Medical Education

Simulation-based medical teaching and learning

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ABSTRACT

One of the most important steps in curriculum development is the introduction of simulation- based medical teaching and learning. Simulation is a generic term that refers to an artificial representation of a real world process to achieve educational goals through experiential learning. Simulation based medical education is defined as any educational activity that utilizes simulation aides to replicate clinical scenarios. Although medical simulation is relatively new, simulation has been used for a long time in other high risk professions such as aviation. Medical simulation allows the acquisition of clinical skills through deliberate practice rather than an apprentice style of learning. Simulation tools serve as an alternative to real patients. A trainee can make mistakes and learn from them without the fear of harming the patient. There are different types and classification of simulators and their cost vary according to the degree of their resemblance to the reality, or 'fidelity'. Simulation- based learning is expensive. However, it is cost-effective if utilized properly. Medical simulation has been found to enhance clinical competence at the undergraduate and postgraduate levels. It has also been found to have many advantages that can improve patient safety and reduce health care costs through the improvement of the medical provider's competencies. The objective of this narrative review article is to highlight the importance of simulation as a new teaching method in undergraduate and postgraduate education.

Key words: Clinical skills, medical education, medical simulation, simulators

INTRODUCTION

Medical education has undergone significant changes all over the world. One of the reasons for the changes is concern for the patient's safety. "To Err Is Human", a landmark report released by the Institute of Medicine (IOM) in 1999[1] estimated that medical errors cause injury to approximately 3% of hospital patients and results in a minimum of 44,000 and perhaps as many as 98,000 deaths per year in the United States. Another important finding came from the Harvard Medical Practice Study 1, in which the authors reviewed over 30,000 randomly selected hospital records at New York State in 1984 as part of an interdisciplinary study of medical injury and malpractice litigation. They found that injuries from adverse events occurred in 3.7% of hospital admissions, 27.6% of which were due to negligence and in which 13.6% led to death.[2] Medical errors also contribute to the cost of medical care throughout the world. The annual cost attributable to all adverse drug events and preventable adverse drug events for a 700-bed American teaching hospital was estimated by one study as $5.6 million and $2.8 million repectively.[3] Though it is expected that such medical errors occur in

Saudi Arabia, there are no studies on their extent in Saudi hospitals.

Calls for a change in the instructional methods have resulted in innovative medical curricula. The new curricula stress the importance of proficiency in several clinical skills by medical graduates rather than mere acquisition of knowledge. As evidenced by their endorsement by many of the international bodies and medical schools,[4] it is universally accepted that clinical skills constitute an essential learning outcome. The acquisition of appropriate clinical skills is key to health education; however, students sometimes complete their educational programs armed with theoretical knowledge but lack many of the clinical skills vital for their work. A major challenge for medical undergraduates is the application of theoretical knowledge to the management of patients. Some medical schools in the Middle East have changed their curricula and adopted such educational strategies as problem-based learning. Also many medical schools have started to utilize clinical skills laboratories for training. However, simulation-based learning is not yet well established in this region. The objective of this narrative review article is to highlight the

importance of simulation as a new teaching method for undergraduate and postgraduate education.

MATERIALS AND METHODS

This is a narrative review of literature on a medical simulator and the use of simulation in medical education. A literature search of MEDLINE/PubMed database for English-language publications and reference lists from relevant articles published between 1990 and August 2009 was conducted. The main search terms were medical simulation, medical simulator, medical education, and clinical skills. All articles thought to be relevant to the title and/or abstracts were retrieved. These articles were reviewed if they were considered relevant to the search.

CLINICAL COMPETENCE

Medical training programs should ensure that students have the necessary learning opportunities and assessed by the appropriate methods. Clinical skills competencies including communication skills, history-taking, professional attitudes, awareness of ethical basis of healthcare, physical examination, procedural skills, clinical laboratory skills, diagnostic skills, therapeutic skills, resuscitation skills, critical thinking, clinical reasoning, problem solving, team-work, organization skills, management skills, and information technology skills should be part of the core undergraduate curriculum.[5] Traditionally, the acquisition and ongoing improvement of high level psychomotor skills required by future physician take place in an apprentice-style model of 'See One, Do One, Teach One.' This apprentice-style of learning is no longer considered acceptable because of the increasing concern for the quality of patient care and safety and change in health care systems. The pressure of managed care has shaped the forms and frequency of hospitalization and led to a higher percentage of acutely ill patients and shorter inpatient stays. This has resulted in fewer opportunities for the medical learner to access a wide variety of diseases and physical findings. Relying on exposure to real hospital patients during training years may result in an ad-hoc method of learning clinical skills, as this depends on the availability of cases, and consequently to less than optimal development and performance of clinical skills. There are many reports that indicate concerns for the level of skills medical graduates even in western countries possess.[6,7]

The acquisition of expertise in clinical medicine requires the learner's engagement in deliberate practice of desired learning outcomes. According to Issenberg *et al* (2002)[8] "Deliberate practice involves (a) repetitive performance of intended cognitive or psychomotor skills in focused domain, coupled with (b) rigorous skills assessment, that provides learners (c) specific, informative feedback, that results in increasingly (d) better skills performance, in a controlled setting." Concerns about patient safety and fewer available patients for learning, and many other factors have led to the introduction of simulation and the development of simulation centers and clinical skills laboratories in medical education.[9,10]

SIMULATION

Aviation and aerospace industries have been using simulation as a teaching tool for many years. Simulators are now widely used in education and training in a variety of high risk professions and disciplines, including the military, commercial airlines, nuclear power plants, business and medicine.[11] Recently, the inclusion of clinical skills training into the curricula of medical students has seen significant growth. There are many examples of curricular reform that include clinical skills training, the use of simulators, and the creation of clinical skills centres.[12] Simulation has been defined as a situation in which a particular set of conditions is created artificially in order to study or experience something that is possible in real life; or a generic term that refers to the artificial representation of a real world process to achieve educational goals via experimental learning.[13] A simulator is defined as a device that enables the operator to reproduce or represent under test conditions phenomena likely to occur in actual performance. On the other hand, simulation based medical education can be defined as any educational activity that utilizes simulative aides to replicate clinical scenarios. Simulation tools serve as an alternative to the real patient. Trainers can make mistakes and learn from them without the fear of distressing the patient.[14] Experiential learning, which is a part of the definition of simulation, is an active process during which the learner constructs knowledge by linking new information and new experience with previous knowledge and understanding. Experiential learning or learning from experience during simulation based training sometimes involves the use of clinical scenarios as the bases of learning.[15,16] The practice of scenarios can be done individually, but it is mostly carried out by a team from the same or different specialties or professions in a simulated environment made to resemble the intended environment as closely as possible in order to immerse students in an experience closest to real life.[17,18] The practice of a scenario can be videotaped for immediate feedback to participants during the debriefing sessions.

Debriefing after a scenario is an important component of full-scale simulation. Video recording of the scenario is also used to initiate discussion and to make sure that all

learning objectives were covered. Debriefing can focus both around the cognitive process involved in the recognition of the problem and the implementation of the management guidelines and the technical level at which the ability of the learner to apply rules and appropriate responses in a stressful situation is evaluated.[19]

During the full scale scenario-based training, the learner can acquire such important skills as interpersonal communication, teamwork, leadership, decision-making, the ability to prioritize tasks under pressure, and stress management.[13] However, training through simulation should be viewed as an adjuvant and not a replacement for learning with real patients. Simulation is not intended to replace the need for learning in the clinical environment, so it is important to integrate simulation training with the clinical practice during curriculum development.

SIMULATOR

Simulators are classified into different categories.[20,21] An example of the classification of simulators is shown in Table 1. Simulators can be classified according to their resemblance to reality into low-fidelity, medium- fidelity and high-fidelity simulators.[20] Low–fidelity simulators are often static and lack the realism or situational context. They are usually used to teach novices the basics of technical skills. Example of a low-fidelity simulator is the intravenous insertion arm [Figure 1] and Resusci-Anne [Figure 2]. Moderate fidelity simulators give more resemblance of reality with such features as pulse, heart sounds, and breathing sounds but without the ability to talk and they lack chest or eye movement. They can be used for both the introduction and deeper understanding of specific, increasingly complex competencies. An example of a moderate fidelity simulator is the "Harvey" cardiology simulator [Figure 3]. High fidelity simulators combine part or whole body manikins to carry the intervention with computers that drive the manikins to produce physical signs and feed physiological signs to monitors. They are usually designed to resemble the reality. They can talk, breathe, blink, and respond either automatically or manually to physical and pharmacological interventions. Good examples of high-fidelity simulator is the METI Human Patient Simulator (HPS) which is model driven [Figure 4] and the "Noelle" obstetric simulator which is instructor driven. In general, the higher the fidelity, the more expensive it is.

Virtual reality can also be incorporated into the simulators (mostly part-task simulators) to enhance learning. Virtual reality is best described as a concept of advanced human-computer interaction. Virtual reality varies greatly according

Table 1: Classification of simulators[20,21]

- Part task trainer
  - Plastic-based non dynamic trainers
  - Plastic-based dynamic trainer
  - Virtual reality trainer with low-fidelity haptics
  - Virtual reality trainer with high-fidelity haptics
- Computer-based system
  - Simulated patients
  - Simulated environments
- Integrated simulators
  - Instructor driven simulators
  - Model driven simulators

Table 2: Features of high fidelity simulation that lead to effective learning[22]

- Integrate simulators into the overall curriculum
- Clearly define outcomes and benchmarks for the learners to achieve using simulators
- Learners should repetitively practice skills on the simulator
- Learners should practice with increasing levels of difficulty if available
- Provide feedback during the learning experience with the simulator
- Adapt the simulator to complement multiple learning strategies
- Ensure the simulator provides for clinical variation if available
- Learning should occur in a controlled environment
- Provide individualized (in addition to team) learning on the simulator
- Ensure the simulator is a valid learning tool

to its level of sophistication in its level of realism and of the user's interaction with the virtual environment.[22] A common form of virtual reality involves the use of haptic (touch) feedback to produce a feeling of resistance when using instruments in a simulated environment. This technology is frequently used in endoscopic and laparoscopic dexterity training. High-fidelity and virtual reality simulations can bridge the gap between theory and practice by immersing the learner in a realistic, dynamic, complex setting.

Nonetheless, simulation can only imitate but not replicate reality. The recreation of "reality" or "fidelity" is important for the success of simulation and for the participant. Since some simulators can be used to encourage independent or self-directed learning, they should be integrated into the overall curriculum. However, to make learning effective, important conditions are necessary during simulation practice. The intended outcomes should be predefined and the training carried out in a controlled environment. Effective learning requires repetitive practice and feedback during the learning experience. Issenberg et al[22] performed an excellent systematic review and identified ten features of high-fidelity medical simulation that can lead to effective learning. Those ten features are listed in Table 2.

Figure 1: Intravenous insertion arm

Figure 2: Resusci-Anne

Figure 3: "Harvey" cardiology simulator

Figure 4: METI Human patient simulator (HPS)

Table 3: Advantages of simulation[21,23]
• Practicing hands-on and invasive procedures
• Continuing and repeated practice
• The ability to allow errors to continue to their natural conclusion
• Risks to patients and learners are avoided
• Undesirable interference is reduced
• The opportunity for same scenario to be accessed by multiple students providing similar learning opportunities
• Planning clinical cases based on student need, rather than patients' availability
• Exposure to rare and complex clinical situations
• Immediate feedback during debriefing sessions
• The use of real medical equipment
• Transfer of training from classroom to real situation is enhanced
• Retention and accuracy are increased
• Standards against which to evaluate student's performance and diagnose educational needs are enhanced

SIMULATION BASED TRAINING

Simulation can be used to resemble existing curricular material. The simulated scenarios are realistic enough to engage the students emotionally, thus providing a unique learning experience, where the high fidelity simulator "patient" actually talks, breathes, blinks, and moves like a real patient. Simulation can be adapted to accommodate the need of various medical specialties such as anesthesia, emergency medicine and trauma, intensive care medicine, obstetrics, pediatrics, and radiology as well as for the use of other professionals such as nurses, paramedics, and respiratory therapists.[13,24,25]

Simulation laboratories are quite costly. A single high-fidelity simulator with its monitoring system and other necessary equipment may cost up to $200 000. In addition, synthetic body fluids, replacement skins, bandages, syringes and other supplies are necessary to simulate the experience of treating real patients in a real hospital. The ability to practise without risk must be weighed against the cost of this new technology. Simulation has many advantages, for it results in highly trained medical graduates who are less likely to make life-threatening or costly medical errors.[21,23] Some of the advantages of simulation are listed in Table 3. Employing medical simulation techniques can help move medical training from the old "See One, Do One, Teach One" method into a "See One, Practice Many, Do One" model of success.[26] Simulation-based teaching has proved to reduce risks to both patients and learners.[27,28] It has also proved to be effective in both undergraduate and post graduate education as well as faculty development.[29,30] Simulation can be used in the primary health care setting to improve confidence in performing life-saving skills,[31] clinical skills,[32,33] communication skills,[34] and the quality

of care for patients with chronic diseases such as diabetes mellitus and bronchial asthma.[35,36] Such simulators as part task trainers, computer-based systems, virtual reality and the haptic system, simulated patients, simulated environment, and integrated simulators have been also used effectively to assess and evaluate clinical skills.[10,37,38] The major challenge to medical simulation is the fact that evidence to date is weak in methodology. Most of the published work is descriptive and limited in generalisability. The assumption that such learning is directly transferable to the clinical context is often untested.[39] Only a few studies have shown a direct positive impact in the clinical outcome from the use of simulation for medical training.[40]

In conclusion, the promise of simulation-based medical training offers useful opportunities to reduce risks to patients and learners, improve learners' competence and confidence, increase patient safety, and reduce health care costs in the long run. However, robust research is needed to see if simulation training does actually improve patient outcomes.

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