Review Article

A Review of the Role of Simulation-Based Training in the Operating Room

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Abstract

Today, clinical simulation as an effective educational technique promotes the learning of students by providing clinical experiences in a safe environment, avoiding personal fears and weaknesses, and through interactive activities. The goal of this study is to review and introduce useful and efficient simulators for simulation-based training in an operating room. For this purpose, the keywords simulator, simulation, training, clinical training, operating room training, and simulation in the operating room were used. Articles available in PubMed, Google Scholar, Science Direct, and Scopus databases were searched between 2000-2023, and among the many articles, articles that were directly related to the introduction and use of simulation-based training methods in the operating room were selected and reviewed. Owing to the importance of the operating room as an important therapeutic area, the expansion of collaborative simulation centers, the increasing acceptance of multidisciplinary, interprofessional, and multimedia educational approaches, the abundance of clinical students, the lack of patients and their different compositions, the inactivity of the patient during the examination, and the lack of providing constructive feedback in clinical environments, the use of simulation methods in operating room training is practical. If simulators and appropriate models were used to design, implement, and evaluate educational programs, the results would be more effective.

Keywords: Simulation, Clinical training, Operating room training, Simulation in the operating room

Introduction

Simulation is an educational technology that can facilitate learning and improve learner performance [1, 2]. Along with the evolution of medical education since 1900 and the need to measure the clinical skills of students in the three areas of knowledge, skills, and behavior, access to clinical skills has become a key goal in medical education [3]. Despite doubts about the effectiveness of these products, the lack of communication between different educational centers and the high burden of responsibility to prove the quality of simulation methods has led to a delay in the acceptance of these methods [4-6]. For this reason, most simulators have been introduced during the last 50 years, although the wide acceptance of certain types of simulators, such as Standardized Patients, Virtual Reality, Human Patient Simulations, and mannequins, has taken place in the last decade [7].

Today, clinical simulation as an effective educational technique promotes the learning of students by providing clinical experiences in a safe environment, avoiding personal fears and weaknesses, and through interactive activities [8]. Among the benefits of this method, we can mention improving patient safety, strengthening interactive learning, improving critical thinking processes, problem-solving, being student-oriented, and self-paced learning [9, 10]. Moreover, the use of this method in medical education seems appropriate because of the large number of clinical students, the lack of patients and their different compositions, the patient's inactivity during the examination, and the lack of constructive feedback in the clinical environment [1]. Although the expensiveness of simulation equipment is always one of the challenges of using them [11, 12], recently due to the expansion of collaborative simulation centers, the cost of personnel equipment and programs has decreased and the acceptance of this approach has led to an increase in multidisciplinary training [13]. They have also become interprofessional and multimedia [14, 15]. Reducing the price of simulation equipment, emphasizing evidence-based practice, establishing clinical competence, and focusing on

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patient safety are among the most important reasons for using these methods [9].

On the other hand, the operating room is an important treatment area, which includes about 60% of unwanted hospital incidents [16, 17]. Although most patients recover without complications, this may be due to insufficient experience of the personnel in this area. Sometimes life-threatening problems can occur in patients [18]. Therefore, the use of simulation-based training in surgical environments also improves technical and non-technical skills, such as interpersonal communication, judgment, leadership, teamwork, the surgeon, and the surgical team, and enables them to act in real critical situations and reduce the occurrence of unwanted side effects [19].

Operating room students, as a group of future personnel based on the surgical team, have an abstract mentality regarding the conditions of encountering problems in clinical environments, and the use of simulation-based training methods is recommended to improve clinical decision-making in this group [20]. However, owing to the wide variety of simulators, if a suitable model is used in the implementation and evaluation of this method, one can have more confidence in the effectiveness of the results [21]. Therefore, according to the aforementioned materials, our goal in this study was to review and introduce useful and efficient simulators in simulation-based training in the operating room.

Materials and Methods

This article is a review conducted in 2023 to introduce useful and efficient simulators for operating room training. For this purpose, the keywords simulator, simulation, training, clinical training, operating room training, and simulation in the operating room were used. Articles available in PubMed, Google Scholar, Science Direct, and Scopus databases were searched between 2000-2023, and among the many articles, articles that were directly related to the introduction and use of simulation-based training methods in the operating room were selected and reviewed.

Results and Discussion

The Importance of Simulated Based Training in the Operating Room

Although not harming the patient is one of the principles of professional ethics in medicine, despite the advancement of medical technologies, medical errors remain the most important threat to patient safety. In the United States, approximately 210,000–440,000 deaths occur annually due to preventable medical errors [22]. One out of 50 patients admitted to the hospital died due to unwanted accidents, and two-thirds of these accidents occurred in the operating room [23].

Contrary to popular belief, the causes of many of these incidents in the operating room are not errors related to technical skills, but deficiencies in teamwork, communication skills, management, and awareness of the patient's condition, all of which are non-technical skills related to teamwork. Studies have shown that by using detailed planning repetition and practice of these skills, it is possible to promote teamwork and improve patient safety [16, 24] because about half of the unwanted incidents in the operating room can be prevented by using constructive feedback. Learning from past mistakes and improving teamwork are preventable. Therefore, the final goal of simulation-based training in the operating room should involve the entire team present in the surgical scene, such as surgeons, scrub and mobile personnel, doctors and anesthesia personnel, nurses, and others, to increase their team performance [25].

Creation and Development of Simulation Programs in Colleges

According to Seropian *et al*. many colleges use a three-step approach to establish and develop their simulation centers:1) assessing the degree of willingness of faculty professors to teach based on simulation and how to promote learning from it, 2) selection and purchase of relevant equipment, and 3) appointment of the center manager and support of its equipment and programs [22]. In addition to the necessary equipment for simulation, training on this basis also requires the preparation of educational scenarios that are prepared by the company that manufactures the simulation equipment or by the professors of each department following the learning goals of the students [26]. This is because the focus on the goals and the key skills of precision in preparing scenarios, providing the possibility of feedback and evaluating the performance of practicing experiments under the supervision of professors, and the suitability of simulators with professional needs, promote learning through simulation [27]. It should be noted that effective learning in this method depends on how the teacher and student interact, their expectations, and their roles during the simulation stages. The role of the professor differed according to the purpose of the simulation. In the implementation of the educational program, the professor plays the role of facilitator and during the evaluation of the role of an observer. Therefore, since the correct definition of the professor's role and position in the program can affect the educational results and self-efficacy of students [28], the selection of professors proficient in simulation-based training is an important duty of the faculty [26].

Low Tech/Part Task Simulators

The simulators used in complex educational situations have different types and categories. Ziv *et al*. classified simulation tools used in medical education into the following five groups:1) Tech/Part Task Simulators, 2) Standardized Patients, 3) computer screen-based simulators, 4) Computer Task Trainers, and 5) Realistic Patient Simulators.

Professor David Gaba, a professor at the Stanford School of Medicine and the inventor of the modern patient body

simulator, also classifies educational simulators into five different groups:1- Verbal simulators to play simple roles, 2- Standard patients for evaluating clinical examinations, taking history, checking how to communicate, and the professionalism of students, 3- Part Task Trainers, which are simple anatomical models of different parts of the body in a normal or diseased state; although more complex and modern surgical task trainers are also included in this category, 4- Computer patients, which have an interactive mode and may be displayed on a screen-based virtual world, which are used today instead of standard patients and have reduced costs in various educational centers; and 5) Electronic patients that are in the form of mannequins or virtual reality and can reflect all clinical conditions [29].

One of the most complete classifications for simulation types was presented by Nehring *et al.* who presented simulation as a spectrum of seven components:1) simple and complex skill training tools, 2) role-playing, 3) games, 4) computer-aided training, 5) standardized patients, 6) virtual reality, and 7) integrated touch and simulation systems that models with high or low fidelity are divided [29]. The term fidelity is the degree of closeness of a simulator to existing reality. Simulators with low fidelity are suitable for showing simple and integrated movements without the need for joint movements in teaching psychomotor skills, while simulators with medium fidelity are used for auscultation of cardiopulmonary sounds and checking pulses and cannot show rack movements. Breasts or changing pupil size against light, whereas high-fidelity simulators are full-body computerized mannequins that can mimic the health and illness states of a real human being of any gender, age group, and condition [26].

There is another classification, in which simulation models are divided into four categories: animals, corpses, inanimate objects, and virtual reality. According to the Supreme Council for Accreditation of Educational Graduates in Ophthalmology, the most used simulators in the education of students in this field are virtual reality and animals [30].

Types of Educational Simulators Used in the Operating Room

According to the study by Lotfi *et al*. the use of educational simulators to improve the clinical decision-making of operating room students with an abstract mentality of clinical conditions is also recommended [20]. For this purpose, two groups of educational simulators were used in the operating room.

A: Simulation-based training that improves clinical and functional skills in the operating room. It should be noted that most of these simulators are of the physical type and have low fidelity, but their use can cause the appropriate transfer of cognitive processes used in simulation to perform real clinical functions.

B: Simulation-Based Team Training, which is a combination of training based on simulation and training on the correct method of team functioning, focuses on establishing close communication, awareness of the situation, supporting behaviors, and the supporting structures [30].

Simulators Used in Simulation-Based Training in the Operating Room

These tools, which are used in simulation-based training in the operating room to improve the technical skills of the surgical team, have many categories, including the following [31]:

1. Web Based Educational tools for teaching surgical procedures use symbols, images, and short video films with written descriptions appropriate to the images [32].
2. Computer-Based Video Training, such as guided computer training to fix fractures, or computer-based orthopedic surgery systems that are widely used in teaching basic orthopedic surgery techniques [33].
3. Virtual Learning Environment Systems are more complex educational systems that include a combination of teaching and learning tools to enhance learners' experiences. The components of this system include curriculum design, student tracking, online support for professors and students, electronic communications, and Internet links with external resources. Among these systems, we can mention model software packages, lotus learning space, and WebCT [34].
4. Learning Management System (LMS), which is designed for online and web-based exchanges, is a structured and interactive educational program with the aim of easy access to multimedia content according to the personal development level of each student. According to a study by Dua *et al*. medical resident students who used a structured learning management system controlled by a surgeon obtained better grades than unstructured programs [35].
5. The Fundamentals of Laparoscopic Surgery (FLS) tool, which is designed based on the McGill system for teaching and evaluating the fundamental skills of laparoscopic surgery, and includes educational materials, web-based training, and a simple physical simulator; it also has specific tasks and recommended curricula [36].
6. Simulation-Based Surgical Training (SIM) is used to repeat the clinically required skills. Different types of virtual reality are among the simulators used in this method, including LAP Mentor, which is used in the training of urology surgical procedures [37].

According to a study by Seymour *et al*. the use of virtual reality-based training in surgery significantly improved the performance of surgical assistants in gallbladder removal and caused fewer errors in the study group [38].

Simulators Used in Training Team Skills

Training based on the simulation of non-technical skills is one of the tools based on teamwork, which is designed based on human emotions and how people react to different situations.

The use of this educational method improved clinical skills and strengthened basic competencies in group work at the same time. Among them are the Integrated Procedural Performance Instrument for teaching communication skills [39], and realistic computer-controlled mannequins such as Sim man 3G, which is based on team training and simulates high-risk clinical scenarios to improve crisis management skills in the surgical team [40].

According to a study conducted by Abdelshehid *et al*. to evaluate the technical and non-technical performance of urology surgical assistants in performing partial nephrectomy procedures using Sim man 3G, there were significant changes in the inter-team communication skills and technical performance of these students. This was observed both before and after the intervention. It should be noted that in this study, to further promote inter-team communication, a question-and-answer session was held by faculty professors immediately after the scenario was completed to provide constructive feedback to students [41].

A Model Designed to Intervene and Evaluate Team Skills Based on Simulation

Despite the importance of training based on team functions in the operating room to improve the safety of patients undergoing surgery [42], until 2010, this training was not carried out through the effect of specific training methodologies, and its effectiveness was not confirmed for this reason. Weaver *et al*. decided to provide a codified training model to conduct training interventions and evaluate simulation-based team skills. According to this model, the following steps are suggested in the intervention and evaluation of team skills:1) identification of training goals, desired qualifications, and target population before starting the training course; 2) determination of training strategies and methods appropriate to the content, number of people participating in each team, and how to provide effective feedback during the implementation of the program; and 3) evaluating the amount of learning, changing the behavior of people, reacting to the program, and achieving the goals at the end of the program [25].

The basic competencies intended in this training program include improving communication skills, management of situations, and role awareness, and as a multidisciplinary approach, it covers all people involved in operating room activities [43]. One of the dominant strategies in the design of this program is the Crew Resource Management (CRM) model, which is designed with the aim of team stability, reducing errors through the promotion of the workgroup and the use of all available resources [44]. In addition, in the design, the model can be used to combine training methods based on simulations with other conventional methods such as training videos or explanations of live patients [45]. The number of people in each team is approximately 3-5 people and the duration of the course can be proportional to the volume. The training content varied from approximately one hour to several days. The feedback should be face-to-face and based on the individual's actual performance and should be provided by department professors immediately after the end of each session during a few-minute question-and-answer session [46].

In this article, to introduce and use simulation-based training in the operating room, a review of studies were considered to express the importance, necessity, advantages, and obstacles of the types of simulators used in operating room training and the way of setting up simulation-based training methods [47]. Education through simulation has many benefits, such as providing a safe environment for acquiring knowledge and developing skills through repetition effective learning practice and active participation of students in learning, improving critical thinking, problem-solving skills, clinical judgment, teamwork learning, improving cooperation, and has interprofessional communication and management of emergencies [9]. Despite many advantages of this method, some of the existing obstacles make their use in education difficult, among which the following can be mentioned:

Simulation equipment is more expensive than other common educational tools, needs a large physical space, and requires a long time to plan, prepare scenarios, and teach students in small groups [11], lack of familiarity with professors with simulators and correct operation. They are the need to hold training courses, resistance to changing the common educational method towards simulation-based methods [48], and creating anxiety in professors and students when working with expensive humanoid simulators due to the fear of harming them [49]. However, due to the importance of using simulation in the training of clinical procedures and inter-team communication in the operating room, various methods can be used in this direction, including web-based tools for teaching surgical procedures, computer-based video training, virtual learning systems, learning management systems controlled by professors, laparoscopic and endoscopic surgical principles tools, simulation-based surgical methods training and simulation-based training of non-technical skills in the operating room [29, 30].

It should be noted that the launch of educational methods based on simulation also requires the cooperation of faculties and professors in the preparation and maintenance of equipment, design of training programs and scenarios suitable for the objectives, its correct implementation using a suitable model such as the model proposed by Weaver *et al*. [25] and providing performance-based feedback at the end of the scenarios. Many of the challenges of using this method can be solved to a large extent with proper planning, and educational institutions can develop and expand simulation-based education by understanding the educational potential of this method [50]. Therefore, due to the clinical focus of medical education, especially in the operating room, the widespread use of this educational method is currently strongly felt, and it is suggested that universities provide the necessary facilities, equipment, and educational platforms for the use of this method [51].

Conclusion

Due to the importance of the operating room as one of the important therapeutic areas, the expansion of collaborative simulation centers, the increasing acceptance of multidisciplinary, interprofessional, and multimedia educational approaches, the abundance of clinical students, the lack of patients and their different composition, inactivity of the patient during the examination, and the lack of providing constructive feedback in clinical environments, the use of simulation methods in operating room training is practical. If simulators and appropriate models are used to design, implement, and evaluate the educational program, the results will be more effective.

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