INTRODUCTION

Stepping into the emergency department (ED) resuscitation room, the emergency medicine resident is immediately confronted with the noise and commotion that often accompany a coding patient. The nurse shuttles around the room grabbing supplies and attaches the monitor leads to the patient. The patient continues to cough and mumble incomprehensible sounds as his mental status further deteriorates. The resident’s primary survey reveals that the patient needs to be intubated. He decides to use the Macintosh blade but also prepares the video laryngoscope as a backup. Rapid sequence induction medications are administered, and the resident realizes that this airway is difficult to manage with direct laryngoscopy. He reaches for the video laryngoscope to help him visualize the vocal cords and establish a definitive airway. Sirens from the monitor blare as the oxygen saturation continues to decrease. With beads of sweat forming on his brow, the resident continues to struggle as precious seconds tick away. Desperate, he considers a surgical airway as his last resort and directs the nurse to prepare the patient’s neck in anticipation of a cricothyroidotomy. With this decision, the monitors are silenced and the instructor walks into the room. The resident is commended on his efforts, and thus begins the instructional component of this exercise—the debriefing. The key difference in this scenario is that the patient was actually a simulator mannequin and the aforementioned code did not occur in the ED but rather was a form of resident education that occurred in a simulation suite.

Emergency medicine resident education and training has traditionally relied heavily on live patient encounters to master the art of medicine and health care delivery. In this setting, residents and educators are often challenged with balancing patients’ safety with their desired educational goals. Furthermore, the expanse of medical knowledge one is expected to master before independent practice continues to increase, whereas duty-hour restrictions have limited the resident’s exposure to these entities in the clinical setting. These components have placed significant stress on the medical education sections across the spectrum of specialties including emergency medicine, in which critical decisions have immediate consequences and the ability to treat all presenting conditions with expertise is required. As a result, many residency programs rely on medical simulation to address the concern for patient safety and to fill the training void of managing uncommon presentations. In this article, we identify the various simulation modalities available to residents, highlight their benefits to all levels of residency education, and encourage residents to use these tools to help meet their educational goals before future independent practice.

DEFINITION OF SIMULATION

Before one can analyze the benefits of medical simulation in emergency medicine residency training, it is critical to define this educational modality. Medical simulation in its simplest form is an educational tool used to mimic actual situations. It can be defined as an artificial recreation of an experience or environment for the purpose of education or evaluation. Simulation modalities exist along a full spectrum, ranging from low to high fidelity according to how closely they approximate reality. No matter the tool, medical simulation is rooted in the educational processes of deliberate practice, reflection, and immediate feedback.

SIMULATION DEVICES AVAILABLE TO EMERGENCY MEDICINE RESIDENTS: THE BASICS

A great deal of variability exists in medical simulation devices and their implementation in emergency medicine residency programs. In 2008, greater than 90% of emergency medicine programs in the country reported the use of some form of simulation to train their residents, with 85% specifically using mannequin-simulators, a significant change compared with 5 years before, in which only 29% could make that claim. Even so, hospital and medical school resources, space limitations, and proper instructor training dictate the type of simulation exposure residents have during their training. It is crucial for the learner and the educator to understand the general applications, benefits, and limitations of each device to optimize the potential benefits of these educational tools.
Task Trainers
Simple task trainers are devices designed to teach a particular task or procedure and generally resemble a specific anatomic region of the body. They are often used to train basic psychomotor skills such as suturing, intravenous cannulation, and gynecologic examinations.1,2,7,8

Animal-Based Simulation
Traditionally used as a form of simulation training, animal models continue to be relied on for complex procedural-based training in emergency medicine and surgery.9 Increased ethical scrutiny and the development of technology that can be reused multiple times at little maintenance cost has led to the reduced use of animal models.10,11

High-Fidelity Human Patient Simulators
This modality uses lifelike mannequins integrated with computers and generators that are driven by complex mathematic models with variable degrees of operation by instructors from a remote site. These mannequins produce visual and auditory physiologic signs such as heart and lung sounds, pupillary responses, and diaphoresis, whereas output measures such as blood pressure, pulse rate, and oxygen saturation are displayed on a realistic patient monitor.1,2,7

Simulated Environments
These environments re-create the features of a resuscitation bay, ward, or operating room and increase the psychological fidelity of the scenario for the learner.2,8 In doing so, these environments promote and allow for the evaluation of resource management and teamwork development, a practice similar to that of the flight simulators used by the airline industry for the past half-century.7

Computer and Virtual Reality Simulation
This technology provides a platform to simulate tasks or environments and allow multiple learners to interact with the computer interface. This form of simulation can incorporate complex components such as handheld haptic devices, an apparatus similar to a joystick, that provide feedback to the user, simulating the tactile and visual experience of the interactions.1,2,8,12 Computers can also be used to create “games” in which multiple operators interact remotely in a designed scenario to test and observe systems interactions one might encounter in an ED during a disaster situation.13

SIMULATION EDUCATION: WHY RESIDENTS SHOULD TAKE ADVANTAGE OF THIS TOOL
The last decade has placed numerous stressors on the traditional model of medical education, with subsequent influence on resident training. This period has seen an exponential increase in disease diagnoses and management strategies, resident duty-hour restrictions, reduced physician teaching time, and a heightened awareness about the use of patients as educational resources.3,14-20 Despite these changes, practicing safe medicine continues to depend on the acquisition of medical knowledge, proper judgment, and practical skill.21 With stricter clinical governance and a greater focus on patient safety, acquiring these skills before independent practice is challenging for residents. Emergency medicine residents should not only understand these challenges but also take advantage of new educational tools, such as medical simulation, to assist in filling training voids and mastering core concepts.

Core Concepts and Knowledge Integration
Medical simulation allows the resident exposure to the full spectrum of core clinical problems in emergency medicine. A training environment can be created in which hallmark cases and physical findings can be displayed with consistency and repetition.22 Interns can practice interview skills and basic assessment strategies and build confidence in the management of “bread and butter” cases.23,24 The learner can more clearly identify the limits of his or her clinical acumen and determine which areas require further self-directed study.25,26 Simulation has also been shown to improve knowledge consolidation and retention compared with traditional teaching strategies.27 Within the time constraints of any training program, simulation allows for the achievement of competence from exposure to high-severity/low-frequency patient cases rather than waiting for clinical circumstances to provide a teachable moment for a distinct few.22,28 These experiences provide trainees with knowledge in a meaningful context and higher confidence, ultimately allowing them to provide expert management when encountering these rare cases clinically.29 The future could see this tool used to assess residents’ clinical competence, interpersonal skills, and systems-based practice—areas important for residents’ maturation as providers.30,31

Patient Safety and Risk-Free Deliberate Practice
Simulation provides residents the opportunity to practice medicine in a risk-free environment without endangering the patient’s or their own safety.32 In the last decade, bioethical literature has highlighted the importance of patient well-being and denounced the use of patients as tools for clinical training.1,33-35 As a result, medical students are often excluded from high-risk procedures and the care of critically ill patients, therefore being forced to delay these encounters until internship.36 In these first-time, high-anxiety moments, the risk of medical error increases.36 Trainees can also be excluded from critical encounters because of patient preference. Some patients may be reluctant to have medical students or junior residents perform procedures on them if the skills had been mastered on a simulator.37 However, a study showed that patients were more inclined to allow a student to perform procedures on them if the skills had been mastered on a simulator.38 Medical education appears to be moving away from the “see one, do one, teach one” mantra. Simulation now allows for the repetitive practice and development of proficiency for high-risk procedures such as intubations, central venous catheter placement, and tube thoracostomy without the pressures of the
true clinical experience—a fact viewed favorably by trainees and patients alike. Instructional science research has shown that deliberate practice is paramount for skills acquisition and maintenance. Furthermore, this modality provides the resident exposure to and training in rare procedures such as cricothyroidotomy, pericardiocentesis, and cardiac pacing-procedural competencies required by the Accreditation Council for Graduate Medical Education before independent practice.

FEEDBACK AND DEBRIEFING OF THE ADULT LEARNER

Feedback is defined as “an informed, non-evaluative, and objective appraisal of performance that is aimed at improving clinical skills” and is valued by the adult learner. One of the strengths of medical simulation is its reliance on reflective learning through constructive feedback and debriefing. In fact, various studies in academic medicine have shown that exposure to simulation without debriefing offers no benefit to the learner. Unlike an ED shift, with its unpredictable nature and time constraints, a medical simulation session allows for immediate and effective feedback. Residents benefit from a clearly structured review of both prepared learning objectives and their actions during the case to help obtain skill mastery. With the advent of digital video recording and associated software management solutions, the resident can not only receive verbal feedback but also visually review his or her performance, thus improving the feedback experience. Lastly, simulation feedback provides an open forum to discuss and learn from poor decisions and bad outcomes without the concern of guilt or liability experienced in clinical practice.

Additional Skills Critical to Emergency Medicine

The military and aviation sectors have been truly innovative in using simulation for crisis management and teamwork training. In medicine, simulation-based team training for advanced cardiac life support and trauma resuscitations have resulted in improvements in process and outcomes. In emergency medicine, simulation offers the resident an opportunity to acquire teamwork skills, train in crisis resource use, and engage in systems-based practice—skills necessary for each ED shift. Participants in these teamwork simulation sessions can be evaluated and provided with real-time feedback. Thus, such training can help ease the anxiety and confusion junior residents might experience when thrust into their first team leadership roles and help improve their communication skills with team members.

SIMULATION EDUCATION: LIMITATIONS RESIDENTS SHOULD UNDERSTAND

There are intrinsic and extrinsic limitations to the use of simulation in resident education. Residents must comprehend the intrinsic limitations to prevent any substantial detraction from the benefits of this educational tool. Similarly, they must be aware of the extrinsic limitations that challenge their program’s incorporation and sustainability of this modality.

Intrinsic Limitations

Simulation relies heavily on suspension of reality and full immersion of the resident into the case. The simulation room characteristics, the simulation modality, and the participation of both the trainers and trainees affect simulation fidelity. Initially, learners may have difficulty suspending disbelief and approaching the simulation as they would approach an encounter in the clinical environment. However, the resident must remember that the purpose of simulation is to create the best possible learning experience by approximating reality but not necessarily reproducing it. Residents should also be aware that simulation education can cause negative transfer, which occurs when the imperfections of simulation result in improper knowledge acquisition. Additional maladaptive behaviors, including hypervigilance, cavalier actions, and the artificial acceleration of tasks by the resident may lend to improper learning. The imperfections of simulation will forever be present in some form, even with further technologic advancements. Through acknowledgment of these limitations and appropriate debriefing, residents can overcome these barriers and arrive at the desired learning outcome.

Extrinsic Limitations

High cost, lack of faculty simulation training, and substantial course development time are some of the extrinsic limitations that prevent the broad incorporation of medical simulation in emergency medicine residency programs nationwide. The establishment and maintenance of a simulation program requires significant financial investment. SimMan, the industry standard for moderate fidelity, costs approximately $27,000 without any adjunctive equipment, computers, or monitors. Consider the additional costs for facility renovations, maintenance of the units, operating expenses, and staff salaries. In doing so, one can appreciate the obvious fiscal barrier to this technology emerging in a residency program. Fortunately, many hospitals and residency programs have overcome this economic obstacle through grant applications, philanthropy, commercial funding, and interdepartmental collaboration. Furthermore, the novelty of simulation has resulted in a lack of sufficiently trained faculty in many emergency medicine programs. Competent simulation instructors must possess skills in scenario design, debriefing strategies, simulation technology, and adult learning theories to effectively teach residents with this tool. Online resources, simulation courses, and faculty development programs have been created to help overcome this deficiency. Finally, the time commitment for development and customizing simulation courses is substantial. Faculty must account for the time spent in the simulation laboratory with residents, as well as the numerous hours needed to prepare cases and
teaching points—a potential challenge when faced with other academic and clinical responsibilities.

MEDICAL SIMULATION RESOURCES FOR RESIDENTS

There are many online resources for residents with limited exposure to simulation-based education and those interested in improving its use in their residency program (Figure).

For instance, the Society of Academic Emergency Medicine Simulation Academy’s Web site offers access to their peer-reviewed simulation case library, a simulation setup checklist, and links to simulation centers around the country. Resources such as these can be a great catalyst for any resident or program trying to expand simulation’s role in their education section. Additionally, Kleinpell et al. recently identified greater than 135 Web-based education sites that include self-directed learning modules, interactive case studies, and video-enhanced programs that residents can use. Moreover, with the increasing availability of portable, handheld devices such as the iPhone and iPad, there are several interactive medical simulation applications available to residents. Programmers such as Anesoft, Medical Joyworks, and SimSuite have developed applications for these devices that simulate patient encounters and provide feedback based on the users’ actions—great educational tools for residents to use on the go.

MEDICAL SIMULATION: BEYOND RESIDENCY TRAINING

Trainees finishing residency should know that simulation stands poised as a possible component in continuing medical education. It has the potential to provide cognitive and procedural practice for established emergency physicians and allow them to compare their performance against predetermined standards. As an example, the anesthesiology community has already embraced simulation as part of their Maintenance of Certification in Anesthesiology. Along with demonstrating competence in core material, simulation would allow those more removed from residency to practice with new techniques and devices, all the while in a supportive, collegial environment. As costs decrease, fidelity increases, and devices become increasingly available, simulation could find roles in board certification, hospital or departmental credentialing, and cutting-edge research in medical education and patient safety.

CONCLUSION

Medical simulation has been an important addition to graduate medical education. Simulation’s true benefit to resident education comes from its controlled environment. Although clearly not a replacement for actual clinical experiences, simulation provides a structured setting for the deliberate practice of clinical skills, the self-reflection of the learner, and the opportunity for appropriate and timely supervisor feedback—elements often not available to residents in a busy ED. Unlike traditional lectures or case reports, medical simulation provides residents a place to assess their knowledge base built from independent study and integrate it safely into a clinical context. The growing evidence validating medical simulation as an educational tool has promoted its use beyond instructing physicians-in-training. As simulation moves out of its infancy, the next generation of residents must continue to embrace this tool and use it to complement their training before and during independent practice.

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