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Incorporating Simulators into Emergency Medicine Residency Training

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Learning Objectives: 1) To state advantages of simulation as a teaching tool for health professions education. 2) To discuss the importance of simulated clinical environments as a resource for optimizing the educational impact of clinical simulation. 3) To identify formation of multi-institutional consortia as a strategy for offsetting costs associated with developing and maintaining simulated clinical environments. 4) To describe features of a simulated clinical environment that can maintain a sense of realism while maximizing instructional effectiveness. 5) To understand the rationale for incorporating simulation technology into an emergency medicine residency curriculum. 6) To describe five aspects of education into which simulation technology can be incorporated.

Abstract

Clinical simulation is a powerful teaching tool for the education of health care professionals. In Part I of this article we describe the process of developing a clinical simulation center (as experienced by Temple College in Temple, Texas, USA), including recommendations for essential features of layout, monitoring, and recording, as well as equipment. In Part II we describe the process of incorporating a simulation center into a residency curriculum (as experienced by the residency in emergency medicine at Penn State Hershey Medical Center in Hershey, Pennsylvania, USA), including observations about its usefulness in teaching and measuring resident success in using treatment algorithms, addressing chief complaints, performing procedures, performing resuscitations, and performing crisis resource management.

One of the authors has a financial interest in a company involved in the production of simulators.

Part I. Designing and Developing a Clinical Simulation Center

Clinical simulation is a powerful teaching tool in the education of health care professionals. Simulated patient contacts can complement and enhance traditional clinical experiences by:

1. Ensuring every learner sees exactly the same set of patients.
2. Permitting controlled manipulation of patient encounters with predictable results.
3. Focusing learner attention on the problem at hand rather than the distractions that occur in real life (unless the distractions are a planned part of the problem).
4. Allowing learners to experience consequences of poor decisions without risk to real patients.
5. Pushing learners up the continuum of clinical competence from novice to expert more rapidly by providing realistic practice in analyzing complex problems, synthesizing information from a variety of sources, and evaluating possible courses of action.
6. Requiring integration of knowledge, skill, and professional behavior in dynamic environments.
7. Developing communication and leadership skills by allowing learners to work together in multidisciplinary teams.

For clinical simulation to be most effective, learners must “suspend disbelief” and interact with the simulator and the environment as if they were real. An effective clinical simulation is very much like a good theatrical production. The set, the actors, and the props support the illusion of reality and allow everyone to become fully immersed in the experience. Therefore, the most effective clinical simulation facility does not simply provide access to mannequins that reliably duplicate patient signs and symptoms. It duplicates the sights, sounds, smells, and other sensations associated with the clinical environment.

Attempting to design, develop, and maintain a simulation center that reproduces the patient-care environment with high fidelity is a challenging task. Such facilities are expensive to build, equip, and operate, and anticipated utilization by a single institution frequently will be too low to justify the costs. Our experiences in designing and developing a facility at Temple College that meets the clinical simulation needs of several academic institutions and hospitals in central Texas demonstrate one strategy for overcoming these difficulties.

Temple College is a comprehensive community college with 4,000 students in Temple, Texas, a city with a population of 58,447 located 120 miles south of the Dallas-Fort Worth metroplex on Interstate Highway 35. Temple also is the home of Scott & White Memorial Hospital, Central Texas Veterans Health Care System, King’s Daughters Hospital, and Texas A&M University System Health Science Center College of Medicine’s clinical campus. Health care is Temple's leading industry, contributing $750 million annually to the economy and creating 15,000 jobs for the community.

In the summer of 2001, Temple College's health care education programs were scattered across three campuses. Several programs were housed in temporary facilities with inadequate space and outdated equipment. The community had expressed strong expectations that Temple College would continue to educate skilled health care professionals to meet an aging population's needs, accelerate recruitment and graduation of professionals to meet existing and projected area health care workforce shortages, and support rapidly developing community initiatives in medical research and biotechnology.

Temple College responded with a plan to consolidate its health care education programs onto a single site, provide adequate classroom/laboratory space and updated equipment for all programs, and develop multidisciplinary, integrated laboratory experiences with expanded use of clinical simulation. Scott & White Memorial Hospital expressed interest in the proposal and offered to assist with developing a state-of-the-art clinical simulation center in the new Health Sciences Center. Discussions quickly expanded to include representatives from Texas A&M University System Health Science Center's College of Medicine.

A formal agreement was approved for joint use of the Health Sciences Center by Temple College, Scott & White Memorial Hospital, and Texas A&M University System Health Science Center's College of Medicine and collaborative planning was initiated, including staff from each institution. The planning team produced the clinical simulation center's functional design, developed and approved scheduling procedures, and prepared the foundation for a permanent clinical simulation advisory council. The partnership soon expanded again to include Laerdal Medical Corporation, a leading manufacturer of patient simulators with facilities 35 miles from Temple at Gatesville, Texas. Laerdal committed to ongoing support to the clinical simulation center's development in return for the opportunity to use the facility as a reference facility for prospective customers and receive feedback on its products from Temple College, Scott & White Memorial Hospital, and Texas A&M University System Health Science Center's College of Medicine faculty and students.

A bond election to raise $7.23 million for construction of a new Health Sciences Center and renovation of nursing and mathematics/biomedical sciences facilities was held on November 3, 2001. The issue passed by a 3 to 1 margin.

The Health Sciences Center opened in January 2004. At the heart of the facility is the clinical simulation center, a state-of-the-art "minihospital" designed for multidisciplinary education in the health care professions using patient simulation technology. The clinical simulation center includes approximately 9,800 square feet with an ambulance bay, a receiving area with nurses' station, two emergency department major treatment rooms, two intensive care rooms, an operating room with adjoining scrub room, a simulation control room, and part-task training laboratories for emergency medical services, respiratory care, and surgical technology. Seven Laerdal SimMan simulators, a Laerdal Sim-Baby (Laerdal Medical Corporation, Gatesville, Texas), and a Medical Education Technologies, Inc. (METI, Sarasota, Florida) Human Patient Simulator constitutes the core of the clinical simulation center's patient simulation capabilities.

The facility is accessed through an emergency department (ED) entrance from an ambulance bay that houses two fully equipped ambulances. Immediately inside the ED entrance is a receiving area and nurses' station.

On a hallway beyond the nurses' station are four 15 x 15 foot simulation rooms. On one side of the hallway, two rooms simulate ED major treatment rooms. On the opposite side of the hallway, two rooms simulate intensive care unit rooms. However, the only significant differences between these areas are the headwall configuration and the presence of a ceiling-mounted procedure lamp in the ED rooms. Built-in cabinets have been minimized with equipment and supplies stored either in carts or in baskets and on clips placed on wall rails. Larger pieces of equipment such as extra beds, stretchers, and wheelchairs are placed against the walls in the hallway, enhancing the learner's illusion of being in a hospital. By rearranging treatment tables, beds, and carts, all four rooms can be configured to look like either an ED or an intensive care unit room.

The simulation room headwalls include active ports for medical-grade oxygen, vacuum, and air. Because all gases are medical grade, the facility can provide surge capacity for area hospitals during disasters. A second set of gas ports near floor level provides oxygen, carbon dioxide, nitrogen, and compressed air for operating patient simulators. This feature eliminates distractions that would result from locating compressors or gas cylinders needed to drive simulators in the rooms. Compressed gas zone valves in the hallway add to the realism of the environment and allow the oxygen, vacuum, and air to be interrupted during simulations.

Data and audio ports in each room permit patient simulators to be operated from a central control room or from computers at hallway charting stations between the simulation rooms. A switch box in each room allows operation of the simulator to be shifted between the control room and the hallway station, depending on whether an instructor prefers to be close to students during a simulation or completely absent. To eliminate trip hazards and distractions, all simulator gas lines and data cables run from their points of origin at the wall through a covered chase in the floor to a point directly under the treatment table or bed.

Each simulation room is equipped with two cameras to allow operators in the control room to observe and record activities while they control the simulators. Use of cameras eliminates the need for one-way glass windows, which detract from the realism of the environment and are relatively ineffective because the operators spend much of their time looking at the learners' backs. A fixed camera above the head of the bed or treatment table allows unobstructed observation and recording of airway management procedures. A pan-tilt-zoom dome camera allows activities elsewhere in the room to be observed and recorded. Coaxial cables connect the cameras to control room computers that record digital video. The cameras are mounted on ceiling panels with approximately 20 feet of slack in the cables, allowing them to be moved easily. An additional cable with approximately 20 feet of slack is installed above each room's ceiling and is connected to the control room to support future installation of additional cameras. A VGA cable connects the patient monitor in each room through a scan converter to the control room computers, allowing the data from the patient monitor to be captured.

Audio is recorded using an omnidirectional boundary microphone mounted in a ceiling panel above the head of the bed or treatment table. The microphones connect to the control room computers through an audio mixer board, which permits placing wireless microphones on participants as needed to improve the quality of voice recordings.

All audio and video is recorded in digital format by a software application that also maintains a log of simulation events that are either sensed by the mannequin or entered by the operator. The digital format allows video and audio from the simulation rooms to be accessed using the Temple College campus intranet. A group of learners in a classroom elsewhere in the Health Sciences Center can watch another group participate in a simulation in real time, or a simulation can be recorded and then played back during a debriefing session so learners can review and discuss their performance. Faculty members also can access recordings of simulations from their offices. Video can be archived by transferring it to digital video disks.

Speakers in the simulators allow operators to be the voice of the patient and interact with learners during simulations. A telephone in each simulation room permits participants to receive calls from actors playing referring physicians, consultants, concerned family members, laboratory staff, operating room control desk personnel, and other individuals with whom they would interact during management of actual patients. Two-way radios with ear pieces allow operators to speak privately with one person in the simulation room, allowing information not available from the mannequin (such as skin color or temperature) to be communicated without the distraction of a voice coming through an overhead speaker. Operators also have the ability to simulate a power failure by activating a switch that interrupts all power in the hallways and simulation rooms for 8 seconds (with the exception of one outlet that stays on to power the simulator) followed by return of power to only the red emergency power outlets.

The clinical simulation center is changing and enhancing delivery of education for health care students and providers at all levels, including Temple College's certificate and associate degree health professions students, medical students from Texas A&M University System Health Science Center's College of Medicine, physicians in residency and fellowship training at Scott & White Memorial Hospital, and practicing physicians, nurses, and allied health care practitioners throughout central Texas. Students and clinicians now have the opportunity to work as members of multidisciplinary teams in a challenging environment that offers limitless opportunities to build competence and confidence without risk to patients or themselves. The development of the clinical simulation center as a partnership between a community college, a state-supported medical school, a private teaching hospital, and a private manufacturer of medical education equipment, has helped expand local and regional capabilities to provide initial and continuing education in the health professions that meets industry needs and accreditation and quality standards.

Part II. Integrating Simulation into a Residency Curriculum

Graduate medical education has undergone a dramatic transformation over the last decade. Traditional training had been very much in the model of an apprenticeship: a resident spent a certain number of years under the tutelage of a recognized expert who would then subsequently attest that the trainee had performed an adequate number of cases in competent fashion. That, plus the successful passage of a standardized examination designed to test knowledge, were essentially the requirements needed to become an independent practitioner.

This all changed in 1999. The Accreditation Council for Graduate Medical Education in that year described the six core competencies of patient care, medical knowledge, professionalism, practice-based learning, interpersonal and communication skills, and systems-based practice.[1] It then fell on us, as educators and program directors, to develop techniques that could be used to teach toward the competencies and, just as importantly, demonstrate their achievement.

Human simulation is a tool particularly well suited to this task.[2,3] In the controlled environment of a laboratory, the educator is not constrained by the vagaries of chance to provide a specific clinical scenario at an appropriate time for supervision and education. Rather, he or she can create a scenario designed to precisely teach and/or evaluate specific elements of the core competencies. A priori standards can be developed and the scenario can be repeated for each of the trainees. Uncommon but important medical problems can be presented. And, just as important, the safety and welfare of patients are not compromised.[4]

In 2004, Penn State Hershey Medical Center enrolled its first class of interns for a new residency in emergency medicine. This provided the opportunity to incorporate simulation technology into the training program from its inception.

We have identified five separate areas where this has been of use.

Review of Treatment Algorithms. Although all our residents have training in advanced trauma life support, advanced cardiac life support, and pediatric advanced life support, the simulation laboratory allows us to review, reinforce, and expand on the algorithms taught in these courses. The scenarios can be altered to stress specific elements of medical knowledge (e.g., cardiac rhythm or interpretation of radiographs) or patient care (e.g., decisions regarding fluid resuscitation, cardioversion, or other diagnostic or therapeutic procedures). The key to success with the technique is the a priori determination of the goals sought and outcomes expected. This can be easily done in a checklist fashion (see example in Figure 1) with the evaluator then noting whether the trainee performed the required actions.

Chief Complaint Competencies. Effective January 1, 2005, the Residency Review Committee-Emergency Medicine (RRC-EM) requires programs to assess the competency of residents to handle key chief complaints.[5] We have found the simulation laboratory to be particularly useful for this.

For example, for the chief complaint of "altered mental status" we have developed a scenario of an individual brought in unresponsive by basic life support. The checklist items for patient care are intuitive and relatively straightforward—performing the primary survey with proper cervical spine protection, obtaining vital signs, performing the appropriate secondary survey, assessing for hypoglycemia, and administering naloxone. When the patient subsequently begins to deteriorate from narcotic-induced noncardiogenic pulmonary edema, the resident is expected to detect this change, reevaluate the patient, and initiate appropriate treatment. What is less obvious is the opportunity to assess the other competencies. How well does the resident interact with the rest of his team (professionalism)? Does he or she inform the family appropriately (interpersonal and communication skills)? Does the resident make the appropriate calls for support, consultation, and disposition (systems-based practice)? As long as these goals are explicitly included in the evaluation checklist, they can be easily assessed and reviewed with the resident.

Procedural Competency. The RRC-EM similarly has a requirement for programs to demonstrate competency with key procedures. Certain procedures (such as intubation and cardioversion/defibrillation) can be easily incorporated into scenarios such as those described here, but it has been our experience that if other procedures are incorporated they tend to dominate the scenario, often to the detriment of the other elements of the case. Therefore, we have found it more effective to separate the evaluation of procedural competency from the clinical scenarios. The evaluation forms are similarly checklists and include not only performance of all the necessary component steps to the procedures, but also answering questions about indications, contraindications, alternatives, and complications. Procedures we have evaluated this way include lumbar puncture, tube thoracostomy, central venous access, and orotracheal intubation.

Resuscitation Competency. The RRC-EM also requires assessment of competency in adult and pediatric trauma and medical resuscitations. We have created cases that far exceed in complexity the typical advanced trauma life support/advanced cardiac life support/pediatric advanced life support scenarios. For example, one of our adult medical resuscitation cases involves a middle-aged man with known coronary artery disease and congestive heart failure who

Resident:____________________________ Date:___________

Evaluator:___________________________

Patient Care/Medical Knowledge				
Obtains focused history for trauma	❑ U	❑ NI	❑ S	❑ E
Performs primary survey	❑ U	❑ NI	❑ S	❑ E
Maintains C-spine precautions	❑ U	❑ NI	❑ S	❑ E
Performs secondary survey	❑ U	❑ NI	❑ S	❑ E
Initiates appropriate initial treatment (general):	❑ U	❑ NI	❑ S	❑ E
IV	❑ U	❑ NI	❑ S	❑ E
Oxygen	❑ U	❑ NI	❑ S	❑ E
Cardiac monitor	❑ U	❑ NI	❑ S	❑ E
Fluid bolus (crystalloid)	❑ U	❑ NI	❑ S	❑ E
Obtains x-rays in timely fashion	❑ U	❑ NI	❑ S	❑ E
Interprets x-rays correctly	❑ U	❑ NI	❑ S	❑ E
Obtains blood work in timely fashion	❑ U	❑ NI	❑ S	❑ E
Interprets blood work correctly	❑ U	❑ NI	❑ S	❑ E
Does appropriate reassessment after fluids	❑ U	❑ NI	❑ S	❑ E
Initiates appropriate treatment for persistent hypotension (general)	❑ U	❑ NI	❑ S	❑ E
Repeat fluids	❑ U	❑ NI	❑ S	❑ E
Prepares for transfusion	❑ U	❑ NI	❑ S	❑ E
Does appropriate assessment for abdominal trauma (FAST or DPL)	❑ U	❑ NI	❑ S	❑ E
Appropriate reassessment for worsening hypotension (general) and ALOC	❑ U	❑ NI	❑ S	❑ E
Performs endotracheal intubation	❑ U	❑ NI	❑ S	❑ E
Obtains central venous access	❑ U	❑ NI	❑ S	❑ E
Communication/Professionalism				
Keeps patient and family informed	❑ U	❑ NI	❑ S	❑ E
Directs team appropriately	❑ U	❑ NI	❑ S	❑ E
System-Based Practice				
Consults Surgery appropriately	❑ U	❑ NI	❑ S	❑ E

KEY:
- U = unsatisfactory (does not meet minimal expectations)
- NI = needs improvement (minimal deficiencies not expected to have significant effect)
- S = satisfactory (meets expectations for year of training)
- E = exceeds expectations (performance or knowledge beyond expectation for year of training)

Figure 1. SimLab resuscitation evaluation for MVA (Motor Vehicle Accident/Crash).

presents in cardiogenic shock from an ST-segment elevation myocardial infarction. The case not only assesses medical knowledge (appropriate diagnosis, proper sequencing of critical action, demonstration of understanding of how the presence of shock affects the decision of thrombolysis versus emergency cardiac catheterization) and patient care (appropriate collection of historic and examination data, and proper interventions), but also addresses professionalism, interpersonal communication skills, and systems-based practice in much the same fashion as described in “Review of Treatment Algorithms.”

Crisis Resource Management. Crisis resource management (CRM) training teaches health care providers how to use good communication skills, positive group dynamics, and efficient personnel and resource utilization during a crisis situation.

The concept began in the airline industry as crew or cockpit resource management.[6] Howard and Gaba first translated the aviation program into anesthesia CRM.[7] Using trainees rotating through the assistant and "hot seat" positions and several actors portraying surgeons and nurses, they created an operating room environment in which to teach the principles of CRM to anesthesiologists. Since then, the program has been broadened to train personnel in surgery and nursing, as well as several other departments.

The key principles demonstrated (and evaluated) in CRM are 1) roles (i.e., leaders and followers); 2) communication (closing the loop on orders and plans); 3) support (calling for the help needed); 4) resources (getting what is needed); and 5) global assessment (keeping cognizant of the larger picture and not getting distracted by details). The session begins with five to eight trainees of mixed disciplines receiving a brief lecture on the principles of CRM and an introduction to the "hospital" in which they will be working. They are given an opportunity to interact with the simulator and explore the room and equipment in a null (no crisis) scenario. They are then taken to a holding area while a second scenario is prepared. Trainees are brought back into the training area in small groups as their comrades request assistance. The second scenario is videotaped. When the crisis is resolved, the trainees are brought to a debriefing area. After a more detailed lecture is given on the five principles of CRM, a video is played that shows a recreation of a real crisis using only actors. The training team critiques the demonstration tape, pointing out what went wrong and how the problems could have been avoided or corrected. Then the trainees watch their own tape as they are guided through a self-critique. To date, the simulation laboratory at the Penn State Hershey Medical Center has trained over 200 health care providers in CRM from many specialties, including anesthesia, surgery, internal medicine, emergency medicine, radiology, and nurses from several clinical areas.

Evaluation

For each of these five areas (algorithms, chief complaints, procedures, resuscitations, and CRM) we use a similar evaluation format. Each item is scored as “unsatisfactory” (unacceptable and requiring remediation before the task can be considered satisfactorily completed), “needs improvement” (containing elements that need improvement but without gross deficiency), “satisfactory,” and “excellent” (exceeds expectations). Feedback is immediate and evaluations can be used to design subsequent scenarios that target deficiencies.

Our experience to date has been very positive. While we are continuing to collect data about its efficacy (i.e., its impact on subsequent patient care), it is already apparent that we can easily identify, and target, resident weaknesses with this tool, i.e., simulation.

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Integration of High-Fidelity Simulation into the Advanced Disaster Life Support (ADLS) Class

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Learning Objectives: 1) To describe an innovative application of high-fidelity human-like clinical simulation in a nationally distributed educational and training program. 2) To list the components of a standardized disaster preparedness course incorporating high-fidelity simulation of human patients into its design. 3) To list the three fundamental learning domains of adult-learner theory that are influenced by this application of simulation. 4) To discuss two different designs of high-fidelity human-like clinical simulators. 5) To discuss the benefits and barriers to implementation of clinical simulation on a large scale. 6) To list the key features of simulation that lead to effective learning. 7) To describe the role of clinical simulation in the Advanced Disaster Life Support course including scenario design, clinical pathophysiologic case selection, and student satisfaction. 8) To describe items important to faculty and course instructors involved in the teaching of this clinical simulation application.

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Abstract

The education and training of health care providers for disaster preparedness is a recognized national concern. Little evidence exists in the literature regarding the most effective ways to train our nation's health care providers to manage large-scale mass casualty events. Critical to health care provider preparedness is the establishment of a uniform, coordinated approach to mass casualty management from all types of hazards. New applications in clinical simulation made possible by recent advancements in human, model-driven, physiologic clinical simulators are being implemented nationally to meet this serious concern. The Advanced Disaster Life Support (ADLS) course is the first known nationally standardized disaster preparedness course to incorporate high-fidelity simulation of human patients into its design. This article will outline this innovative application of clinical simulation in a nationally distributed educational and training program.

Disaster response is a complex process that involves many different types of providers with many different skill levels and jobs. A review of the literature reveals a well-established concern for the public health infrastructure, health care facilities, and health care providers' preparedness to mitigate and manage the consequences of large-scale mass casualty events.[1-18] Analyses of most disasters have shown problems with communication and coordination.[2] Results of this literature review also revealed that only modest evidence, and in some cases, very little evidence, exists regarding effective ways to train health care providers to prepare and respond to many types of public health emergencies and related health care disasters.

The education and training of health care providers for disaster preparedness is a recognized national concern.[2,15,19,20] To meet this national concern, the National Disaster Life Support (NDLS) Foundation was created. Critical to health care preparedness is the establishment of a uniform, coordinated approach to mass casualty management from all types of hazards. Under a congressional appropriation originally managed by the Centers for Disease Control and Prevention, the NDLS series of courses was developed to implement and maintain a nationwide foundation in education and training, resulting in a measurable effect on disaster preparedness to a critical mass of the health care workforce. Table 1 describes and lists some of the NDLS courses.

The NDLS Foundation is sponsored by the American Medical Association, is nationally endorsed by such groups as the American College of Emergency Physicians, and is the result of a Delphi expert panel of national stakeholders in disaster preparedness.[21,22]