of rare events that some students may not experience during their clinical rotations. Emergencies such as cardiac arrest, poisonings, and pulmonary embolism are serious scenarios that medical school graduates will need to manage, but may not be seen during a relatively short rotation in the emergency department or on internal medicine. Simulating these scenarios ensures that all trainees obtain a standard baseline experience. Wayne et al. writes that since real life ACLS situations are rare "a reliance on clinical exposure alone may be insufficient to adequately train and assess resident performance in these procedures."[21] This logic applies to medical students as well. Even if students are exposed to these rare cases, that may not be enough to ensure mastery.

Simulation requires a certain amount of suspension of disbelief. Students must buy into the simulation and treat it as a real situation. Student satisfaction with simulation is important. If students do not like simulation there is the risk that they may be less engaged during the educational session. Furthermore, unpopular educational modalities could potentially hurt a medical school's reputation and impair recruitment of top students. Finally, it would be unethical to force students to endure an unpleasant experience if there was another learning modality that was equally efficacious.

Numerous studies have found that both faculty and students enjoy simulation sessions. [22,23,14] Ali et al. performed a study in which final year Canadian medical students were randomized into three groups. One group received trauma training using a mannequin, a second a standardized patient, and the third group had no simulation component. The students preferred using the mannequin to the standardized patient because they felt that the simulator was more dynamic, more interesting, and more realistic. [24] Despite this preference, there was no differences in knowledge gain on a multiple choice test between the mannequin and standardized patient groups. The study was fairly small, with only 70 students divided into groups of 22, 24, and 24. Therefore it is possible that it was underpowered to detect a meaningful difference in learning between these two groups. Both the mannequin and SP groups did score higher (84.8% +/- 3.6 and 86.3% +/-3.2) than a third group that had no simulation component but received a lecture about trauma (77.5% +/- 3.8) with a $p<.05$.[24] The majority of research on medical education has examined student satisfaction.[25] While student satisfaction is important, it cannot be used as a proxy for improved clinical competence or patient outcomes.

A related issue to enjoyment is developing confidence. One would expect that as a learner practices a skill they would be more confident in their abilities. Some studies suggest that simulation can improve confidence. Marshall et al. studied surgical residents undergoing simulator based trauma training and found that self reported confidence in the residents, ability to manage trauma increased after the course.[26] It should be noted that subjects are notoriously bad at judging their own abilities, so an increase in confidence may not be associated with an actual increase in skill. Eva et al. examined medical students' abilities to predict future written test performance and found that students were not able to accurately predict how they would perform despite knowing both their previous scores and their standing in relation to their peers. [27] This discrepancy between perceived skill and confidence is concerning in medicine because an overconfident doctor may attempt to manage situations beyond his/her skill level rather than calling for help.

On the other hand, a potential concern with medical student simulation, is that students may feel discouraged in their abilities when a simulation goes poorly. They may have lower confidence than their true skill level warrants. Simulated death may lower students' confidence in their ability to manage critically ill patients if they perceive that death occurs as the result of their own incompetence. At the same time, a balance must be maintained with preserving the realism of simulation by ensuring that the patient's response to treatment is predicable. In order to decide if the benefits of simulated death justify these risks, one must first understand the impact of such a death may have on the learning process.

Chapter 2 Learning and Simulation

Determining the impact of simulated death on learning is a focused question regarding how elements of simulation impact learners. The larger question is if simulation itself is an effective learning tool. Kirkpatrick's hierarchy of levels of evaluation, as cited by Linda Hutchinson, describes how educational interventions are tested. The lowest level is evaluating student reaction; do they like simulation? The next level is evaluating knowledge gains. The third level is evaluating how knowledge gain transfers to actual clinical practice. The final level is how the intervention impacts on society, such as demonstrating better health outcomes. [28]

As one goes up the hierarchy, educational research becomes more difficult and expensive to conduct. Therefore the majority of the simulation research has focused on the first level of analysis with some studies focused on the second level. With regard to knowledge gains, most of the research has examined increases in learning over relatively short time periods. Student satisfaction or transiently improved test scores do not convincingly reflect improved learning; the most important outcome measure should be whether simulation leads to learning that reduces morbidity and mortality in real patients.

What current data demonstrates that simulation improves learning? Cherry et al. examined the ATLS (advanced trauma life support) course and found that residents who had simulation as part of the course scored similarly to those who did not. The authors used both written multiple choice tests as well as OSCEs (objective structure clinical examination) to assess learning. The lack of difference may have been due to the small sample size of 44 learners. Also, it appears that the testing occurred immediately after completing the instructional portion of the course. Since there was so little time from learning to recall it would be harder to detect long term differences in learning between the two modalities. The authors did find that students "preferred the simulator as a teaching tool and found it most useful in learning how to integrate data from hemodynamic monitors into clinical decision making." [29]

Schwartz et al. randomized fourth year medical students to either case based learning or a simulator. At the end of the emergency medicine clerkship students were tested on their abilities to manage a chest pain scenario using an OSCE. No difference in the performance of the two groups was found.[30] The authors note that the OSCE exam focused on whether the students obtained the history and performed the appropriate interventions. They suggest that "the interactive learning environment of HPS [Human patient simulation] is particularly effective when training cognitive strategies and situational awareness and may be less geared toward simple factual knowledge."[30] Therefore they may have been testing knowledge rather than advanced decision making. Also, since the study population was fourth year students, they may have already been exposed to chest pain management and therefore it would be more difficult to a difference between the interventions since each group would start the course with a fairly high baseline ability. Of note there was no testing of student knowledge before the clerkship began so student improvement as a result of the interventions is unknown. It is possible that teaching the same material may have had a different outcome between the interventions if third year students rather than fourth years had been the subjects.

Okuda et al. recently published a review of the literature on medical simulation. They determined that the evidence supports simulation as useful in a variety of educational situations, including that of training medical students and residents. They also suggest that simulation may be useful in other areas such as testing of impaired physicians and for continuing education requirements. [31]

The above studies suggest that simulation is comparable to other interventions but thus far there is little evidence that it is markedly superior in terms of knowledge gains to other educations methods. Due to the high cost of simulators and simulation centers, many authors argue that convincing proof is needed that simulation improves outcomes and learning over other modalities. However, since general education literature supports the idea that practice is important to learning, the advantages of simulation education is that it provides this practice. Is it necessary to prove simulation superior to lecture or small group sessions in order for it to be utilized? It is quite possible that given the role of deliberate practice in mastering a skill, it is logical to use simulation for that practice despite the lack of evidence that it is superior to other forms of teaching.

Furthermore, if simulation is deemed acceptable in general for teaching it may not be necessary to “prove” the effectiveness of simulation for each type of learner. In other words, if simulation can be shown to be comparable or better to other methods such as lecture, research does not need to prove it for separate groups such as medical students, nurses, and paramedics. This should not alleviate the need to determine how simulation should best be employed for each group, as they have different learning objectives and baseline levels of knowledge. Clearly a team of final year emergency medicine residents would be expected to differ significantly from first year medical students in the complexity of the scenarios they can manage, the amount of guidance needed, and interventions that they should be expected to employ.

What remains to be determined is how to integrate simulation into the curriculum. It is likely that the ideal curriculum includes a variety of modalities including lecture, problem based learning, simulation with mannequins, task trainers, and standardized patients.

How Should Learning Be Measured?

The goal of medical school is to teach students how to be doctors. The logical question therefore is how to determine if the students have learned the core elements of being a physician. Potential evaluation instruments include written tests, oral exams, evaluations by clinical faculty and simulation. Simulation modalities include computer based, actor based OSCE, and computer controlled high fidelity mannequins. Different modalities may be better at assessing different types of learning. For instance, a partial task training simulator might best assess procedural skills such as intubation, while written tests may be a preferable method to determine a student's recall of information. However, performing well on one type of test may not indicate full mastery of the material. Rogers et al. compared student's improvement on OSCE, written tests and simulation and found that "although students score well on traditional written examinations, the results of these examination fail to predict the student's ability to apply this knowledge to clinical problem solving." [32]

Simulation is often validated using non-simulation based methods such as improvement on a written test. Methodologically this seems advantageous because previous experience with simulation would enhance students' comfort and familiarity with the simulator and therefore augment performance as compared to students with no simulation experience. Validating the effectiveness of prior simulation using additional simulation session requires more faculty supervision and therefore becomes more expensive in terms of required resources. While written exams may be easier to administer, the efficacy of simulation in medical education needs to be evaluated by more complex measures that include not only knowledge but also clinical judgment, leadership skills and communication. An ideal evaluation instrument should be able to demonstrate that simulation improves how students are able to treat patients in the real world. [33]

This is a difficult proposition for a number of reasons. Since students have little autonomy, patient outcomes are unlikely due to medical student interventions. At the attending level, one could examine outcomes such as infection rates, mortality rates, or litigation in an attempt to determine if a simulation program improved clinical outcomes. Such measures do not apply to medical students. Furthermore, since students rotate through a variety of specialties, knowledge gained in a simulation may not apply to the next rotation; a very short time period exists to expose the student to the simulation and then test their learning on a clinical rotation. The most significant measure of the value of simulation is on students' long term learning, on the order of months to years. Unfortunately, most of the simulation research is conducted during a specific rotation so the time frame is closer to hours to days. Long term research on medical students is difficult since once students graduate they enter a variety of different fields creating a large number of confounding variables. It also becomes difficult to obtain follow-up data on students once they leave medical school and often move away from the institution.

It remains likely that validation of simulation for medical students will continue to use short term learning measures. Evidence that simulation improves clinical outcomes may need to be obtained from higher levels of training such as residents and attendings.

Chapter 3 Stress and Learning

A major concern in allowing simulated patients to die is that it may be too stressful for medical students.[34] Educators worry about stress for several reasons. First, it may not be ethical to create extreme stress in students. Second, a stressful simulation may represent an unpleasant learning environment, and thereby reduce student support for simulation. Third, the stress of the simulation may detract from the learning experience. This stress may be so distracting that it will inhibit learning the information that is presented during the simulation and in the subsequent debriefing. Balancing these concerns is the belief that too little stress leads to underperformance of students.[35] The benefit of stress may be that an appropriate level of stress serves to focus attention on the scenario at hand and helps motivate learning, though this has not been shown in simulation.

Stress is the state of psychological distress. A stressor is the stimulus which causes this distress.[36] Stress can be measured in multiple ways. In humans self report is a common way of measuring stress.[36] Other methods utilize biological markers such as heart rate, blood pressure, or circulating levels of peptide hormones. [37,38,39,40,41] The reaction to a stressor depends "upon the physical (intensity, frequency, duration) and psychological (predictability and controllability) nature of stressors and individual differences." These variables control the levels of hormonal activation, the behavior exhibited, and the degree of impact on cognitive function.[42] One of the important aspects of cognitive function affected by stress is the ability to learn new information.

Stress interacts with learning in a complex fashion. Stressful events are often well remembered and that "people who experience a very stressful event often show unreliable memory for details."[43] Gülpmar and Yegen write that "any physical or psychological stressor that threatens the homeostasis of an organism can initiate a set of behavioral and neuro-endocrinological responses, which help the organism to adapt to the altered situation."[42] This neuro-endocrinological response can make a major impact on learning and memory retrieval.

This impact on learning follows the Yerkes-Dodson law, which defines the relationship "between cognitive efficiency and stress."[44] Cognitive performance follows an inverted U shaped curve, with performance increasing with increasing stress to a point, after which further increases in stress lead to a decline in performance.[43,44] It is hypothesized that this curve exists because at moderate levels of arousal, attention is focused on the learning task. At higher levels of stress the stressor itself or its resultant arousal may distract the learner from the learning task.[44] This effect can be replicated based on the measuring or altering of circulating levels of stress hormones such as catecholamines and glucocorticoids. At low levels these hormones can facilitate learning, while at high levels they are inhibitory[42] thereby demonstrating that specific hormones interact with receptors in the brain to modulate the effects of stress on learning.

Stress can either facilitate or harm learning depending on a number of factors. George Mandler writes "both a potentially threatened individual and a properly interpretable situation are needed to produce the stress reaction."[44] Since simulation creates an emotional stress, the impact of stress during a simulated patient death depends on the combination of the psychological makeup of the learner and the details of the situation. The current view in the simulation community appears to be that residents and attendings are psychologically prepared to handle the stress of simulated patient death while medical students are not. This can be seen from studies in which the simulator dies for residents [55,56,85] and where such death is avoided for medical students.[48,58] It must be shown through experimentation if simulated patient death creates significant stress for medical students, and if such stress impairs the learning objectives for those simulations. The Yerkes-Dodson law shows that stress can either help or hinder learning. The question is where medical students fall on that curve during a supportive and safe simulated death experience.

Even if the patient does not die, the simulation experience can be stressful. This stress may be desirable at low levels because it is a sign that students are taking the situation seriously and are emotionally engaged in the care of the patient. Dr. Gordon at Harvard states, as quoted by MJ Friedrich, that "‘we do want the students to experience the care situation emotionally,’ because once students become emotionally engaged in a care process, they begin to integrate and understand information at a deeper cognitive level. ‘This emotional involvement allows students to create a framework on which they can hang important intellectual concepts.’"[45] If an emotional response is a goal of simulation then it is important to determine if learners are having this response.

Deladisma et al. examined second year students and rated their displayed emotion when working with actors vs projected computer generated patients. They found that even with the projected patient students displayed anxiety and empathy.[46] A student at a simulation center reported “my heart pounded and my hands were sweating-just like I was taking care of real patients.”[47] Several authors note that students report feeling stress during their scenario. Dr. Weller reports that “they felt ‘thrown in at the deep end’, and felt under pressure.” Interestingly the students who reported feeling stress were reported to have felt that it was still "a positive learning experience, describing the value of 'hands on experience under pressure."[48] Formal research has yet to determine which factors make a simulation stressful for students. Logically, elements such as unfamiliarity with simulation, discomfort at being observed by an attending, and lack of confidence in one's knowledge or skills would be expected to increase stress.

Regarding high fidelity mannequin simulators, there are a number of anecdotal reports of students becoming upset or anxious during simulation, but emotional response during high fidelity simulation has not been rigorously studied. Curran et al. reported when third year Canadian medical students were videotaped during neonatal resuscitation simulation 56% agreed or strongly agreed that they felt anxious because they were being videotaped, while 62.5% felt anxious because they were being observed.[49]

It is possible that simulation courses with repeated student exposure to scenarios would decrease many of these stressors by increased comfort and familiarity but this has not yet been shown in the simulation literature.

Van Dulmen et al. performed a very interesting study with second year medical students in the Netherlands. Students rated their stress using a State-Trait Anxiety Inventory and Visual analogue scale before and after a simulation in which they had to deliver bad news. Their vital signs and salivary cortisol levels were measured before and after, and their performance was rated during the simulation. The authors found that the students' pre-simulation stress was not related to performance, and that students who did well had lower levels of stress after the simulation. They suggest that students may not have been stressed enough to markedly impact their performance.[93] The study suggests a useful model for future medical student education research in which stress is measured by a variety of modalities. It would be interesting to repeat their measures with simulated patient death to determine if there is a measurable impact on performance.

Dr. Ikuta in Japan measured the forehead sweating of medical students during simulated intubation. Students who failed their first intubation had higher levels of forehead sweating.[50] There may be other explanations for these findings such as physical exertion during the intubation attempt. However, forehead sweating may be added to skin conductance, heart rate, blood pressure, and cortisol levels as potential markers of internal stress. While more research is needed to validate these markers as measures of medical student stress, recent simulation research has moved beyond self report to more objective measures of stress.

In a study in Italy, doctors and nurses participating in an advanced life support class had their blood pressure and heart rate measured before, during and after a simulation in which the patient was in cardiac arrest. The patient deteriorated from a shockable rhythm to asystole or pulseless electrical activity (PEA) after several defibrillation attempts. There was a “significant increase of both blood pressure and heart rate during all phases of the simulated ALS scenarios.”[51] Their score on a multiple choice test of ALS knowledge was not correlated with “the hemodynamic changes observed during the testing scenario.”[51] The authors concluded that these changes in blood pressure were indicative of mental stress experienced by the subjects. It is unclear if this conclusion is valid since participants were not asked about their perceived level of stress. Furthermore, more direct measures of stress such as salivary cortisol may have been better indicators of physiological stress. It should be noted that the subjects were not medical students but doctors and nurses who would be expected to already have a higher level of knowledge regarding proper cardiac arrest management. Finally, these scenarios occurred during the testing phase of the class, so the stress experienced may have been due to the scenario being in the context of an exam rather than due to the stress of managing a patient in cardiac arrest. Nevertheless, this is one of the few studies attempting to examine the interaction between stress and knowledge during cardiac arrest simulations.

What are the causes of stress during simulation?

The goal of a simulation scenario should be to optimize stress such that the students are engaged but not distracted from the learning objective. Therefore it is important to identify causes of student stress and anxiety during simulation and attempt to quantify it. Unfortunately there is little published research on the amount of stress that students experience during simulation and its effect on learning. Elfrink et al. focused group discussions with student nurses who participated in a mannequin based simulation and found that "while all students were feeling highly anxious, a pre-dominant theme was the notion that the primary nurse 'was on the spot,' while others in the group were given a 'free pass."'[52] This study did not measure the amount of anxiety or stress or determine its etiology but did suggest that the amount of perceived stress may vary based on the student's role in the simulation.

Girzadas et al. at Advocate Christ Medical Center performed a study in which heart rate and perceived stress was measured during two difficult airway simulations. They report that stress and perceived learning did not vary significantly by role in the simulation. Heart rate was measured using a pulse oximeter before the scenario and during the critical airway intervention. They had the roles of a team leader, a procedure chief who was responsible for the airway procedures, and team members. The study was limited by only having 38 participants, only 5 of whom were medical students. Some subjects were tested in both scenarios, some in just one.[53] This possibly diminished the reported stress as they became more comfortable with simulation or difficult airway management. A larger study should be done before concluding that role does not effect perceived stress. The sample should also be limited to either one group of subjects, such as just medical students, or be large enough that meaningful comparisons can be made between different groups. It is likely that a medical student would find being a team leader more stressful than a resident, but that would have to be better tested. Finally, it is unclear how these roles during a difficult airway class compare to standard simulation training, where the focus is often more on proper diagnosis and communication rather than on procedures.

Another cause of stress during simulation may be due to who is observing the scenario. It is likely that a student would find being observed and critiqued by an attending to be more stressful than being observed by a resident. The level of stress may also be impacted by whether the student is planning a medical career in the same specialty as those who are evaluating the scenario; it may be more stressful for students to perform in front of those who may be evaluating them for residency. Conversely they may feel more comfortable with scenarios involving their chosen field and therefore experience less stress.

There are likely interactions between group size and stress; if the group is too small, the students may be overextended or too many students may make the scenario too chaotic. The presence of other students observing the scenario may be stressful for some students. They may fear the embarrassment of poor performance in front of their peers. These causes of stress may be elucidated through further investigation.

Chapter 4 Medical Students and Death

One major question in the field of simulation is the appropriateness of allowing the simulator to die. [54,55] Simulated patient death is often used in resident and faculty training when specified critical actions are not met.[55,56] Other times simulated death is the predetermined outcome regardless of treatment.[57]

While Gaba et al. at Stanford prevent simulated death in their basic simulation courses, they allow simulated death to occur for more advanced learners. They prevent simulated death regardless of learner actions so that “the emotional overlay of a patient’s death does not interfere with the main focus of ACRM (Anesthesia Crisis Resource Management) teaching.”[58] Researchers in Denmark also prevent simulated death in a set of cardiac arrest scenarios during an ambulance transport in which junior physicians manage the patient. They write “to ensure a supportive learning environment, we therefore chose to make a scenario in which the patient would always recover. Thus we avoided making the simulation a defeat for the physician by losing the patient and thereby counteracted negative effects of the participation.”[59]

Dr. Jennifer Weller, a simulation educator in New Zealand, writes that “simulator ‘death’ can be particularly stressful and should be avoided, but it would be misleading if inappropriate actions resulted in a good simulator outcome.”[22] Faith Stafford reports that “there is anecdotal evidence of trainees becoming upset when the simulator dies.”[60] The only research study regarding the appropriateness of simulated patient death is an unpublished post simulation course questionnaire that found that physicians, nurses, and paramedics generally supported simulated death.[61]

Are medical students are able to emotionally cope with simulated death as an outcome? Does patient death inhibit learning during the course of the simulation scenario?[60,48,54,58] The concern is that if, for example, students are treating a simulated patient suffering from a stroke who then dies, they may be so distracted that they will not be able focus on learning the proper treatment of stroke. Due to these concerns many simulation programs avoid simulated patient death for medical students.[48,58] A counter argument is that students may better remember how to treat a disease if the seriousness of the patient's condition is driven home by simulated death. As of yet there are no published studies examining medical student's reactions to simulated death or its effect on their learning.

Ziv et al. writes that "in the a simulated environment, errors can be allowed to progress in order to teach the trainee the implication of the error, or to enable him/her to react to the errors and attempt to rectify them."[5] Noeller et al. writes that "simulation allows residents to make decisions and observe the consequences of their action or inaction."[62] This raises the important question of how far errors should be allowed to proceed, and how severe the consequences of those errors should be.

There are two major concerns with allowing students to make critical errors. One of the main concern is prolonging the simulation; core educational material may not be covered if much of the simulation is spent with the students going down the wrong path and dealing with their error. If the goal of the simulation is to learn the proper treatment of a heart attack, when students decide that the patient's pain is due to pneumonia they may never do crucial actions such as ordering an EKG and core learning points will not be covered.

Another concern is that learners may encode the mistake as proper treatment, particularly novice learners who may be unsure of the proper pathway for treating a given condition. For example, if a student decides to administer the wrong medication, months later he/she may only remember the association between the patient's diagnosis and the name of the medication he/she gave but not the proper medication. There is this tension between allowing students the freedom to make their own decisions and the need to ensure that they will learn proper diagnoses and treatments. Therefore even if simulated death is appropriate in some situations, allowing student error to progress to patient death may be counterproductive by prolonging the simulation, missing key objectives and allowing the opportunity to encode errors.

Simulation programs that prevent simulated death have three options to ensure that the patient does not die. The first is to simply not allow the simulator to die regardless of learners' actions.[12] This option has the potential to reduce the fidelity of simulation since some procedures or drug dosages would not be compatible with sustaining life. A second option is to prevent the learners from performing critical actions at high risk of harming the patient. Many authors use a "facilitator " who is in the simulation milieu with the learners to assist them. These facilitators may assist with diagnosis by giving physical exam findings or relaying information, such as from family members or paramedics. Associate Professor at the University of Auckland Dr. Jennifer Weller writes that "simulated death was avoided by prompts from the 'nurse, who wore a headset and could follow directions from the instructor."[22] A third option is to allow the simulator to enter cardiac arrest, but always have the patient regain pulses. This third option forces the teacher to decide if the learners should be coached to ensure proper management of the cardiac arrest, or if the pulses should return regardless of clinical management.

The optimal strategy for facilitation during the scenario remains an open question. For example, if the students request to administer morphine at ten times the standard dose, what should the facilitator do? One option would be to simply inform the student that that dose is incorrect. Another option would be to guide the student by forcing reflection, asking questions such as "are you sure that is the right dose?" An additional problem occurs when student insists on following his/her order in spite of being asked to confirm. The facilitator may keep asking the student to re-examine his/her choice but eventually teachers are once again forced to either let the simulator respond like an actual patient would or to refuse to follow the order.

Larew et al. uses an interesting system in which students are presented with escalating prompts of increasing intensity until they recognize the information. While Larew et al. do not directly address using prompts to prevent simulated death, escalating guidance of students may be a potential strategy to prevent students from making life threatening mistakes during simulation. An example is trying to help a nursing student to recognize that the simulated patient has abdominal pain. The simulator starts with a vague prompt of being "a little sore." If the student does not follow up with more questions the patient gets more specific saying "my belly hurts." The simulator keeps providing the student with prompts at specified intervals until they are recognized and acted upon.[63] Similarly, escalating prompts could be use to help prevent dangerous actions that would otherwise lead to simulated patient death.

Additional research needs to be performed to determine if escalating prompts is the ideal strategy. In real life, patients often provide information that will not be repeated unless follow up questions are asked. It is possible that some missed communication should be reflected upon during debriefing rather than repeated multiple times during the simulation. The risk is that if certain basic information is ignored, such as that a patient with a myocardial infarction has chest pain, many key learning objectives may be missed. If the student misses that the patient has chest pain, they may not request an ECG or order troponins and therefore miss the opportunity to practice such interventions.

One possible solution may be to ensure that simulations have overlapping objectives, so that if a simulation gets off track due to missed information, those learning objective can still be addressed in other simulations as well as through the debriefing session. Since curricular time for simulation is often limited, each simulation session may have distinct educational objectives and therefore not have the flexibility to include learning objectives from other simulation scenarios.

Most of the literature regarding training medical students for patient death can be divided into two categories. The first is delivering bad news. These sessions are designed to teach the learner how to give bad news such as telling a family that a patient has died or giving a patient an upsetting diagnosis. [64,58] The other common topic is teaching about palliative care and end of life issues. These articles often explore such issues as “do not resuscitate” orders (DNRs), pain control, and exploring how the patient feels about his/her terminal illness. [64,65,66,67,68,69]

In the actual hospital setting, there is a third scenario in which a patient who is not terminally ill unexpectedly suffers a cardiac arrest and dies. There is little research on how providers in general, and medical students in particular, cope with this situation. Gettman et al. performed a study where urology residents are called to the room of a postoperative patient who is deteriorating. While assessing the patient, the high fidelity simulator enters cardiac arrest. The resident manages the cardiac arrest, then informs the family members of the situation and eventually has to inform them that the patient has died. The residents felt that the scenario increased their abilities to break bad news.[70] A related training program, reported by Scmidt et al., teaches emergency medicine residents to give the news of a sudden death to family members.[71]

These studies are the only two to examine unexpected patient death. They both focused on notification of the family and were conducted with residents. No research regarding the training of medical students for sudden, unexpected patient death is described in the literature. The best methods to prepare medical students for unexpected patient death remains an open question. If other patient death scenarios such as hospice care are to be simulated, it may be useful to simulate unexpected death as well. Further studies of unexpected death with both residents and students will help determine optimal implementation of such scenarios.

There is scattered literature on medical student exposure to patient death and their subsequent reactions. An early study from 1982 found that students had little change in their own anxieties and fears about dying during their surgical rotation.[72] A study of pre-clinical students found that while 99% "stated they had parents, close relatives, or friends whom had died, though only 32% were actually part of the dying process." The study also found that 32% of students had witnessed the death of a person, with the study suggesting that many of these students had worked in the emergency department or as emergency medical technicians (EMTs).[73]

Interestingly, in this study, 68% of the pre-clinical students had never witnessed the death of a real patient. This suggests that many students will see their first real death while on clinical rotations. It also suggests that simulated death prior to third year may be beneficial in that it may help students prepare for exposure to their first actual death. Finally, it raises the point that educators must be careful when utilizing simulated death with preclinical students because a number of them may have never seen a real death and will not have previous experience to fall back on when processing their feelings of guilt or loss.

A relatively large number of students experience the death of a real patient on their clinical rotations. In a study by Ratanawongsa et al. in which 32 third-year medical students were invited to be interviewed regarding their experience with dying patients, all 28 students who agreed to participate had "encountered death or dying patients." [74] Students discussed many aspects of dealing with patient death, including coping strategies such as exercise, "writing, music, therapy, and prayer." The study also found that the behaviors exhibited by their residents and attendings served as models for the students in their reaction to the patient's death.[74] This interview format may be a good first step for exploring medical student experience with sudden patient death. This study also suggests that good role modeling behavior and adaptive coping mechanisms are important facets of how medical students deal with patient death. Further research needs to explore if students require similar support for coping with simulated death, or if debriefing at the end of the simulation is sufficient.

The students described in the above study had just completed their first clinical rotation, an internal medicine clerkship. It would be interesting to know how their experience compared with students on other rotations. One would expect that students on rotations such as oncology or emergency medicine would encounter more patient deaths, but no data are available on when during their clinical rotations, medical students tend to encounter either terminally ill patients or sudden patient death.

Literature on medical student exposure to death rarely distinguishes between expected and unexpected death. Students are probably affected differently when a patient with terminal brain cancer dies as compared to when a patient dies suddenly during an operation. If a death is unexpected, one would assume that an attempt would be made to resuscitate the patient. Therefore one way to view medical student exposure to unexpected death is to examine their experiences with cardiac arrest resuscitations.

Cardiac arrest likely reflects a sentinel event during medical student education. Watching or participating in a resuscitation may be exciting; it may be sad. It may also be important for medical student preparation for the day during residency when he/she may have to lead the resuscitation. In their study of 102 fourth year medical students, Schwartz et al., at Wayne State University in Detroit, found that 94% had witnessed a medical resuscitation and 54% had participated in one.[30] Milzman et al. at Georgetown reported a survey of third and fourth year medical students in which 49% had participated in a cardiac arrest. Thirty six percent of the students reported being prevented from being in the room during a cardiac arrest. Students reported a mean of 3.7 cardiac arrest per year (95% CI 1.9-5.1).[75] It is unclear during which rotations the students were exposed to cardiac arrests and how the number varied between third year students and fourth year students.

These numbers do not easily generalize nationally as they likely vary by the specialty sponsoring the rotation, the individuals involved, and the institution. Medical schools that do not have emergency medicine and anesthesia as required rotations may have less cardiac arrest exposure. Personal factors may also be involved in that students who are motivated to observe resuscitations may become involved than those who try to avoid such situations.

One of the major benefits of simulation that has been cited is "safety." [76] Dr. Gordon at Mass General Hospital argues that an advantage of simulation is that it allows "students to 'practice without risk.'"[15] This usually refers to the safety of patients because mistakes will not impact real patients. But numerous authors have also been impressed by the fact that simulation can create an environment that is "safe" for learners. Ziv et al. write that "because mistakes made during simulated exercises do not cause harm to living patients, they can be reviewed openly without concern of liability, blame, or guilt."[5] An important question is how learners in simulation feel about their mistakes. If there is true suspension of disbelief during simulation, the learners should be treating the simulator as a real patient. One would expect that this may include feelings of guilt after a serious mistake. Furthermore, students may feel embarrassed about making mistakes in front of other students or faculty members, even if there is no academic consequence.

How students feel about their mistakes may be crucial to the effect of simulated death on learning. If they view simulated death as indicating a "mistake," and if they feel guilt or shame about such an event, it may influence how they learn. This may be true even if the simulated death would have happened regardless of that specific mistake.

Some authors minimize the potential impact of simulated death. Sinz and Taekman write that "unlike real patients, if the simulated patient dies it can be restarted easily, making the learning encounter safe for patients and students."[77] While their point is valid in that the consequences of simulated death are lower than with real patient death, it ignores the possibility that simulated death may not be "safe" for certain learners. It is quite possible the simulated death may be an emotional and stressful experience.

The idea of "restarting the simulator" brings up an interesting question of what should be done once the simulator is dead. Most educators would agree that a debriefing should occur after the simulation scenario to address emotional feedback and correct mistakes.[6, 58] This is especially true in simulation paradigms where learners' mistakes can result in patient death. But should the simulation then be run again after the debriefing? This would give the learner a chance to correct mistakes made and solidify learning through deliberate practice. Repeating the simulation may minimize the impact of patient death by showing the ease at which the simulator can be reset. A crucial aspect of simulation is the suspension of disbelief which is made possible by the fidelity of the simulator. Seeing the patient "come back to life" may reduce this suspension of disbelief and remind learners that "it is just a simulator." Further research is needed to determine the most effective teaching strategies to employ once the simulator is pronounced dead.

Most simulation experts agree that the debriefing session is a crucial element of effective simulation. It gives students a chance to reflect on what happened and determine areas where they can improve. Debriefing also allows the coordinators to give information and correct mistakes. Ideally debriefing should allow students an opportunity to discuss their emotional responses to the simulation, especially after challenging scenarios such as a cardiac arrest or patient death.

It remains unclear how students should be debriefed after patient death. Should students be informed that the simulator would have died regardless of their actions assuming that was true? This may minimize the impact of the simulation, and may make the points of the scenario less ingrained in memory. Rather than going through the process that occurs during real patient death where caregivers naturally ask themselves if anything could have been done differently, learners may not bring the same focus to those questions. Conversely, knowing that their actions did not cause the patient to die may serve to reassure students, especially those who may be upset. Reducing the emotional impact to those who are highly stressed may enhance learning by preventing interference.

When during the debriefing should the death be discussed? It is possible that students may be so preoccupied in thinking about the cardiac arrest that they do not pay attention to the review of the case leading up to the resuscitation. Gordon et al. describe that pre-clinical students tend to be so focused on the death of the patient during debriefing that other learning objectives are often not met.[12] It is possible that the cardiac arrest and patient death should be initially discussed in the debriefing, and then backtrack to review the diagnosis and management that preceded the resuscitation. Further studies of the optimal way to debrief after simulated patient death will hopefully provide additional guidance.

If educators decide to use simulated death in a course, what should students be told beforehand about the possibility of patient death? Clearly students should not be told the simulator will never die if that is not true. But should students be specifically warned at the beginning of the course that death is a possibility? Should they also be told if their mistakes can lead to patient death or that patient death may occur regardless of their actions? It is possible that students should not be told that the simulator will not die during the course even if that is true, because it may reduce the fidelity and emotional engagement with the simulation. How these variables affect student satisfaction, stress levels, and learning has yet to be studied.

One argument for allowing simulated death is that it may better prepare medical students for the outcome of actual cardiac arrests. The majority of real cardiac arrest patients do not survive. In one study of in-hospital cardiac arrests, 58% of patients who experienced ventricular fibrillation and only 35% of asystole patients had a return of circulation.[78] Another study found that only 23% of in-hospital adult cardiac arrest patients had an initial shockable rhythm (ventricular fibrillation or pulseless ventricular tachycardia) and 35% presented in asystole. Overall, only 27% of the adult cardiac arrest patients in the hospital survived to discharge.[79] This does not include patients who suffered cardiac arrest prior to hospital arrival by EMS, who have a much worse prognosis. A meta-analysis of out-of-hospital cardiac arrest patients published in 2009 found a "pooled survival rate to hospital admission [of] 23.8% (95% CI, 21.1 to 26.6) and to hospital discharge [of] 7.6% (95% CI, 6.7 to 8.4).[80]

Public opinion found that people have much higher expectations of the effectiveness of CPR than the true rate. In a study of “lay people” (non medical professionals) visiting one hospital in 1998/1999, they estimated that CPR was successful in 52% of adult patients and 63% of pediatric cases.[81] A possible reason for this misperception is that most people have not seen CPR performed in real life, but rather only on television. One study examined a season of the TV shows ER and Chicago Hope and found patients had short term survival after CPR of 65% and 64% respectively.[82] In a study of school children in Belgium it was found that students who watched a TV show about an emergency department had a small but significantly higher expectation of the success of CPR than students who did not watch this show.[83] Interestingly, it was also found that the students who had training in CPR had a higher expectation of survival from CPR.[83] The authors argue that there is an advantage to giving the public a more realistic view of the success of CPR: “lay people attempting CPR are confronted with a traumatizing experience they are not really trained to deal with on a psychological level. The realization that CPR is important but all CPR is not successful might be an important means to help lay responders deal with the outcome of their attempts at saving lives.”[83]

Since real cardiac arrest often ends in patient death, there may be unwanted learning occurring if students successfully resuscitate all simulated cardiac arrest patients. This may create unrealistic expectations of the effectiveness of CPR and ACLS, similar to how TV may be contributing to the high expectations of the public for cardiac arrest survival. If educators never allow the simulator to die they are faced with the potential problem of being forced to choose between avoiding cardiac arrest scenarios all together, or potentially setting their students up for future emotional hardship when their patients do not survive a cardiac arrest. If certain medical situations are to be realistically presented in medical school, simulated death must be a possible outcome.

Hypothesis and Specific Aims

Numerous authors present arguments pertaining to the emotional capability of medical students to deal with the outcome of simulated death. It has been postulated that patient death may have an adverse outcome on the retention of learned information presented during the simulation experience. Due to these concerns, many simulation curricula avoid simulated patient death for medical students. The objective of this study was to determine the perceived stress of medical students during simulated patient death and the interaction with assigned role. We hypothesized that the perceived stress by medical students was higher when exposed to simulated death and this stress level correlated with assigned team role. We hypothesized that the stress associated with simulated death would not negatively impact student learning of scenario-specific material. Additionally, we hypothesized that exposure to simulated death would not lead to student hesitation in participating in future simulations, nor the belief that death was an inappropriate outcome, regardless of patient management.

In order to test the above hypotheses, the specific aims were to:

1. Expose third year medical students to resuscitation simulations in which the patient lived or died and measure their perceived stress during those resuscitations,

2. Test medical student learning of material related to these simulations by administering pre- and post- written tests, and explore student opinion regarding simulated death with a post-course questionnaire.

Chapter 5 Methods

Study Design

This was a prospective, randomized cross-over study of third year medical students at a United States medical school with clinical rotations at a 944 bed tertiary care hospital. This study was granted exemption from full review by the Institutional Review Board.

Study Setting and Population

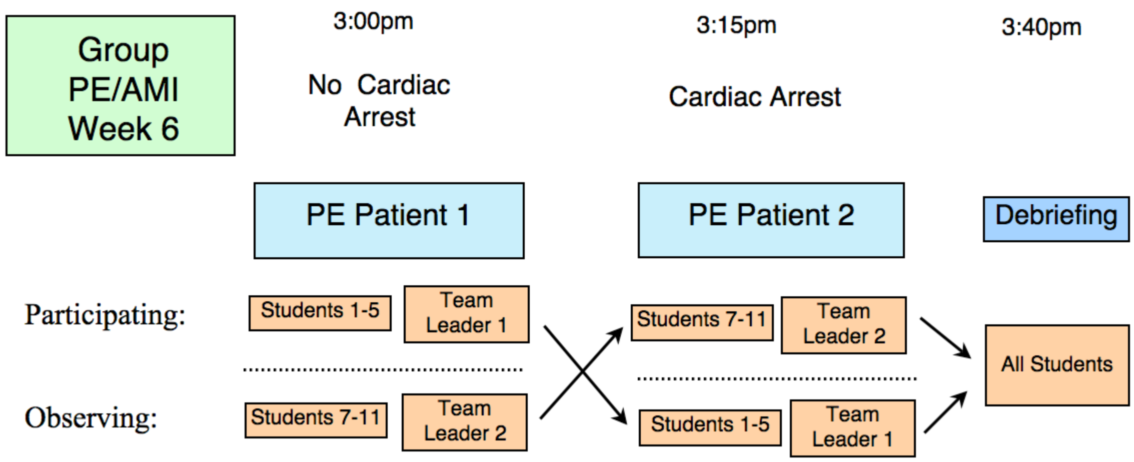
All third year medical students participating in a mandatory 12-week clinical simulation program during a surgical clerkship from September 2007 to June 2009 were eligible for the study. 176 third year medical students started the simulation program during that time. The study took place at the Emergency Department Simulation Laboratory consisting of a well equipped Emergency Department examination/resuscitation room, a control/observation room with a one-way mirror, and a conference room for debriefing. Each 12-week course included approximately 24 medical students who participated in 26 clinical acute care scenarios over the duration of the rotation. Faculty members in the Department of Emergency Medicine and Department of Surgery participated as faculty experts and faculty debriefers. During the simulations, the faculty expert functioned as the consultant. The student team leader was required to give a concise presentation to the consulting faculty expert. During the debriefing session, the faculty expert focused on the clinical management of the scenario while the faculty debriefer focused on team interactions, communication with the consultant and the discussion with the patient regarding the care plan. Exclusion criteria were failure to complete the entire 12-week rotation or absence from one of the clinical scenarios included in the study.

Study Simulation Protocol

All students received an orientation session at the beginning of the 12-week course to familiarize them with the simulation room, equipment, and the capabilities of a high fidelity mannequin (Laerdal SimMan®) used in the sessions. On the first day of the surgical clerkship, each student completed a 30 question written test. The test consisted of 10 questions on the management of each of the following conditions: pulmonary embolism (PE), acute myocardial infarction (AMI), and biliary tract disease. The test was a multiple choice questionnaire and questions were devised by Dr. Evans. The order of the test questions was randomized using an internet based random number generator. Students were provided a syllabus of the topics to be covered and were randomized into two groups: Group PE/AMI and Group AMI/PE.

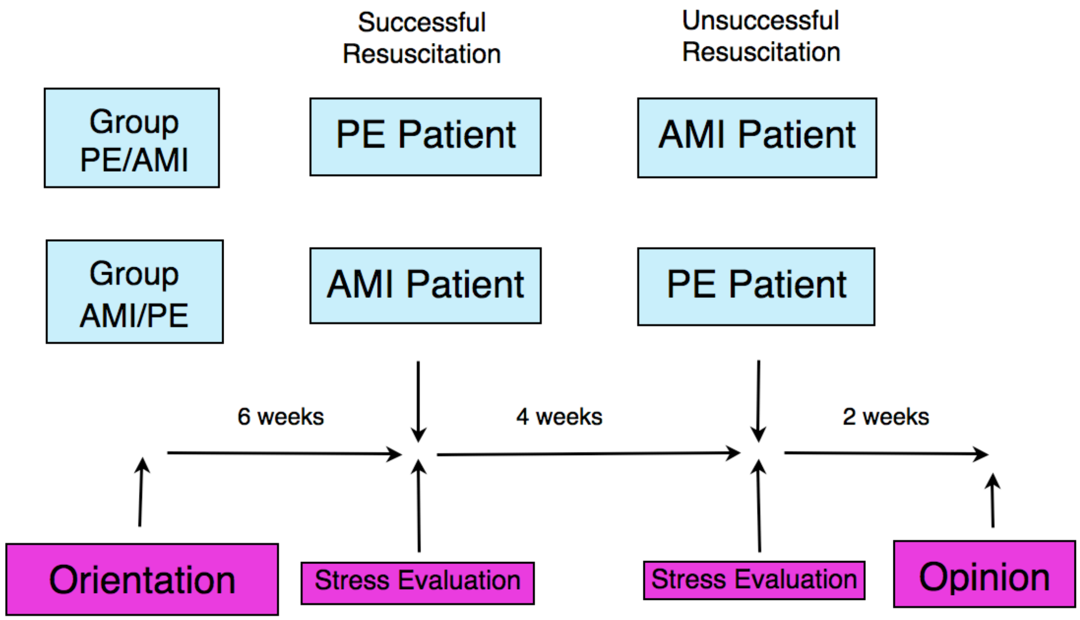
Each group managed two scenarios during a 1-hour weekly session as follows: five participants and an assigned team leader participated in the simulated scenario, while the remaining six students observed from behind a one-way mirror; the students then switched roles from participant to observer for a second scenario (Figure 1). Another faculty member, the simulation coordinator with simulation expertise operated the computer-based simulation from behind the one-way mirror and provided the patient's "voice" by communicating through a speaker in the mannequin's mouth. A senior level emergency medicine resident played the role of "nurse" in the simulation laboratory to facilitate the flow of the scenario and to prevent the students from becoming sidetracked or misinformed by imperfections in the simulated environment.

Fig. 1 Example of Simulation Session



Each group was exposed to a successful resuscitation (control) during week 6 and a simulated death (exposure) during week 10. (Figure 2) At the conclusion of the sessions, students participated in a debriefing session involving two faculty members. One faculty member functioned as the "expert" and discussed clinical management, and the other faculty member functioned as the "debriefer" and discussed team interaction and communication skills. The faculty experts focused their reviews on the clinical critical actions for the cases. Students were encouraged to reflect on their experience during both the simulation and the cardiac arrest. At the end of the debriefing, students completed a study questionnaire.

Fig. 2 Study Overview



Successful Resuscitation (Week 6):

Group PE/AMI managed two scenarios with patients having hemodynamically significant pulmonary emboli (PE), and Group AMI/PE managed two scenarios with patients suffering from acute myocardial infarctions (AMI). During the second scenario during both sessions, once students had stabilized the patient for transfer from the Emergency Department, the patient experienced a sudden cardiac arrest. The students then managed the arrest with prompts as needed from the "nurse." The PE patient (Group PE/AMI) suffered from a massive PE. When the patient was ready to be transferred to the medical intensive care unit, he stated that he did not feel well. He became unresponsive and apneic within one minute of that statement. He entered pulseless electrical activity (PEA) cardiac arrest with a heart rate of 40 on the monitor. His heart rate increased with epinephrine but he remained pulseless. The patient regained pulses after successful intubation, with a blood pressure of 80/40 and a heart rate of 80. One minute after regaining pulses, the team was told that the scenario had ended. Debriefing began immediately at the end of the successful resuscitation. For Group AMI/PE, when the patient was ready to be transferred to the cardiac catheterization lab, he stated that he did not feel well. He became apneic and unresponsive within one minute of that statement. The patient was in pulseless ventricular tachycardia with no blood pressure. After the patient was defibrillated twice, he regained pulses with a heart rate of 120 and a blood pressure of 80/40. One minute after regaining pulses the team was told that the scenario had ended.

Debriefing began immediately at the end of the successful resuscitation. The debriefings began with the faculty debriefer asking open ended questions to the team leader to determine how he/she thought the scenario ran and what aspects of the simulation could have been better. The rest of the team was encouraged to give feedback. The debriefing then focused on clinical management: the proper diagnosis and treatment of the underlying disease (AMI or PE). The debriefing of the AMI case covered such topics as proper use of ECGs and cardiac enzymes in the diagnosis of AMI, the role of aspirin and beta blockers, and the indications for activation of the cardiac cath lab. The debriefing of the PE case included discussion of the most common ECG findings of PE, indications for thrombolytics, and the utility of d-dimer. While the focus of the debriefing was on the underlying pathology and not the cardiac arrest, students were given the opportunity to ask questions about the management of the resuscitation and to reflect on their experience.

At the end of the debriefing, students completed a short questionnaire where they identified their role during the cardiac arrest scenario (team leader, participant or observer), their level of stress during the cardiac arrest and the stress felt at that moment while completing the survey. At the end of both scenarios, both groups completed a five item standardized study questionnaire in which they identified their role during the cardiac arrest (team leader, participant, observer), rated their stress during the arrest scenario on a 0-10 semantic differential scale anchored on “completely relaxed” and “completely stressed”, and rated their current stress level. This scale was based on visual analog scales that have previously been used.[93,94] There was also space for general comments about the day’s simulation.

Simulated Death:

At week 10, Group PE/AMI managed the same two AMI scenarios that Group AMI/PE resuscitated during week 6, and Group AMI/PE managed the two PE scenarios that Group PE/AMI resuscitated during week 6. Again, at the conclusion of the second scenario, the patient experienced cardiac arrest. During this scenario, after specific critical actions were performed, the patient deteriorated to asystole. After a pre-designated time period, the students were told that the simulation had concluded and resuscitation was discontinued. Students participated in a similar debriefing session with two faculty members.

At the end of both scenarios, both groups again completed the same five item standardized study questionnaire, rated their stress during the arrest scenario on a 0-10 semantic differential scale anchored on “completely relaxed” and “completely stressed”, and rated their current stress level.

On the final day of the course at week 12, students reported their opinions about specific statements presented about simulated death by rating their agreement on a five point Likert type scale. These questions were based on questions developed by Phrampus and colleagues. [61]

Several steps were taken to minimize stress due to extraneous factors, including access to information. These steps included: (1) a standardized orientation session, (2) a standard syllabus for the course and topics related to the simulated scenarios, (3) randomized Group assignment and team leader designation, (4) a cross-over study design to control for extraneous factors that may influence learning, (5) carefully constructed clinical scenarios of comparable complexity, and (6) same faculty experts and debriefers for both groups.

Outcome Measures

The primary outcome of the study was to compare stress levels in medical students exposed to simulated death versus successful resuscitation. The secondary outcome was an assessment of medical student attitudes towards inclusion of simulated death in future educational programs.

Authorship

I was the main designer of the research methodology, in consultation with Dr. Evans. I also designed and created the stress tests, the opinion measurement instrument, I created the Access database and performed all data entry. Data collection was supervised by myself, Dr. Evans or another faculty member. The data were entered into a Microsoft Office Access (2003) database created by the author. SPSS analysis was done on the data by our statistician Brian Biroscak. Data analysis was conducted by our statistician Brian Biroscak, testing hypothesis generated by myself and Dr. Evans. Mr. Biroscak also helped with the description of data analysis below. Many of the tables in the results section were originally made by Mr. Biroscak and modified by the author.

Data Analysis

Student responses were de-identified using a study identification number. Data were entered into a Microsoft Off ice Access database. Paired sample t-tests were used for comparison of mean stress levels between successful resuscitation and patient death. One-way analysis of variance (ANOVA) was used for comparison of mean reported stress level across the three simulation roles. Pearson product-moment correlation coefficients (*r*) were estimated for each opinion question against reported stress during the death scenario. All tests of statistical significance were two-tailed (alpha = 0.05). Statistical analyses were performed using SPSS version 16 (SPSS Inc., Chicago, Illinois).

Chapter 6 Results

176 medical students participated in the simulation course from September 2007 to June 2008, with 13 students excluded for absences, leaving 163 subjects for analysis.

Table 1. Characteristics of medical student participants

	Group PE/AMI (n=79)	Group AMI/PE (n=84)	*P value*
Age in years, mean (SD)	26 (2.8)	27 (3.7)	.34
	Count (%)	**Count (%)**	
Female sex	43 (54)	37 (49)	.47
Completed IM clerkship	46 (58)	52 (62)	.63
Joint degree program	15 (19)	17 (20)	.84
Time off prior to third year	16 (20)	17 (20)	.99
Months off, mean (SD)	5.3 (13)	7.2(18)	.09
Prior EMS training	12 (15)	3 (3.6)	.01
Witnessed resuscitation of a real patient prior to simulation course	22 (28)	19 (23)	.44
Witnessed resuscitation of a real patient during simulation course	51 (65)	49 (58)	.45
Participated in resuscitation of a real patient prior to simulation course	10 (13)	4 (4.8)	.07
Participated in resuscitation of a real patient during simulation course	32 (41)	20 (24)	.02

Witnessed death of a real patient prior to simulation course	38 (48)	32 (38)	.20
Witnessed death of a real patient during simulation course	39 (49)	44 (52)	.70

Abbreviations: SD-Standard deviation; IM –Internal Medicine; EMS – Emergency Medical Service. Data may not equal 100% due to rounding.

(Table 1) The two groups were not significantly different in age, sex, membership in a joint degree program or time off from their clinical rotations. There was a significant difference in the number of students who had prior EMS training. 12 students in Group PE/AMI (15%) and 3 students in Group AMI/PE (3.6%) reporting such training (P=.01) The groups were similar in having witnessed resuscitations of real patients during or prior to this rotation. There was no significant difference in the number of students who had participated in resuscitation of a real patient prior to the rotation. There was a significant difference in student participation in the resuscitation of a real patient during this rotation, with 32 students in Group PE/AMI (41%) vs 20 students (24%) of Group AMI/PE (P=.02) reporting such an experience. There was no significant difference between the groups in having witnessed the death of a real patient either prior to or during the rotation.

Previous EMS training was examined to determine if it affected the likelihood of students having observed or participated in resuscitations or witnessed patient death.

Table 2. Previous EMS training, patient resuscitation and death				
N=163				
		Previous EMS Training		Fisher's exact test
		Yes # (%)	No # (%)	*P value*
Witnessed resuscitation of a real patient prior to simulation course	Yes	8 (53)	33 (22)	.024
	No	7 (47)	115 (78)	
Witnessed resuscitation of a real patient during simulation course	Yes	11 (73)	89 (60)	.410
	No	4 (27)	59 (40)	
Participated in resuscitation of a real patient prior to simulation course	Yes	6 (40)	8 (5)	<.001
	No	9 (60)	140 (95)	
Participated in resuscitation of a real patient during simulation course	Yes	7 (47)	45 (30)	.246
	No	8 (53)	103 (70)	
Witnessed death of a real patient prior to simulation course	Yes	11 (73)	59 (40)	.026
	No	3 (27)	89 (60)	
Witnessed death of a real patient during simulation course	Yes	11 (73)	72 (49)	.102
	No	4 (27)	76 (51)	

Previous EMS training was significantly correlated with having witnessed or participated in the resuscitation of a real patient, or having witnessed the death of a real patient prior to the simulation course. Students with previous EMS training were not more likely to see or participate in cardiac arrests or patient death during the 12 week clerkship. (Table 2)

Table 3. Pre-test scores by question category, correct out of 9

	Group PE/AMI, n=79		Group AMI/PE, n=84		
Question Category	Mean	SD	Mean	SD	P value
Acute Myocardial Infarction	4.8	1.3	5.0	1.5	.30
Pulmonary Embolism	4.2	1.3	4.2	1.3	.86
Biliary Tract Disease	5.3	1.6	5.5	1.3	.30

Table 4. Score improvement from week 0 to week 12, by question category

N=163	Mean Score Improvement	SD	P value
AMI	1.5	1.7	<.001
PE	.4	1.6	.002
BI	1.2	1.6	<.001

During analysis it was found that three test questions were unclearly worded or reproduced. This was discovered based on comments written in the margins from students and the extreme low numbers of students who answered the questions correctly or did not put an answer. There was one such question in each of the three categories of knowledge: acute myocardial infarction (AMI), pulmonary embolism (PE), and biliary tract disease (BI). Each of these questions was eliminated from analysis and the data from those questions not recorded. The two groups were similar in the knowledge of treatment of each of the three conditions examined. (Table 3) Students demonstrated a statistically significant increases in the number of questions answered correctly during the post test, for each of the three categories. (Table 4)

The self reported stress levels not significantly different for the AMI and PE scenarios, with students reporting a mean stress during the AMI scenario of 4.9 SD 2.5 and the PE scenario 4.8 SD 2.7 (P=.604) (N=125). (Table 5)

There was no significant difference in stress between the scenario in which the patient lived and died, with a mean stress during the successful resuscitation of 4.8 SD 2.7 and the unsuccessful 4.9 SD 2.6 (P=.878) (N=125). During the study 24 students were given the wrong form after the simulated death and therefore their stress levels and roles during that simulation are not known. Another ten students had the simulator enter cardiac arrest during their first simulation of the day rather than the second, and their stress levels were not therefore known. In both these groups the compromised data were discarded. Because of this, and when students may not have answered a specific question, the analysis contain different numbers of subjects. The simulation where the patient died is called "unsuccessful resuscitation," the one where the patient experience cardiac arrest and survived the "successful resuscitation."

Table 5. Self reported stress during successful resuscitation versus role, on a semantic differential scale (0-10)

Role	N	Mean Stress	SD
Observer	75	3.9	2.6
Participant	62	5.5	2.4
Team Leader	13	6.7	2
Total	150	4.8	2.6

ANOVA shows significant difference between roles with P =.000

Table 6 Self reported stress during unsuccessful resuscitation versus role, on a semantic differential scale (0-10)

	N	Mean Stress	SD
Observer	71	4.1	2.4
Participant	54	5.2	2.3
Team Leader	12	7.3	2.5
Total	137	4.8	2.6

ANOVA shows significant difference between roles with P=.000

Role was significantly correlated with reported stress for both the successful and unsuccessful simulated resuscitations. Team leaders reported more stress than participants, who reported more stress than observers. (Tables 5 and 6)

When examined by role, there was a significant difference in knowledge score improvement for the AMI scenario based on the role, with team leaders improving more than participants or observers. (Table 7) For the PE scenario there was not a significant difference between the roles. (Table 8) Some of the observers during each of these cardiac arrest scenarios included students who had been the team leader for the first scenario of the day, a similar scenario that did not include a cardiac arrest. The analysis was performed again, grouping the team leaders from both related scenarios together, and comparing them to the other students who had not been a team leader that day. As a control their knowledge score gains on the related scenario was compared to their knowledge gains on biliary tract (BI) questions. (Tables 9 and 10)

Table 7. AMI knowledge score difference by role

	N	Mean Score Difference	SD
Observer	78	1.4	1.8
Participant	59	1.4	1.7
Team Leader	13	2.8	1.4
Total	150	1.5	1.8

ANOVA P=.018 between groups.

Table 8. PE knowledge score difference by role

	N	Mean Score Difference	SD
Observer	82	.39	1.7
Participant	67	.24	1.5
Team Leader	14	1.2	1.6
Total	163	.4	1.6
ANOVA P= .120 between groups			

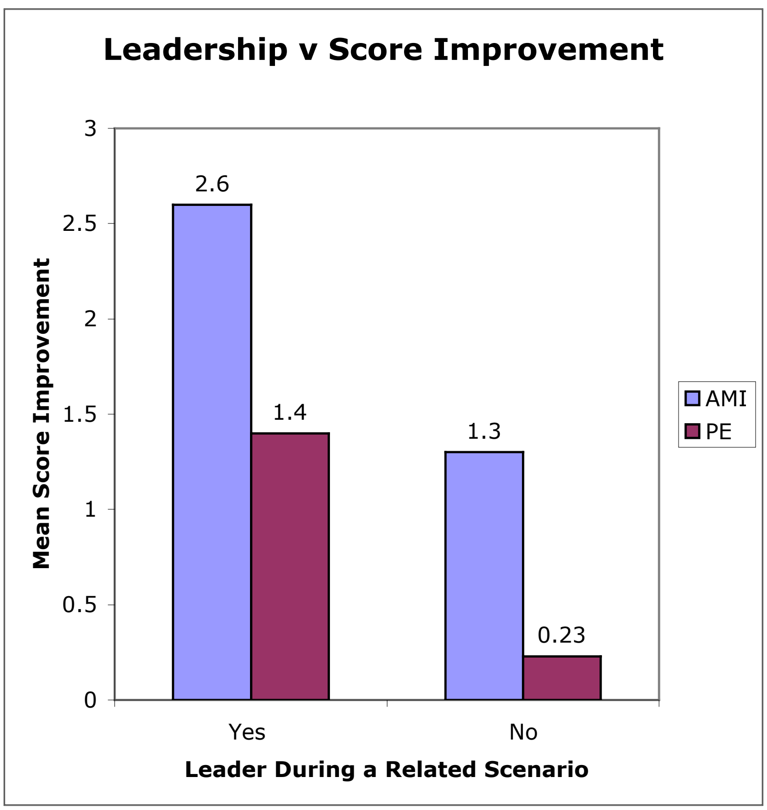
Table 9. Knowledge score difference versus having role of team leader during either AMI scenario

		Mean AMI score difference	SD	Mean BI score difference	SD
Leader during either AMI scenario	Yes (N=23)	2.6	1.9	0.73	1.4
	No (N=140)	1.3	1.6	1.2	1.6
	P=.001			P= .17	

Table 10. Knowledge score difference versus having role of team leader during either PE scenario

		Mean PE score difference	SD	Mean BI score difference	SD
Leader during either PE scenario	Yes (N=24)	1.4	1.6	1.4	1.2
	No (N=139)	0.23	1.6	1.1	1.6
	P= .001			P= .39	

Figure 3



As demonstrated in tables 9 and 10, for both the PE and AMI scenarios students who were team leaders during either of the related scenarios improved knowledge scores more than those who had been participants. As a control the score improvement for the biliary tract questions was included. The team leaders for the PE and AMI scenarios did not score significantly better on biliary tract questions than the other students. This argues that their score improvement on the related questions was due to being a leader rather than simply better students.

Table 11. AMI Score improvement, by group and role

	Mean AMI score difference	SD	N
Group PE/AMI (Unsuccessful AMI cardiac arrest)	1.7	1.8	78
Group AMI/PE (Successful AMI cardiac arrest)	1.3	1.8	72

Difference due to group was not significant with a p value of .10, therefore there was no observed difference in score improvement due to success of resuscitation of the AMI patient.

Table 12. PE Score improvement, by group and role

	Mean PE score difference	SD	N
Group PE/AMI (Successful PE cardiac arrest)	.42	1.7	79
Group AMI/PE (Unsuccessful PE cardiac arrest)	.38	1.6	84

Difference due to group was not significant with a p value of .50, therefore there was no observed difference in score improvement due to success of resuscitation of the PE patient.

Table 13 Score improvement on related questions versus stress of successful resuscitation			
	Mean	SD	N
Score improvement on questions related to the successful resuscitation	0.83	1.7	163
Stress during successful resuscitation	4.8	2.6	150
	Pearson correlation =-.001		
	P=.990		

Table 14 Score improvement on related questions versus stress of unsuccessful resuscitation			
	Mean	SD	N
Score improvement on questions related to the unsuccessful resuscitation	1.0	1.8	163
Stress during unsuccessful resuscitation	4.8	2.6	138
	Pearson correlation=.084		
	P=.328		

The score improvement on related questions was not associated with the stress experienced during either the successful or unsuccessful resuscitation. (Table 13 and 14) For the successful resuscitation the related questions would be those relating to AMI treatment for the group that the AMI patient lived, and the PE questions for the group in which the PE patient lived. There was no significant changes in score improvement due to the reported stress during the simulation.

Below is the graphic representation of the opinions of students regarding various aspects of simulated death. Each graph contains the statement prompt and the percentage of students who agreed or disagreed with each statement. SA= Strongly agree, A= Agree, N= Neutral, D= Disagree, SD= Strongly disagree.

Figure 4

Figure 5

"Death of the patient during simulator training....May cause me reluctance to participate in future simulation training"

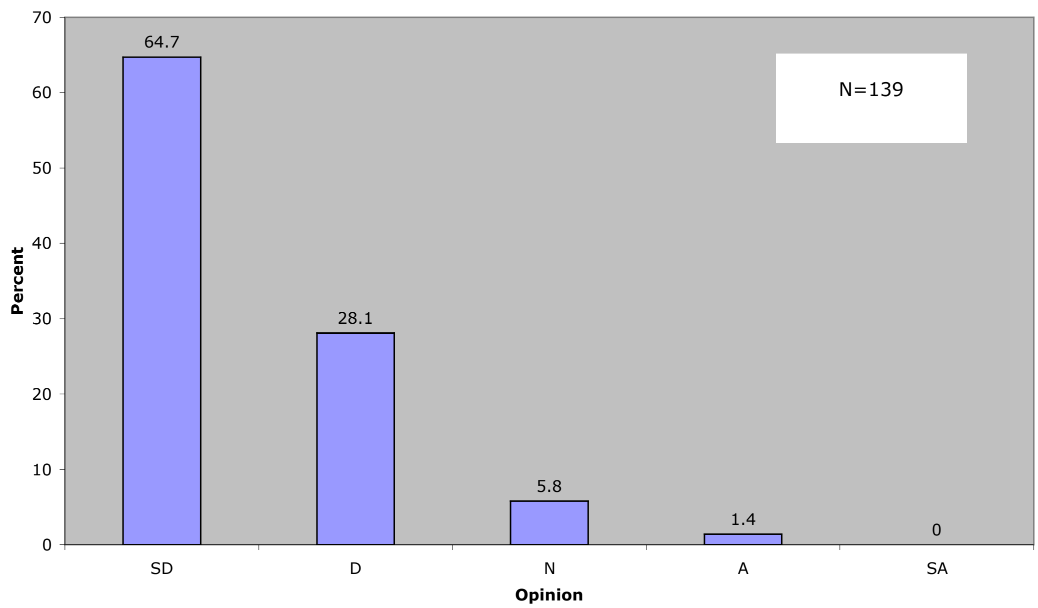


Figure 6

"Death of the patient during simulator training....Is always inappropriate regardless of patient management"

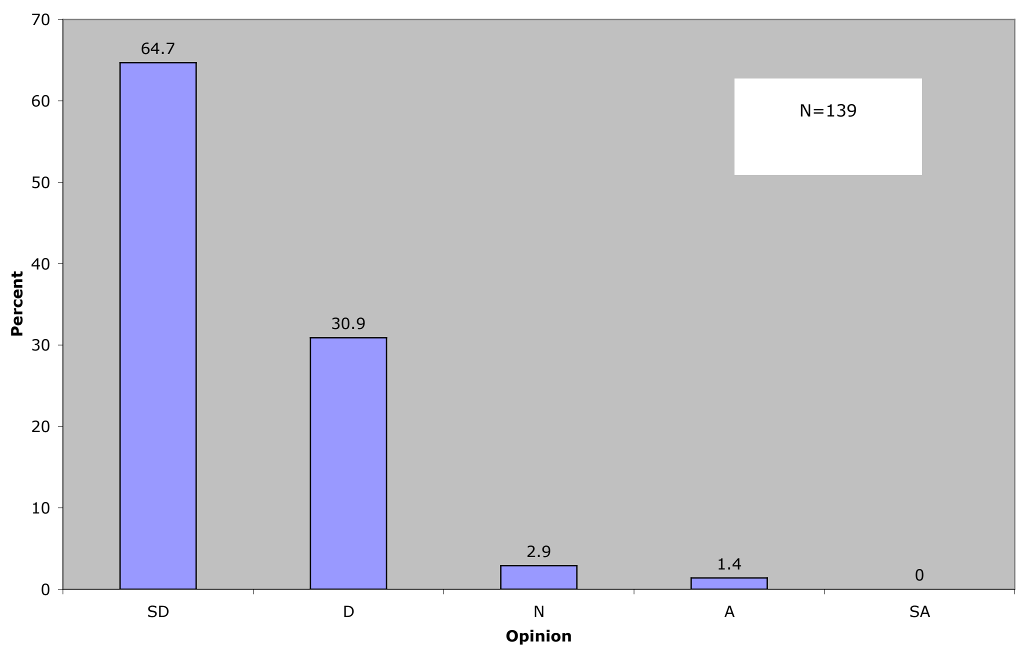


Figure 7

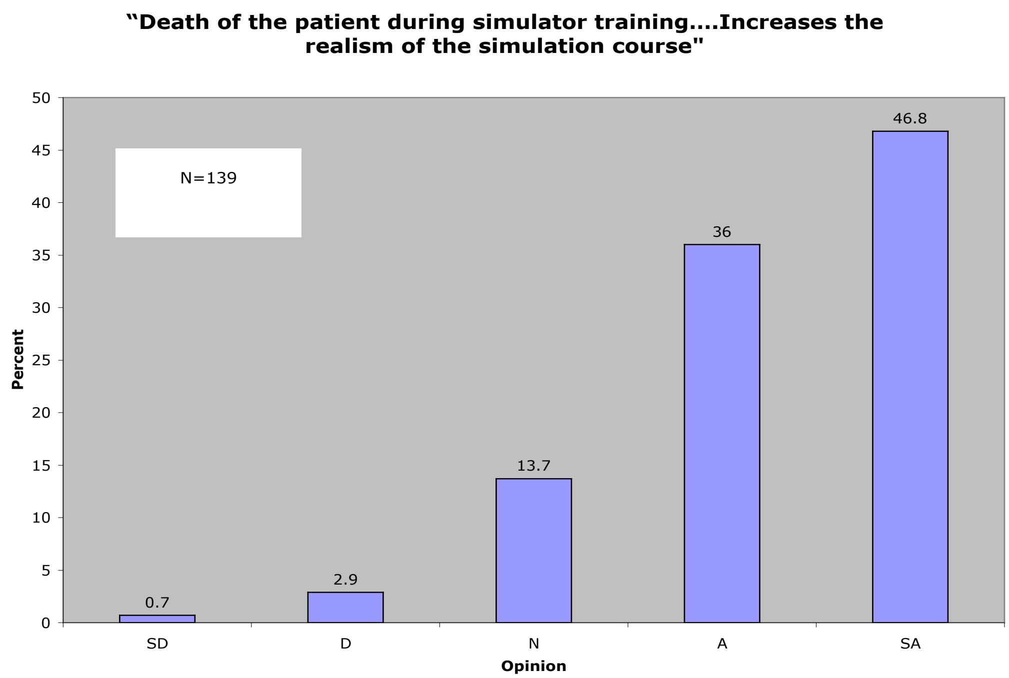


Figure 8

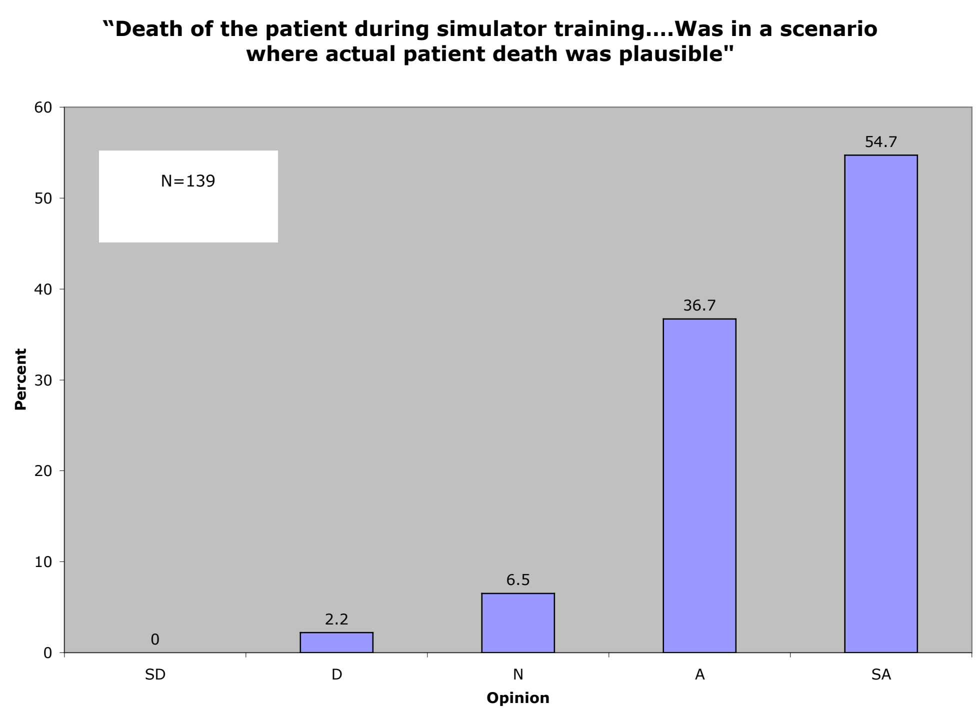


Figure 9

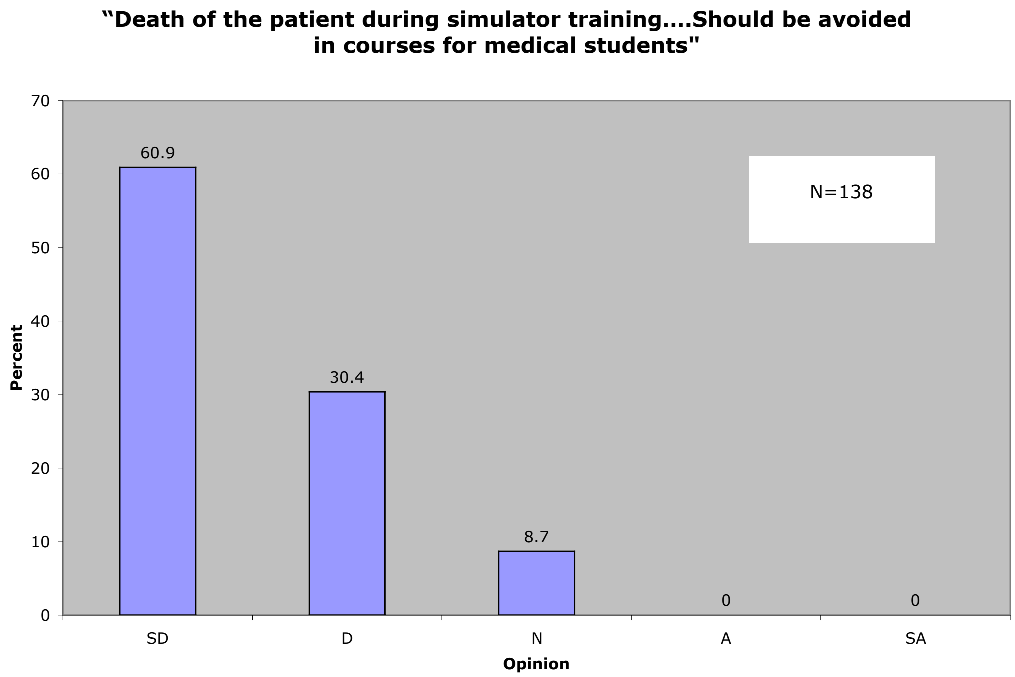


Figure 10

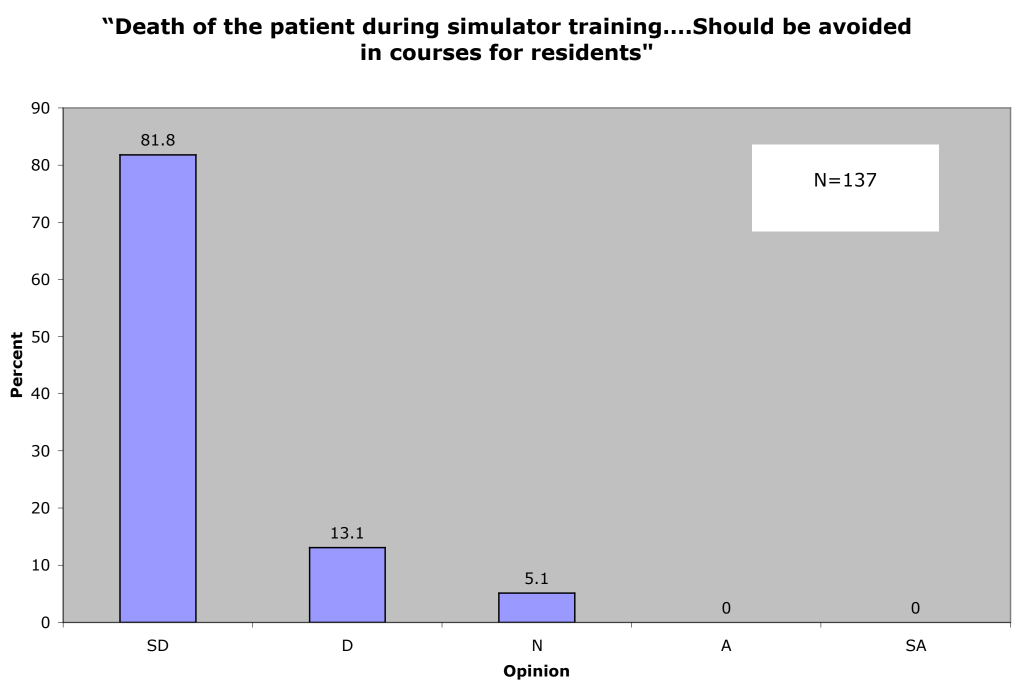


Figure 11

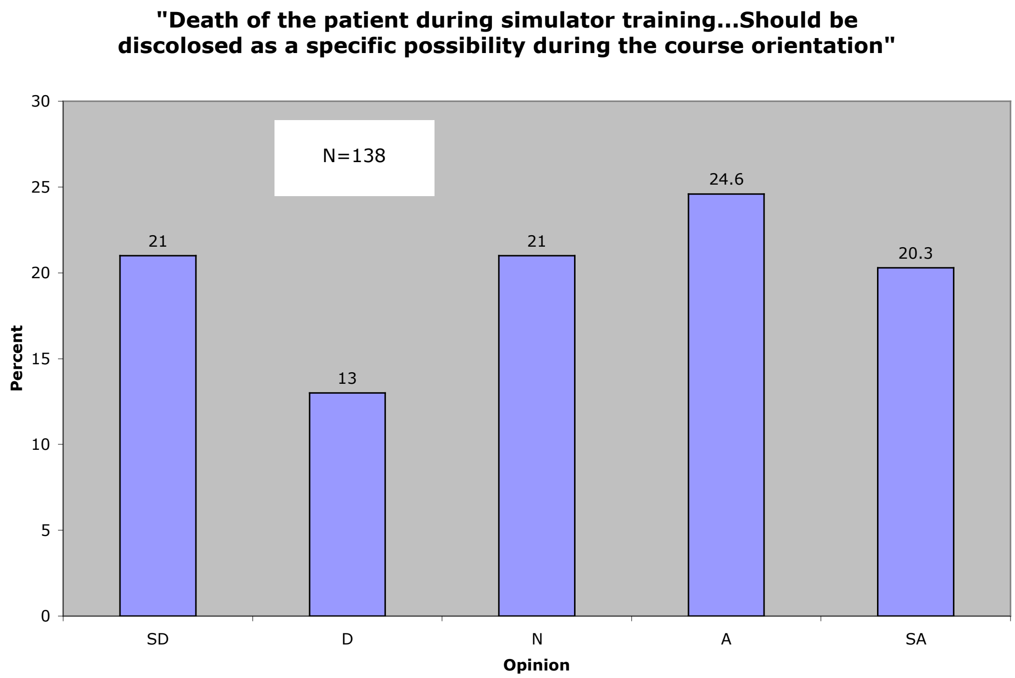


Figure 12

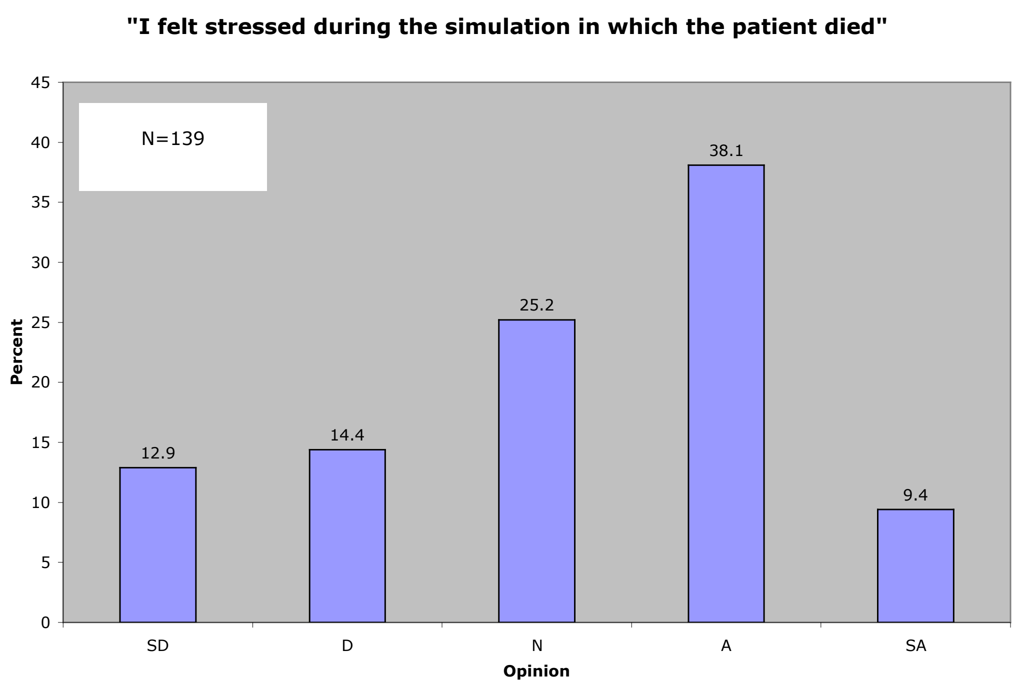


Figure 13

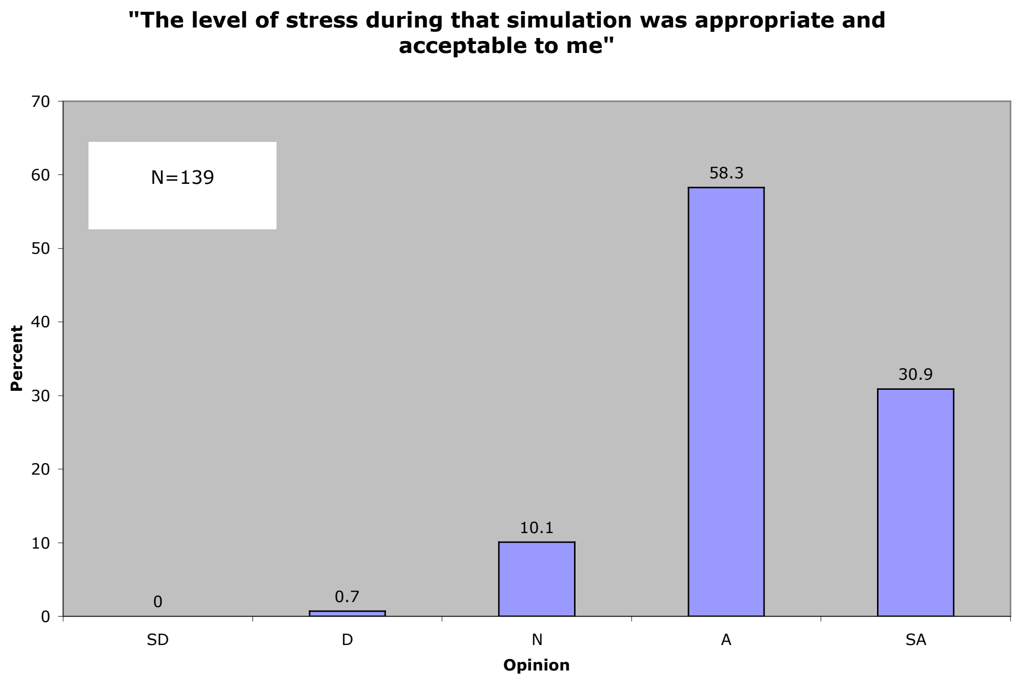


Figure 14

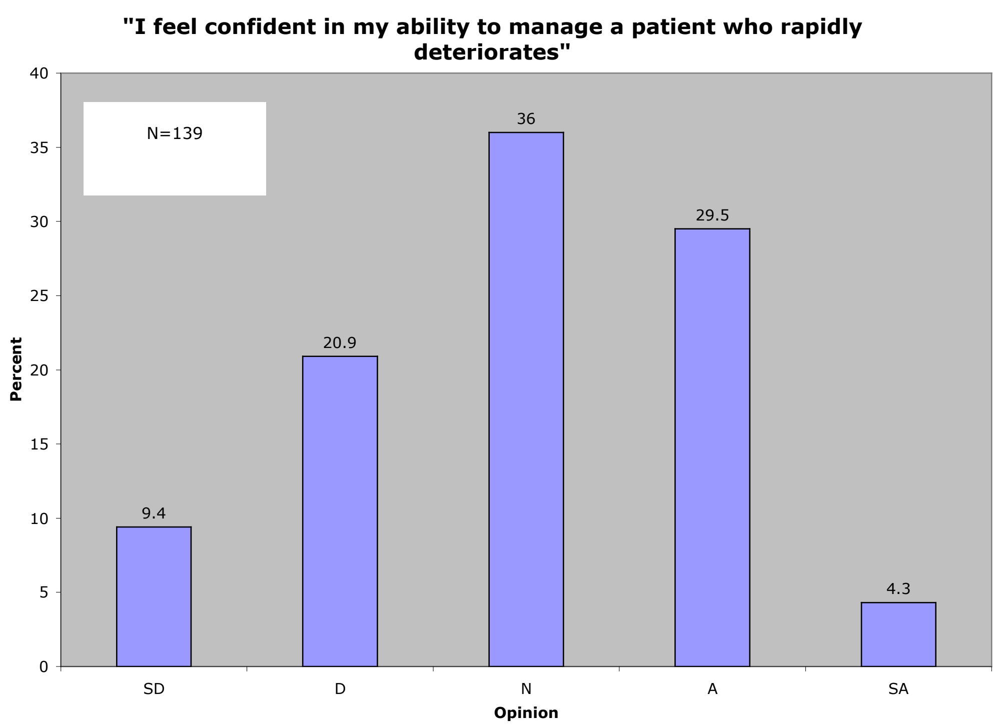
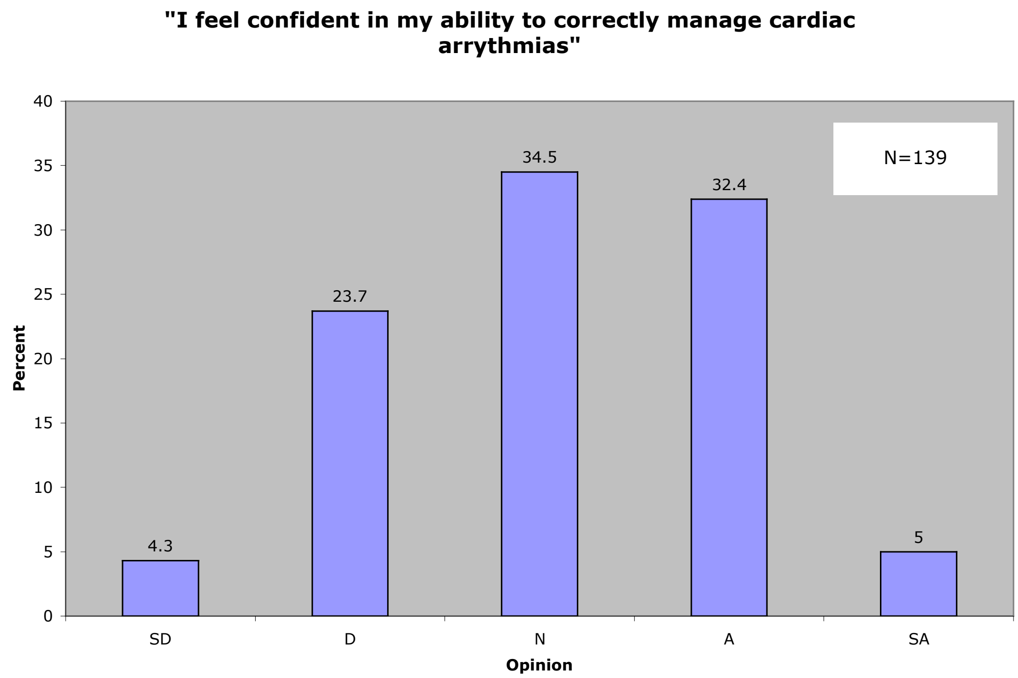


Figure 15



Each opinion answer was given a score, with SD=1, D=2, N=3, A=4 and SA=5 permitting average opinions of each question to be determined. The analysis of the variation of option by student experience was performed by the statistician Brian Biroscak.

Opinion v Experiencing Real Patient Death During Rotation

The only significant opinion difference was that students who had witnessed the death of a real patient more strongly agreed that the simulated patient death was plausible. Those who had witnessed real patient death agreed with a score of 4.6 (SD 0.6) versus 4.3 (SD 0.8) with a (P= .045).

Opinion v Experiencing Real Patient Death Prior to Rotation

The only significant opinion difference was that students who had witnessed the death of a real patient prior to the rotation more strongly agreed that that they were able to manage a patient who rapidly deteriorated. Those who had witnessed real patient death agreed with a score of 3.3 (SD 1.0) versus 2.81 (SD 0.1) with a (P= .012).

Opinion v Participating in Real Resuscitation During Rotation

The only significant opinion difference was that students who had participated in the resuscitation a real patient during the rotation more strongly agreed that that the level of stress during the death scenario was appropriate to them. Those who had participated agreed with a score of 4.4 (SD 0.6) versus 4.1 (SD 0.62) (P= .008).

Opinion v Participating in Real Resuscitation Prior to Rotation

Those who had participated prior to the rotation more strongly agreed that the amount of stress they experienced was appropriate 4.6 (SD 0.52) than those who had not participated prior 4.2 (SD 0.64) with a (P= 0.026).

Opinion v Witnessing Real Resuscitation During Rotation

Those who witnessed a resuscitation during the rotation agreed more strongly that the situation in which the simulator died was plausible 4.6 (SD 0.64) compared to those who had not 4.2 (SD 0.77) P=.001. They also felt more strongly that they were confident in their ability to manage a patient who rapidly deteriorates 3.1 (SD 1.1) than those who had not had that experience 2.8 (SD 0.86) (P= 0.026)

Those who had not witnessed a real resuscitation agreed more strongly that the simulator should not die for medical students 1.6 (SD 0.69) versus those who had witnessed real resuscitation 1.4 (SD 0.62) (P= 0.028)

Opinion v Witnessing Real Resuscitation Prior Rotation

Students who had witnessed resuscitation prior to the rotation agreed more strongly that the level of stress during the simulated death was appropriate 4.4 (SD 0.64) than those who had not had that prior experience 4.1 (SD 0.62) (P=0.018) They also agreed more strongly that they felt confident in their ability to manage a deteriorating patient 3.3 (SD 1.1) compared to 2.8 (SD 1.0) (P=0.006)

Group PE/AMI and B were similar in all their opinions except with the that Group AMI/PE more strongly agreed with the statement that they were able to manage a deteriorating patient 3.2 (SD 0.92) compared to Group PE/AMI 2.8 (SD 1.1) (P=.031)

Opinion v Stress During Simulated Death

The only significant correlation between reported stress during the simulated death and their opinions was with agreement that they had felt stressed during the simulation in which the patient died, a Pearson correlation of 0.554 (P<0.001).

Chapter 7 Discussion

Stress was reported as similar by students during both the AMI and PE scenarios. This stress was also similar between the scenarios where the patient lived or died after the cardiac arrest. It is interesting that the scenario in which the patient died did not produce a detectable increase in the amount of stress. One possible explanation is that it was not the patient outcome that was creating stress for the students. Other factors such as wishing to avoid embarrassment in front of attendings or fellow students, or anxiety about remembering the proper treatment was the cause of stress.

Since both the unsuccessful cardiac arrests occurred four weeks after the successful resuscitations, students had had several additional simulations to become more comfortable with simulation and managing acutely ill simulated patients. Therefore some of the stress during the first resuscitation may have been more from unfamiliarity with equipment and ACLS protocols, where more of the stress during the second cardiac arrest may have been from patient outcome. It is possible that if the unsuccessful resuscitation had been earlier in the course it would have been more stressful. But it is reasonable to allow students to practice a successful resuscitation before the added complexity of dealing with patient death is added. Further work should be done to identify the causes of stress in students during resuscitation

The leaders experienced significantly more stress than participants or observers for both the successful and unsuccessful cardiac arrest. (Table 5 and 6) This variation of stress with role is logical as one would expect that leading a scenario would be more stressful that observing. It also makes sense that those participating in the case would feel more suspension of disbelief and more investment in the outcome of the simulation than those watching. Further work is need to determine if there are different causes of stress for different roles.

The pre-test scores in each category were similar between the two groups. Also, since the average category score ranged from 46% to 61%, it suggests that the test was challenging and allowed opportunities to detect learning during the rotation. If the students had been starting with scores in the 90% range it would have been very difficult to detect learning as a result of simulation because there would have been little room for improvement.

Student's knowledge scores improved across all three score categories. This was expected if for no other reason than students retaking the same test. It is also likely that the clinical experience during these 12 weeks contributed to the learning, as well as the simulations in the three topics tested. It is interesting that students did not improve as much on the questions related to pulmonary embolism, answering on average .4 questions more correct compared to 1.5 more for AMI and 1.2 for biliary tract disease. It is unclear why there was this difference. It is possible that students did not have as much clinical experience with pulmonary embolisms, a difference in the didactic portion of the rotation, or that there was a difference in how successful the simulations were in teaching about the disease.

We found that the team leader learned more about the treatment of the condition which they treated then those who had other roles during that scenario. (Table 9 and 10) Since each group had two scenarios during a simulation session, there were two team leaders each day. Only one of these students was the leader during the resuscitation. Therefore these result do not suggest that leadership during resuscitation improves knowledge gains, but it is rather the leadership role in general. It is important to note that for the leaders of the AMI and PE scenarios, their learning on biliary disease was not greater than the other students. Therefore the leaders of these scenarios do not appear to simply have been better students but rather have learned more because they were team leaders.

Why the leaders learned more is unclear. Though all students were told to prepare for the simulation, it is likely that those who knew they would be in charge prepared more for the day's simulation. Each student knew which days the would lead from the beginning of the course, allowing a significant amount of time for preparation if the student were interested, though from personal experience it appeared that most students started preparing no more than a day or two before the simulation.

Another possibility is that the leaders were better able to remember lessons from the simulation in which they were in charge, either because they remembered the simulation itself or they were able to remember information from the debriefing. If leadership really is so important to learning then the optimal simulation program may focus more on the leaders. Smaller groups would be expected to result in more learning since each student would get to be a leader more often. In response to our results the surgery rotation at Yale School of Medicine has already changed their simulation curriculum. Now simulations are done in groups of four students, which allows each students to be the team leader three times during the rotation rather than the previous two. This change was made because of this study's suggestion that simulation leadership leads to improved learning. Further research is needed to elucidate this interaction between leadership and learning, but this is the first study to suggest that the role of medical students during simulation effects their learning.

The two groups, PE/AMI and AMI/PE, had similar improvement to one another in both the AMI and PE knowledge tests. (Table 11 and 12). While it is tempting to say that this shows that the outcome of the resuscitation did not change learning, it must be remembered that the unsuccessful resuscitations occurred four weeks closer to the post test than the successful ones. As the learning was closer to the test one would expect that students should do better on those more recent items, which may hide differences cause by the death. Another experiment could be done to directly address this issue. Furthermore, there were two weeks that elapsed after the last resuscitation before the post-test, allowing time for learning to decay. Currently there is not a standard time period for medical education learning, so it is hard to compare their improvement to the improvement seen in other simulation courses. The real world question is not if students remember treatments two weeks after a simulation, but rather if they can remember it months to years later during their practice. Those studies are difficult to perform because the longer the gap between learning and testing to greater the opportunities for confounding factors to have an effect.

The lack of correlation between perceived stress during a scenario and the score improvement on related questions (Tables 13 and 14) also argues that the stress of the resuscitations did not negatively impact learning. It also fails to show that the higher stress improved learning, which is somewhat surprising given that the team leaders reported the highest stress as well showed the most learning. It is likely that the number of observers made detecting an effect of such stress difficult. Determining if stress improves team leader learning will be difficult as the leadership elements that may be improving learning may also be leading to higher stress. For example making treatment decisions may be stressful, but may also help encode learning. In such as case the stress is a marker of the cause of the learning, rather than the cause itself.

The fact that in spite of higher levels of stress leaders tended to learn more gives some support to other educators who wish to study simulated death. It also suggests that they may be able to expose students to such an outcome while still teaching other information. This would make it much easier to do this research as one would not need a simulator session just dedicated to patient death.

The overall test score improvement was not correlated with the reported stress during either the successful or unsuccessful resuscitation. This suggests that the stress did not impair learning. It should be noted that team leaders, who reported the most stress during resuscitations, also had most improvement of the related questions. But since there was no correlation between their scores and stress levels it does not appear that the stress helped their learning.

I have little doubt that a simulation could be created which was so stressful that it impaired student learning. But the question that we were addressing was if the level of stress that students experienced during simulated death could be kept low enough that it did not interfere with learning. This study suggests that in a supportive environment educational objectives may not be automatically sacrificed by the presence of simulated patient death.

The two groups were similar for most demographics, though Group PE/AMI had significantly more students who had had previous emergency medicine training such as being an EMT. When we examined the questions on student experience with cardiac arrest in real patients it was clear that more of the students in Group PE/AMI were participating in the resuscitation of real patients during the 12 weeks of the course. Since this could have been due to previous training possibly making students more comfortable with being involved in resuscitations, we examined how those experience varied by if students had previous EMS training (Table 2).

Students with such training were not found to be more likely to witness or participate in real resuscitation or patient death than other students. This suggests that previous experience is not determining who had these experiences during the rotation. It was found that students with EMS training had significantly more experience with resuscitation and patient death prior to the start of this rotation. While we did not ask students if they had had such experiences on previous rotations or prior to medical school, it makes sense that those students who may have worked on ambulances or in other emergency settings would be more likely to have encountered a cardiac arrest patient.

Examining the opinion responses (Figures 4-13) it is show how overwhelmingly was the student's support of simulated death. Only 8.7% of students disagreed or strongly disagreed that the student should expect the death of the patient if that was the likely outcome (Figure 4). Only 1.4% of students agreed that the death of the patient would make them reluctant to participate in simulation, the same percentage who said the simulator should never die regardless of management. (Figure 5 and 6) The students felt that the death was realistic and plausible (Figure 7 and 8). Most telling is that no students agreed with the statement that the simulator should not die in courses for medical students (Figure 9).

The most contentious question was if students should be specifically warned during their orientation that the simulator could die during training. (Figure 11) There was a wide range of agreement and disagreement. Research should be done on the effects of such a warning. It may be useful to mentally prepare students for such an outcome, but there are a number of students who don't think it needs to be disclosed. Equally important to the question of if students are should be told that the simulator can die is what they are told about the reasons for why it may die. Should students be told the simulator will die in response to their actions? Or that it may die regardless of if their treatment is correct? Perhaps it is best to tell students that the simulator will react like a real patient, sometimes it will improve and sometimes deteriorate often in response to their actions but sometimes in spite of them. It is likely that how students understand the reason for the response of the simulator will effect their suspension of disbelief during simulation and possible learning.

Stress levels reported during the death were not correlated with most of the opinion questions. Those with the highest stress levels were no more likely to feel that simulated death should be avoided. The only correlation was that those who had high levels of stress were more likely to agree that they felt stressed when the patient died. It is encouraging that even 2 weeks after the death, students were consistent in remembering if they had felt stressed. It also suggests that the death was an important experience since they were able to remember how they felt.

The opinion questions showed some variation with student experience with death and resuscitation, both during and before the rotation. The effects were generally small but overall it seems that students who had experienced real cardiac arrest resuscitation were more in favor of the simulator dying and felt that the stress was manageable.

Limitations

This study was conducted at one medical school. It is possible that the students felt a level of comfort managing cardiac arrest that is different from those at other schools. The deaths also took place towards the end of a long simulation course. During this rotation students participate or observe about 26 scenarios. It is possible that the students had a level of comfort with simulation that makes such a simulated death more acceptable than at a program where students may only experience a few simulations. The biggest limitation is that this study relied on students' self reported stress levels. While our scale has not been validated, there is no standard for stress measurement in simulation. It is possible that other measures of stress such as vital sign monitoring or salivary cortisol would have led to different results. Finally, it is hard to tell how much of the reported stress was due to the cardiac arrest itself rather than just managing a critically ill patient. Future studies may examine how the stress of managing cardiac arrests, both successfully resuscitated and not, compare to other types of scenarios.

The goal of medical simulation is to replicate situations that allow learners to practice and experience elements of patient care. A major issue is that of fidelity. Does the simulator look real? Does it react like a patient would? Are learners able to do the same procedures and exams as in real life? The issue of simulated death is important to this fidelity. Clearly real patients die, and there are real actions incompatible with life. Certain conditions have a significant chance of the patient dying, and allowing them to survive may reduce the realism of the simulation. Balancing this is the concern that death can be an intense and emotional experience.

I argue that simulation provides the opportunity to experience the next level of one's career whether it is a medical student pretending to be an intern, a resident acting as an attending, or an attending mastering a new concept or procedure. Therefore the question to ask is not would a student be experiencing this situation or this role currently, but rather will they in the future? The fact that students are not responsible for being in charge of resuscitation or managing critically ill patients does not mean they should not be striving for that goal. Once they are residents they will have to deal with cardiac arrests, and patient death. This study suggests that many of these students are encountering these scenarios on their rotations. Therefore arguing that students cannot handle patient death ignores the reality that they not only will they have to learn such skills, but they are already facing those challenges. It must also be noted that we teach not only by what we do and say to our students, but also by what we omit. By eliminating death from simulation thereby ensuring that all cardiac arrest patients survive, we are teaching students from those experience. It is possible that they will have misperceptions about the success of CPR, or that they will become overly confident in their abilities. More research is needed to learn the consequences of not allowing students to experience simulated death. Not allowing the patient to die must be recognized as a choice on the part of the educator and should be deliberated.

Real patients die suddenly and unexpectedly, fortunately not often, and for some practitioners almost never. But if we are to prepare students for residency where they will be in the emergency department, in the operating room, in the ICU and on the medical floor, we should prepare them for these situations. Medical simulation may provide an excellent way to train students for these encounters.

Conclusions

Medical students did not find simulated death to be more stressful than successful resuscitation. The role of team leader was more stressful than participating or observing cardiac arrest scenarios. Higher stress levels were not associated with different opinions regarding simulated death. Students were overwhelmingly in favor of simulated death being a part of their course. The role of team leader was associated with significantly high test scores on material related to the simulation they lead. Simulated death does not appear to negatively impact on medical student learning and may be an appropriate scenario for third year medical students.

Chapter 8 Future Directions of Research on Medical Simulation and Simulated Death

The following are questions that were raised in the course of our research, but were not directly addressed in this project. They are suggestions of possible next steps in researching how best to utilize simulated death in medical education, as well as general questions regarding medical students and simulation.

Should Simulated Death be Used as a Marker for Failure?

In a number of papers about resident simulation the death of the simulator is used as a marker for scenario failure. [55,56,85] The military also uses death as a marker for sub-optimal care. In a documentary about simulating the Iraqi battlefield a solider reports that if the casualties, played by mannequin simulators, are not evacuated quickly enough they "die."[86] It is an interesting way to give instant feedback to the user. In such a paradigm where it is known that death is a marker for failure it would be very clear to the learner that they had made a mistake. One potential risk of such a strategy is that it may cause the learner to believe that real patient death represents sub optimal care. The palliative care discipline has been struggling against this idea for years. An important teaching of palliative care is that death is the normal and expected end of a terminal illness. Simulation should take care not to hamper this effort; but in situations where the learners action or inaction would likely lead to the death of a real patient fidelity demands the simulator should die. With students such an outcome can be prevented by prompting the correct action or preventing the administration of inappropriate care. But at the resident and attending level where there is often less direct oversight, such prompting and supervision may be artificial. It is possible that simulated death may be an effective outcome to mistakes for advanced learners, but so far such a paradigm has not been explicitly studied.

CPR Training and Managing Expectations of Success

One of the major benefits of simulation that has been cited is that it can be used for the “rehearsal of serious and/or rare events.” [31,76] Clearly cardiac arrests are serious and fairly rare events. But if students are to be exposed to cardiac arrest scenarios, what should be the outcome of such scenarios? Often such situations end in patient death in real life. There may be a risk that if the patient is “saved” in all cardiac arrest scenarios students may not be mentally prepared for unsuccessful resuscitations in real life. Conversely, if they have already seen a number of unsuccessful codes, the recovery of the patient in simulator may detract from the believability and fidelity of the scenario. This may be even more true if the patient is saved in spite of egregious mistakes.

I believe that there is a risk of creating false expectations in learners by only exposing students to successful outcomes in simulated cardiac arrests. A study was done by Bayley et al. in which paramedics lead teams in cardiac arrest scenarios, and the number of mistakes by double paramedic teams was compared to paramedic/EMT teams. Regardless of the mistakes made, all patients had a predestined return of spontaneous circulation. [87] From personal experience it seems that most simulated cardiac arrests in CPR classes and ACLS classes end with a return of a pulse. This unrealistic expectation of the success in treating cardiac arrest may make it more difficult when students start seeing real patients in cardiac arrest, the majority of whom will die. So there may be some advantage to having some cardiac arrest scenario patients “die” at all levels of training including BLS CPR and ACLS. Clearly it would not be beneficial to have every cardiac arrest scenario end it death. That may lead to many students saying “what is the point of even trying, everyone dies.” Research is needed to determine if there is an optimal percentage of unsuccessful cardiac arrests for students that will help maintain realistic expectations of successful CPR while not discouraging them.

Debriefing

Numerous authors have emphasized the need for debriefing as a part of a successful simulation experience. Faith Stafford writes that part of the debriefing process is the chance for the learner “to acknowledge himself or herself as a student in a learning situation; not a doctor with the responsibility for the safety of his or her patients’ lives.” [60] Multiple papers have stressed the importance of good debriefing as part of a simulation program. [88,33] It still is unknown how debriefing should be changed in the wake of a simulated patient death. Does the death need to addressed before reviewing the management of the patient? How much extra time is typically needed for a post death debrief? What should students be told in the debriefing? I would argue that students should not be told that the patient would have died regardless of their treatment, even if that were true. In real life doctors don’t know if different treatments would have yielded a different outcome for a specific patient. Dealing with that uncertainty may be a valuable part of the simulated death experience.

Training Different Learners

One major question for simulation is if there are differences between the optimal learning environments for different types of students. Medical students, PA students, nursing students, and paramedic students may need different levels of fidelity and may respond differently to similar scenarios. Where simulated death may not affect learning with third year medial students, it may have a greater impact on another group. Currently there is little literature comparing simulation modalities for different types of students. The nursing literature looks at nursing students, the medical literature examines medical students. If simulated death is deemed appropriate for medical students some research should be done on its effects on other types of students before it is widely implemented. This is an important consideration as simulation centers try to determine what kinds of simulators they will need to buy. There also seems to be a trend towards a number of integrated simulation centers where multiple kinds of students are trained at one center. Such a center should have guidelines for each kind of student.

Group Size and Interaction with Stress

One future area of research is what the optimal group size is during simulated resuscitation for medical students. Group sizes vary a group of 2 students [19] 3-4 medical students [17], 4-6 students. [30,91] There is a trade off between group size and educational expense. Clearly to run simulation for smaller groups and still train the same number of students means more simulations run, more faculty time, and possibly more simulators needed. The converse is that with every additional person added to the team each person gets to do less. There may be a critical number at which any more people added to the simulation reduces learning.

It is also possible that the stress experienced by participants may vary with group size. One would expect only having two people to manage a cardiac arrest would be more stressful than having several more. It is also possible that at a higher number of participants stress may increase due to crowding and more people observing the performance of the leader. Similarly, while having student observers allows more people to be educated during the simulation, there may be a risk that being observed by peers may also impact stress levels and learning. These impact may turn out to be minimal but are good avenues of future simulation research to determine optimal simulation design.

Efficiency in simulation is clearly important. Bond et al. notes that "from a long-term health care systems perspective, the cost of trainee time may well dwarf capital expenditures for facilities, computers, and mannequins."[88] They were arguing for research to validate simulation and justify the cost, but it also raises the point that the cost of people's time is an important element. More simulation sessions not only means more learner time be shifted towards simulation, but more instructor time as well. Given the current model where many simulations for medical students are overseen by attendings, this is clearly a major expense as it diverts attendings from other activities that would increase revenue such as clinical time or grant generating research. If the research argues for smaller groups, and therefore more simulations, simulations may have to modify how they are staffed. It may be reasonable to have some simulations run only by a resident. Another model might be to have multiple simulations run by technicians at the same time, and only have faculty present for a general debriefing of the large group. Further work will have to be done to determine where adjustments can be made. But basic assumptions, such as who should runs a medical student simulation, should be examined.

Is a Successful Resuscitation Needed Before Patient Death?

Once the effects on student of managing a cardiac arrest are better known investigators can start to determine the optimal way to integrate cardiac arrest into a simulation curriculum. The theory of deliberate practice put forth by Ericsson argues that if a goal is for learners to improve at a task, such as running a resuscitation, they need multiple opportunities to engage in that scenario. [92] Therefore multiple cardiac arrests should help students be better prepared than experiencing a single simulated cardiac arrest. Then the issue becomes one of what should be the outcomes of each cardiac arrest.

One interesting question is if it is important for students to have a successful resuscitation before exposing them to simulated patient death. One could foresee that it may be helpful for students to have a successful resuscitation in order to get some confidence in their skills and practice managing cardiac arrest before having the more difficult scenario of managing a patient who is not responding to the ACLS treatment. But there may be interactions between having the first patient live and the next one die. It is possible that students may suffer a drop in their confidence after the simulated death. It is possible that students may benefit from having several short, successful resuscitation, such as having to defibrillate the patient once, before they are exposed to simulated death.

There is much still to be determined about how best to utilize simulated death in training healthcare providers. It is likely that a variety of factors such as group size, reasons for the death, and stage of medical education will all impact on the stress produced by simulated death, the effect on learning, and how learners feel about such an experience. By carefully examining these factors we can maximize the simulation experience and help prepare learners to treat real patients.

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