Conventional Medical Education and the History of Simulation in Radiology

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Simulation is a promising method for improving clinician performance, enhancing team training, increasing patient safety, and preventing errors. Training scenarios to enrich medical student and resident education, and apply toward competency assessment, recertification, and credentialing are important applications of simulation in radiology. This review will describe simulation training for procedural skills, interpretive and noninterpretive skills, team-based training and crisis management, professionalism and communication skills, as well as hybrid and in situ applications of simulation training. A brief overview of current simulation equipment and software and the barriers and strategies for implementation are described. Finally, methods of measuring competency and assessment are described, so that the interested reader can successfully implement simulation training into their practice.

Key Words: Simulation; medical education; resident education.

Medical education has traditionally revolved around the apprenticeship model outlined by Flexner (1) and Cameron (2), in which skills are learned under the tutelage of physician mentors and perfected by trainees through extensive hands-on experience in the hospital setting. However, there have been many changes in the way health care is delivered, reimbursed, and perceived by society (Fig 1). Recent cost-containment and quality and safety mandates at the national and local levels challenge this model of medical education. A decrease in hospital length of stay, restrictions on resident work hours, and decreased resident autonomy have led to fewer opportunities for hands-on experience with patients. Work hour regulations, productivity pressures, and patients' awareness of trainees "practicing" on them has led to a decline in training opportunities (3,4). These changes translate to a truncated training experience, fewer direct patient encounters, and fewer opportunities to perform procedures, which complicates traditional models of medical education. Simulation represents an attractive supplement to these traditional training methods in radiology.

Simulation training allows trainees to practice a procedure or clinical scenario in a simulated environment before treating actual patients. These training modules use different scenarios and equipment and vary in realism.

Simulation is used in many nonmedical settings to teach crisis management skills to professionals such as pilots, military personnel, firefighters, and nuclear power plant workers (5,6). Currently, simulation is being expanded in the medical field to enhance clinical training. For example, medical schools use simulated patients to help teach communication and professionalism skills to students, allowing for constructive feedback in a safe environment and at the same time students gain experience. In fact, simulation-based learning in medical school is proving to be superior to problem-based learning for the acquisition of critical assessment and management skills (7). Medical specialties spanning from general practice to surgical subspecialties use high-fidelity simulation as a promising method for enhancing team training, increasing patient safety, preventing errors, and improving clinician performance (8–14).

Computer-based simulations are also being used for enhancing medical training and assessment, such as Advanced Cardiac Life Support recertification through the American Heart Association, which incorporates multiple comprehensive patient scenarios to determine competency in

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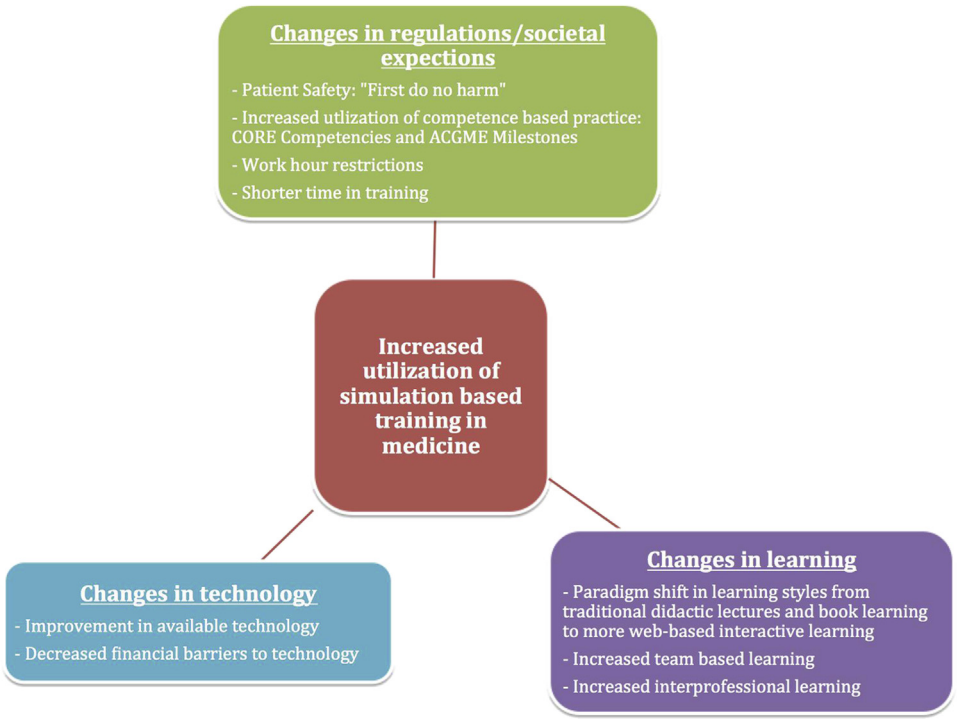

Figure 1. Reasons for increased use of simulation-based training in medical education. (Color version of figure is available online.)

certification. Similar assessment with objective structured clinical examinations for medical students and residents are being used for board certification. Objective structured clinical examinations offer formalized review of necessary clinical skills, including interviewing patients, physical examinations, ordering and interpreting diagnostic tests, performing procedures, peer to peer communication, and patient handover. This kind of training assesses a clinician's decision-making process with multiple scenarios to test competency and can be both formative if offered mid-course, providing an opportunity for improvement based on feedback, or summative, for a final grade.

Simulation-based methods of training are becoming more widely used in radiology and have the potential to be used for acquisition of both interpretive and procedural skills (15). Simulation-based training methods have many advantages over traditional training methods. First, simulators allow trainees to learn and practice skills in a safe and controlled environment, without risks to patients (16). Second, simulation curriculums are adaptable, interchangeable, and can be modified to fit evolving educational needs. Tailoring simulation curriculums allows for targeting strengths and weaknesses of individual trainees and can be easily adaptable to multiple skill levels. Basic and complex skills and scenarios can be taught on a phantom in a bench-top setting to optimize safety (17–20). Diagnostic interpretive skills can be taught with use of computer-based electronic teaching files, allowing the user to interact with a set of normal and abnormal images (7,8). Third, simulation-based training allows trainees multiple opportunities to practice and learn in a less stressful environment (21), which has been shown to be an important factor for acquisition of skills and expertise (22). Finally, studies have shown that the skills acquired by simulation training can be translated to improvement in both technical/procedural and diagnostic abilities (17,23–26).

A common application of simulation in radiology is procedural skill acquisition, as it allows trainees to gain experience when mitigating the risk of harm to patients. Other equally important applications include simulation training for interpretive and noninterpretive skills such as management of contrast reactions, interpersonal and communication skills, professionalism, and team training (Fig 2). The following is a review of the current simulation-based training methods used for these areas in radiology.

SIMULATION TRAINING OF PROCEDURAL SKILLS IN RADIOLOGY

Expertise in procedural performance is an important goal in medical training, and deliberate practice is necessary to achieve this goal. However, successful training requires repetition, assessment, and feedback on performance (22). Simulation-based methods of training allow for the "deliberate" practice required to master technical skills (27). Although many different educational tools are used in medical simulation, such as synthetic models, animal models, human cadavers, and virtual reality models (28,29), part-task trainers (which replicate only the specific part(s) of the patient or task being learned) and mannequin simulators are the most useful for procedural training (4,22). The use of phantoms for