Simulation-Based Training in Radiology

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Although the apprenticeship model of medical training has been in use for centuries, there are several problems with its use. The fundamental ethical principle of nonmaleficence requires that no preventable harm come to patients involved in the training process. In addition, changing medical practice patterns with shorter hospital stays and duty-hour restrictions are making it difficult for trainees to be exposed to enough patients to prepare them to deal with the many possible scenarios they may face in practice. Despite these limitations, the apprenticeship model cannot be completely rejected because it is essential for trainees to perfect their technique by caring for real patients with the guidance of experienced practitioners. Simulation-based training can allow novices to learn from their mistakes in a safe environment and in accordance with the principles of deliberate practice, thus allowing simulation to be a bridge to help get trainees from the novice state, in which they have a higher risk of causing harm, to a more experienced state in which they are more likely to do what is needed for patients.

Key Words: Radiology, simulation, training, quality, principle of nonmaleficence, apprenticeship model

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Apprenticeship is the traditional model of medical training. This model involves an experienced practitioner demonstrating the exercise of a profession to a trainee. The trainee then attempts to learn the profession by practicing it over a traditionally set period of time under the guidance of the experienced practitioner. Although this model has been in use since the time of the ancient Egyptians, the current iteration of this model was championed by Abraham Flexner and William Stuart Halsted in the early 20th century [1]. An integral and problematic part of the current model of clinical training is the use of patients as the primary teaching materials.

The sole use of this training model places both trainers and trainees in direct conflict with the central medical ethical principle of nonmaleficence. The principle of nonmaleficence is best expressed by the classic dictum "Primum non nocere": "First, do no harm." This conflict is poignantly illustrated by the "July effect," a measurable increase in mortality at training hospitals during the year-end transition, when new trainees arrive at the hospital and continuing trainees are trusted to take on new and expanded work roles [2].

Although nonmaleficence is an essential medical ethical principle, health care professionals also have an obligation to beneficence, namely, providing safe and effective care [3]. They can fulfill this obligation to beneficence only if they are adequately trained, and trainees cannot appreciate the complexity of caring for patients without actually providing patient care during their training. Thus, the need to protect today's patients from harm must be tempered by the need to train competent health care professionals who will be able to provide safe and effective care for future patients. This conflict between the principles of nonmaleficence and beneficence requires us to find ways to limit the harm to patients while training health care professionals to perform competently. One of the ways to deal with this conflict would be to use alternative training methods during the early phase of training, methods that limit the potential harm an unskilled trainee may do to a patient.

Even after this initial phase of training, sole reliance on the apprenticeship model may not be enough to produce truly competent health care workers. According to Epstein and Hundert [4], "professional competence is the habitual and judicious use of communication, knowledge, technical skills, clinical reasoning, emotions, values, and reflection in daily practice for the benefit of the individual and community being served." Although other, more formal definitions of competence have been established, specifically, the 6 core competencies defined by the ACGME [5], Epstein and Hundert's definition explains the spirit of the more formal definition and helps connect the 6 areas of competence with the fundamental emphasis on the ethical principles of nonmaleficence and beneficence.

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Ericsson [6], who has done extensive work on the nature of expertise and how it is obtained, stated that "superior performance does not automatically develop from extensive experience, general education, and domain related knowledge." When applied to medicine, this statement can be interpreted to mean that the traditional apprenticeship model of health care training may not be enough when relied on exclusively to produce competence. Rather, Ericsson continued, "superior performance requires the acquisition of complex integrated systems of representations for the execution, monitoring, planning, and analyses of performance." These "complex integrated systems of representations" that form the basis for competent performance are the fruits of deliberate practice. Ericsson described 4 aspects of deliberate practice. First, a training task must have clearly delineated goals. Second, trainees must have the motivation to improve their performance. Third, trainees must be provided with critiques of their performance. Finally, trainees must be given the chance to repeat training tasks and gradually refine their performance.

Simulation-based training could potentially overcome the shortcomings of the traditional apprenticeship model by allowing trainees to engage in deliberate practice while avoiding conflict with the principle of nonmaleficence and also ensuring adherence to the principle of beneficence. Aviation, nuclear power, the military, and other potentially hazardous and complex industries have turned to simulation-based training for this very reason [7]. Medicine has only recently begun to embrace this approach.

SIMULATION AND DELIBERATE PRACTICE

Simulation has been defined as "a technique, not a technology, to replace or amplify real experiences with guided experiences, often immersive in nature, that evoke or replicate substantial aspects of the real world in a fully interactive fashion" [8]. But as with all techniques, we must determine the best method of using the technique on the basis of the goals we wish to achieve. In the case of medicine, the goal is to train competent medical workers, so the technique must be used in accordance with the guidelines of deliberate practice so that the trainee can develop the "complex integrated systems of representations" that form the basis for competence. The importance of the 4 elements of deliberate practice in promoting competence in medicine was emphasized by Issenberg et al [9] in their review of the available evidence on aspects of simulation that lead to effective learning.

The first two elements of deliberate practice lay the groundwork for the use of simulation and must be in place before simulation can be used to fulfill the third and fourth elements.

Once the first two elements of deliberate practice are in place, the third element of deliberate practice, namely, an assessment and critique of the trainee's performance to point out errors in practice and gaps in knowledge, can be addressed through simulation. With simulation, the trainee can make errors without harmful consequences to patients. Therefore, instead of trainees' responding to medical errors with denial, mitigating responsibility, or distancing from the consequences [10], trainees in the simulated environment can make errors without harm and thus can openly analyze those errors to enable behavior modification. Learning from errors is an essential part of enhancing expertise and helps redirect behavior in the future [11,12].

Traditional oral, paper, or computer-based tests focus on assessing cognitive abilities and neglect the broader range of abilities integral to medical practice. As a result of this neglect, essential abilities such as procedural, communication, and teamwork skills are not given the appropriate attention during training that these abilities deserve given that shortcomings in these abilities have been shown to be causal factors in poor patient outcomes [13,14]. Simulation-based assessment can be used to test and thus emphasize the abilities required for safe and effective delivery of health care. Simulation is already being used for this purpose in various specialties, including radiology [15-20]. Simulation will continue to be more commonly used as an assessment tool as professional boards start to include simulation-based assessment in their certification and recertification procedures [21,22].

Fundamental changes in the practice of medicine today compared with the time of Flexner and Halsted have made it challenging to repeat the training task and gradually refine performance (the fourth element of deliberate practice). Outpatient care has come to the fore, and hospital stays have decreased in length. Patients who are admitted to hospitals tend to be sicker. Significant work-hour restrictions for residents have been put into place by the federal government, without changes to the duration of training [23]. These factors work together to limit the time dedicated to training [24-26]. Simulation-based training may mitigate the deficiencies resulting from limited training time by providing trainees with experience with a wide variety of clinical and procedural situations, allowing them to be prepared for unusual presentations, rare diseases, and crises. Furthermore, simulation allows trainees to learn and practice at their own pace rather than at the often hectic pace of daily clinical practice [27,28].

THE VARIETIES OF SIMULATORS

A health care simulator is "a device that presents a simulated patient (or part of a patient) and interacts appropriately with the actions taken by the simulation participant," according to Gaba [8]. In addition to this definition, Gaba enumerated a taxonomy of the types of technology used for health care simulation (Table 1).