AANA Journal Course 6

Update for Nurse Anesthetists

*6 CE Credits

Full-body patient simulation technology: Gaining experience using a malignant hyperthermia model

Melissa A. Hotchkiss, CRNA, MSNA
Sharlene N. Mendoza, RN, MSNA
Richmond, Virginia

Simulation technology is extremely useful for training workers in a variety of industries. Simulation concepts have been developed and refined in full-body patient simulators. Contemporary full-body patient simulators can be used to teach the essential concepts of many healthcare professions, and they offer practice dealing with critical events, concentrating on the thought and decision-making processes related to favorable patient outcomes. Full-body patient simulators provide practitioners the opportunity to manage realistic and advanced physical findings in a variety of areas and are capable of responding to a large number of pharmacologic agents and a host of clinical interventions.

The ability to combine high-fidelity educational tools with both classroom lecture and clinical experience provides nurse anesthetists the opportunity for a unique experience in a highly controlled and safe environment. Numerous technological and educational advantages and the chance for hands-on assessment and treatment of some of anesthesia's rarest and most life-threatening events provide a one-of-a-kind educational session for CRNAs.

Key words: Clinical simulation, education, full-body patient simulation, malignant hyperthermia.

Objectives

At the completion of this course, the reader should be able to:

1. Identify the various types and components of simulators available for education and training of healthcare professionals.
2. Discuss the rationale for using simulation of clinical events.
3. Describe the basic design of simulation centers and standard equipment used in these facilities.
4. Describe the similarities and differences among contemporary anesthesia simulator models.
5. List the advantages and disadvantages of full-body patient simulation over traditional approaches to gaining clinical knowledge and experience.

Introduction

Simulated training has long been used in a variety of industries to shape worker performance. Occupations that require understanding of complex systems in conjunction with quick psychomotor skills may be associated with hazardous outcomes. Just a few settings where simulators have gained a foothold include the nuclear power industry, the armed forces, and the space exploration effort.

One example is the airline industry, which has a long history of using simulated training devices for pilots. Today, flight simulation is a required component for all commercial and military pilots. Pilots are mandated to participate in simulated cockpit training experiences in which participants often find themselves at the controls of a virtual airplane in distress. These simulation practice sessions permit pilots to gain skill and experience in managing rare and potentially disastrous situations in a safe and controlled atmosphere.

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Simulation in anesthesia

During the last 10 years, the healthcare domain has awakened to the possibilities inherent in simulation. For example, the use of simulation in anesthesia has taken a variety of pathways. One method is computer screen–based simulation training (Table 1). These educational computer programs usually are accompanied by specific learning objectives. The user is presented with information on a computer screen monitor and then is able to interact with the computer program. This interaction is called computer-assisted instruction and is used to educate, build skills, or test behavior.[1]

Another example of simulated training is the partial body simulator, such as the IV (intravenous) insertion simulator and the resuscitation mannequin. These partial body simulators offer participants the opportunity to practice hands-on skills for various techniques specific to the healthcare field (Table 1).

One of the most innovative methods of simulation training is the full-body patient simulator. This training device consists of a full-body programmable "patient" interfacing with a computer system. Such systems offer high-fidelity realism in a variety of patient scenarios and healthcare professional–patient interactions.

Full-body simulation dates back to the 1960s, when "Sim One" was developed by J.S. Denson, MD, and Stephen Abrahamson, PhD, from the University of Southern California School of Medicine and the Department of Anesthesiology of Southern California Medical Center, respectively. This simulator was a computer-controlled mannequin that was designed to teach medical students and residents specific manual skills in patient care. Sim One resembled an actual person and had breath sounds, heart sounds, carotid and temporal pulses, a functional airway allowing placement of an endotracheal tube, and the capability to "respond" to 6 anesthetic drugs.[2]

Table 1. Types of simulators currently in use in anesthesia

Type of simulator	Concept
Computer screen–based simulators	Computer programs that permit limited interaction with user
Partial-body simulators	Task-specific simulators that are limited to teaching a precise skill component
Full-body patient simulators	Full-body mannequin that interfaces with a sophisticated computer system capable of generating a wide variety of human physiology models

The computer system of Sim One offered the ability to program various patient complications, such as cardiac arrest, cardiac arrhythmia, bucking in response to foreign material in the airway, blood pressure changes, and laryngospasm.[2] Sim One experienced a brief life; it was abandoned because of the tremendous costs of operation.

Currently, 3 companies manufacture computerized full-body patient simulators: (1) Medical Education Technologies, Inc, Sarasota, Fla, (2) Medsim, Inc, Fort Lauderdale, Fla, and (3) Medical Plastics Laboratory, Inc (Laerdal), Gatesville, Texas.

While there are differences between the 3 simulators, there are significant similarities. Each simulation system consists of 3 basic components (Table 2). The first is a full-body patient mannequin with audible heart tones, breath sounds, interactive airway, palpable pulses, and a drug identification system.

The second component is a computer system that permits the operator to change various elements of the simulator and to create and save specific patient profiles for later use. The completely programmable nature of the tool allows flexible instruction and demonstration in almost any imaginable setting. Healthcare professionals can experience everything from operating room (OR) fires, airway disasters, or cardiogenic shock to anaphylaxis. The ability to adapt and create events specific to a healthcare practitioner's profession and level of knowledge and experience offers an immense advantage to his or her education. Each company offers a remote computer-controlled capability that allows operation of the simulator from a nearby but isolated location.

Table 2. Essential components of a full-body patient simulator

Component	Comments
Lifelike, full-body mannequin	Offers realism, lungs that exhale carbon dioxide, heart and breath sounds, palpable pulses, and ability to identify and respond to a large number of pharmacologic agents
Computer system	Sophisticated computerized system that has the ability to generate multiple human physiological models, alter patient profiles, and administer numerous pharmacologic agents
Interface cart	Separate cart that may contain pneumatics, compressed gases, and gas analyzers of the system. The cart also may contain computer boards that allow for accurate interaction between the full-body mannequin and the computer system

The third feature is an interface cart that communicates between the computer system and the full-body patient mannequin. These carts may contain gas analyzer systems, sound cards, and pneumatics for control of specific simulator functions. The 3 components working in harmony allow the simulator to approach a degree of realism that approaches working with a living patient.

While screen-based simulation systems are widely recognized in the education community, full-body patient simulation is becoming ever more popular. According to a recent Web search, there are more than 130 full-body patient simulators located throughout the United States. Numerous healthcare professions are entering into simulation education and training, and basic and advanced professional curricula for these programs are increasingly using simulation-training experiences.

The performance of a clinician or a trainee in a simulated environment may be different from that in a real clinical situation. One can envision where performance is better in a simulator; alternatively one can imagine a situation where performance might be better in the real-world setting. A heightened sense of vigilance, either because one knows they are being watched in the simulated setting or that a patient's life is at stake in the real-world setting, might logically be expected to play out to differing degrees in different people undergoing the same experience.

Authenticity of the experience

Because unrealistic simulation of the workplace or a clinical scenario might have a negative influence upon performance, it is critically important to model an experience in the most realistic fashion possible. For example, the real world of the OR is quite different from what might be present on a screen-based simulator. Fidelity of the simulator model and simulation thus becomes essential.

Recently in our simulation center, the issue of authenticity of the model and the experience has begun to undergo systematic study.[3] A study was developed whose purpose was to determine strengths and weaknesses related to simulation authenticity. Forty-two archived videotapes of anesthesia provider student performances during crisis resource management were reviewed by 3 trained observers. Reviewers had a sophisticated knowledge of the OR environment but had not actively participated in simulator training. While the study is currently in progress, but with only about two thirds of the tapes already analyzed as of this writing, preliminary findings follow. The recording camera often is a significant source of distraction, especially for the actors, although it rarely appeared of obvious consequence to the anesthesia provider. Concerns abounded regarding a failure to mirror the OR "culture" convincingly (eg, hierarchical relationships often were not intact, conversations appear muted or discordant, surgeon portrayal was often viewed as unrealistic), as well as concerns that care provided was often substandard, leading to an air of improbability. Reviewers rated the case scenarios themselves as very realistic and well conceived.

Discussion

Although simulation exercises appear to be well embraced by the anesthesia community, little data exist regarding impact on measurable outcome or authenticity of the experience. Many studies demonstrate student and practitioner perceptions regarding worth of the experience, yet in the absence of ongoing formative and summative evaluation of the credibility of mirroring real-world encounters, simulation experiences may be led more by visceral than intellectual factors. In aviation simulation, a particular scenario is only valuable to a pilot trainee if that individual perceives the experience as legitimate and authentic. Our study is directed at assessing the authenticity of the experience with the goal of making future adjustments targeted at enhancing the overall worth of the experience. Preliminary findings suggest that there are domains of improvement that can be undertaken.

Another area of simulation use is the use of full-body simulators as a specific station for advanced cardiac life support courses (Bernadette Henrichs, CRNA, PhD, oral communication, March 2000). Full-body patient simulation is beginning to be used for ongoing educational programs both for nurse anesthetists and anesthesiologists as a value-added service by some hospitals in the United States (Alfred Lupien, CRNA, PhD, oral communication, April 2000).

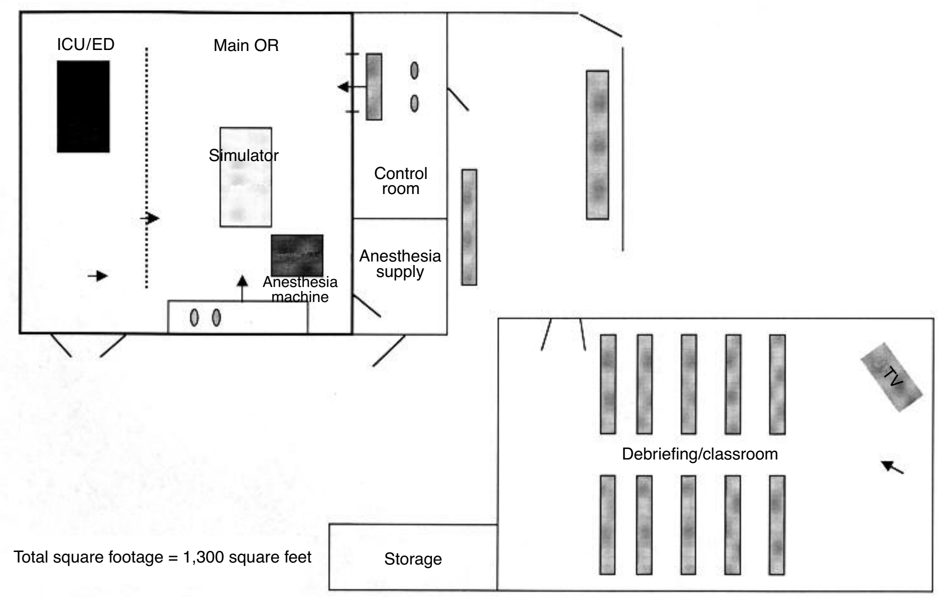
Simulation center designs

In order for simulation sessions to become a reality for more CRNAs, a greater number of simulation facilities need to be available. This can be accomplished through commercially available simulation centers, regional simulation centers, or sharing simulation resources among simulation users.

Currently, simulation centers around the world vary greatly in their architectural design, their proximity to the target or interest group, and the professional staffing available (Figure 1). Facilities tend to be designed specifically around the groups that train at the specific facility. Some of the common features of anesthesia simulation centers include the following: a mock OR, a control room, and a classroom and debriefing room.

Mock ORs generally include standard equipment that is routinely available for anesthesia care and surgical intervention. Simulation centers often provide other

Figure 1. Schematic of an architectural design of a simulation center



ICU indicates intensive care unit; ED indicates emergency department; OR indicates operating room.

necessary OR sights and sounds, such as OR lights, radio, x-ray view boxes, cautery, and vacuum source (Figure 2). This type of supplementary equipment dramatically enhances realism and fidelity and encourages participants to believe that they are in an actual OR environment administering anesthesia to a real patient undergoing surgery.

To offer simulation sessions that assist participants to suspend their natural sense of disbelief, it becomes critically important to model the scenario realistically to the very last detail (see "Authenticity of the experience," above). As the CRNA participants are given a specific patient profile and scenario, the simulated patient, the chart, and the environment must represent the desired situation with unerring accuracy and exquisite detail. "Patients" have an accurate identification bracelet and allergy bracelet, if applicable, and the patient chart number and conditions must exactly match those of the simulated patient. All records must be completed up to the exact point in time of the session, and the clock in the OR must represent the simulated time for the event.

Figure 2. Mock operating room with a full-body patient simulator

Simulation center faculty members are often the actors for many of the scenarios and will portray roles ranging from the surgeon to the scrub nurse to the circulating nurse. Realistic role playing is a vital asset to simulation because it offers simulation faculty the ability to control the scenario as it unfolds and to answer participant questions that arise about reality versus simulation.

Centers for simulation usually design a control room that is separated from the main simulation room (Figure 3). The control room often includes unidirectional windows that allow one-way viewing of participants. Control rooms include a variety of equipment, including the main computer system, which drives the simulator, and sophisticated audiovisual controls, which permit intricate manipulations. Many centers use videotaping capabilities so participants can view their performance after the simulation session.

Classroom and debriefing rooms generally are located in immediate proximity to the simulation cen-

Figure 3. Control room housing the simulator computer system and high-fidelity audiovisual equipment

ter and offer the opportunity for immediate feedback, under the guidance of skilled faculty facilitators, about simulation session performance. Ideally, center faculty members are trained in debriefing methods that are performed in a nonjudgmental, nonintimidating manner so trainees can discover areas in which they may need to focus attention. Some of these classrooms are equipped with a closed-circuit, large-screen television set that offers live viewing of simulation sessions.

The malignant hyperthermia model

In considering how the anesthesia provider might actually experience a full-body simulator, a malignant hyperthermia (MH) model will be described. Clinicians who register for a nurse anesthesia simulation session in MH are provided peer-reviewed literature and established protocols for the scientific foundations and clinical management of MH. CRNAs arrive at the center dressed in appropriate OR attire including their personal anesthesia equipment, such as precordial stethoscope and biaural stethoscope, and they know in advance that the simulated event will be an MH scenario.

On initial arrival at the center, all participants sign nondisclosure statements providing anonymity and absolute confidentiality for all aspects of training. Both participants and faculty sign legally binding documents stating they will not discuss the scenario or the performance of any participant. At the completion of the session, CRNA participants are given the sole videotape of their session, thus assuring further confidentiality and offering the opportunity to critique their own performance privately at a later time.

Next, all participants are given a tour of the simulation facility so they can become familiar with the equipment and OR setup. Time is allotted for CRNAs to look through the anesthesia cart, check out the anesthesia machine, and browse the monitoring system to ensure they understand the operation and location of all equipment. This period of familiarization is important to ensure that the participants become comfortable with the environment, have a sense of where things are, and can assume the role of provider in a well-informed manner.

Before the start of any session, CRNAs are given a brief overview of what to expect for the day. There is an audiovisual presentation and introduction on the full-body patient simulator model that they will be using. Following this orientation, the CRNAs return to the simulated OR where they are given the chance for hands-on practice on the basics of patient simulation. Specific areas are identified so CRNAs will know where to listen for heart and breath sounds, where intravenous sites are located, what the patient's airway looks like, and any other special features specific to that simulator model. Simulator facilitators are available to clarify information and answer participants' questions that arise during the session.

Session participants return to the classroom and debriefing room, and one CRNA at a time enters the simulated OR for the MH scenario. In one approach, a surgical case is in progress, and the participant is asked to relieve the anesthesia provider presently managing the case. After receiving a report on the patient and the procedure, the CRNA is given time to adjust to the case and the patient.

Simulation sessions may be offered in a CRNA "team" format or individual sessions. Team sessions offer CRNAs the opportunity to learn as an anesthesia team, in which the CRNAs take turns as nurse anesthetist, anesthesiologist, and secondary nurse anesthesia helper. During the individual simulation sessions, the CRNA participant is the only nurse anesthetist in the room during the session. These individual sessions benefit participants who may become stressed when asked to perform in front of their peers.

Eventually, the simulated patient begins to experience signs and symptoms of MH. The severity and rapidity of the onset of MH can be tailored specifically to the desired or required intensity in a highly realistic manner. Once the CRNA arrives at a diagnosis of MH and recognizes that the patient is experiencing an MH episode, the CRNA enters the treatment phase. When necessary, the CRNA is assisted in managing this highly realistic event (Figure 4). It should not escape the reader's attention that valuable experience is being gained by participating in a rare, potentially catastrophic, yet real-world event at no risk to a living patient. Simulation participants continue to treat the patient for MH until the simulation session has covered the specific learning objectives for MH. With proper

Figure 4. Certified Registered Nurse Anesthetist participants in the midst of managing a simulated malignant hyperthermia case

management, the patient recovers quickly from the event. Recent review of MH materials followed by simulation experience allows the participant to apply didactic knowledge in a realistic clinical setting and augment learning.

Debriefing occurs immediately following the event by the simulation faculty who participated in the event. A videotape of the session is used so that CRNA participants can visualize the unfolding event with close attention to the timeframe within which the event was diagnosed and treated. CRNAs review the MH protocol with the simulation faculty, and the CRNA identifies areas of weakness that might need review. After viewing the tape, participants are given an opportunity to ask questions related to the specific anesthetic event. All videotapes are given to the participant at that time.

Postsimulation evaluations offer participants the opportunity to provide feedback. The evaluation forms are anonymous and are placed in a central location in a secured area. Feedback from participants allows simulation centers to make necessary adjustments in program design and implementation to provide the most beneficial learning experience. Evaluations also may be used for subsequent research, for which complete confidentiality is assured.

The goal of a simulation session is not to provide a certificate documenting the participant's competence for identifying and performing MH treatment protocols. Centers would not provide reports, written or verbal, to employers about the performance of the participant. The only documentation provided to the session participant would likely be a certificate indicating the CRNA participated in a particular type of simulation session and a list of the objectives that were covered. Such a session would not testify to, or guarantee, clinical competency.

Advantages of simulation

While full-body patient simulation is a relatively new and underused training adjunct, the advantages are irrefutable (Table 3). Simulation sessions offer participants the opportunity to experience rare and uncommon events in a controlled environment. Scenarios can be tailored specifically to each participant's education level, work environment, and experience.[4] Also, the ability to view one's own simulation session permits participants to sit back and reflect on performance. Often, this is a powerful learning tool that aids faculty and trainees in identifying areas that need strengthening. In addition, because they are given the videotape, participants can review the scenario repeatedly, thus becoming more adept at recognizing and treating this rare event.

Potential disadvantages of simulation

Although the advantages are quite apparent, there are a few notable disadvantages to simulation. Most important is the cost of simulators and simulation centers. Full-body patient simulators list from approximately $30,000 to $200,000. Once the cost is added for renovating or constructing the facility, including the cost of OR and audiovisual equipment, the total may well be more than $300,000. There also are costs related to the faculty and staffing required to operate a center effectively. Core simulation center faculty ideally should be healthcare professionals and/or educators who are proficient in identifying and treating a variety of patient pathophysiological conditions. These faculty members are the content and educational experts who work with other simulator technicians or operators to design realistic patient profiles for education.

Table 3. Advantages and disadvantages of full-body patient simulators

Advantages

- Experiential practice in managing rare and uncommon clinical events
- Scenarios tailored specifically to each practitioner's level and work environment
- Video, for later review, of CRNA managing specific event

Disadvantages

- High cost of simulators
- High cost of facilities and support equipment
- Salary of personnel associated with operating and overseeing the simulation center
- "Fear of the unknown" and intimidation associated with using a new technology

Another disadvantage relates to the relatively small number of simulation centers accessible to CRNAs, which translates into travel issues, scheduling issues, and high cost. Realistically, as simulation education becomes more popular, more simulation facilities will be opened for CRNAs. Also, such individualized simulation sessions are costly and faculty intensive. This may be a drawback of individualized simulation sessions.

Another perceived disadvantage of the simulated setting is that many participants have voiced concerns that these experiences are intimidating and threatening. Perceptions such as this may be due to the lack of hands-on experience with the simulators for CRNAs. Many who have seen the simulators have done so only in demonstrations at the various professional meetings in which CRNAs are not given the opportunity to work with the simulator. The responsibility for acceptance of simulation into the CRNA community ultimately falls in the hands of the present simulation faculty.

Conclusion

Although simulation in anesthesia is still a technology in evolution, enormous progress has been noted in this domain. As the technology advances further and the number of simulation centers around the world increases, new ways for healthcare professionals to access information and meet their educational needs may be available. Simulators have marshaled an impressive record in a wide range of industries and are increasingly finding their way into the healthcare education sector. A growing number of anesthesiology residency programs and graduate programs in nurse anesthesia use anesthesia simulators as a part of their curriculum.

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SUGGESTED READING

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AUTHORS

Melissa A. Hotchkiss, CRNA, MSNA, is an assistant professor in the Department of Nurse Anesthesia at Virginia Commonwealth University, Richmond, Va. She also is the director of the Center for Research in Human Simulation in the Department of Nurse Anesthesia.

Sharlene N. Mendoza, RN, MSNA, has recently completed her graduate education in the Department of Nurse Anesthesia at Virginia Commonwealth University, Richmond, Va.