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History of Simulations for Medical Education

A.R. Bobobekov[1], Sh.A. Bobokulova[2]

[1]PhD, Senior Lecturer, Department of General and Pediatric Surgery-1, Tashkent Medical Academy, Tashkent, Uzbekistan;
[2]Assistant of the Department of General and Pediatric Surgery-1, Tashkent Medical Academy, Tashkent, Uzbekistan;

Abstract

The article is devoted to one of the most interesting and important modern trends in medical education — simulation training. The main historical milestones in the development of medical simulators are discussed. The main proven advantages of using simulators in the training of medical specialists in various areas are briefly highlighted and some controversial aspects of their use are shown. An overview of the main classifications of modern simulators is presented. The main provisions on training simulation centers and simulation equipment that saturate them are formulated.

Corresponding author: Sh.A. Bobokulova - Assistant of the Department of General and Pediatric Surgery-1, Tashkent Medical Academy, Tashkent, Uzbekistan, Shokhista.Bobokulova@gmail.com

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Currently, simulation education is one of the main methods of teaching practical medical skills in developed countries. Even in Avicenna's treatises, there are references to original methods of teaching the technique of repositioning bone fragments in comminuted fractures: a ceramic jug was placed in a cloth bag and broken into relatively large fragments, which the trainee had to collect into a whole vessel [1].

The first mention of specialized training devices dates back to the 18th century, when the "Machine" by Angelique du was demonstrated and approved at a meeting of the French Academy of Surgeons. Coudray, chief midwife of the oldest Parisian hospital. Designed to practice midwifery skills, this design was a complex, full-size female manikin with a detailed pelvic region made from real human pelvic bones, cotton, and leather straps. Changing the tension of the belts made it possible to simulate complex childbirth with an anatomically and clinically narrow pelvis. Also included is a baby figurine with realistically movable joints and palpable anatomical landmarks. The demonstration of the machine to the King of France, Louis XV, impressed him so much that a decree was issued according to which Angelique du Coudray was appointed responsible for the training of midwives and doctors throughout France in midwifery [2]. Later, similar simulators were created in the UK, Germany and Japan. However, until the middle of the 20th century, training manikins were mainly used only for training nurses and midwives.

The need to train physicians in standardized manual skills and, as a result, the development of appropriate commercial proposals appeared in the middle of the 20th century, when Peter Safar developed and substantiated the modern system of cardiopulmonary resuscitation in 1957 [3]. Already in 1960, the Resusci mechanical simulator was created. Anne, which, after being refined together with the author of the CPR technique Peter Safar, became suitable for training in the full cycle of cardiopulmo-

nary resuscitation and remains popular to this day.

The development of computer technologies has inevitably led to their application in medicine in general and in simulation training in particular. So, in 1965, the first standardized robot patient SIM 1 (SIM One) was developed - a machine that reproduced the symptoms of various diseases using a lying mannequin with imitation of breathing, heartbeat, pulse and pupil diameter, which responded to the "introduction" of a wide range of drugs and gave the opportunity to practice cardiopulmonary resuscitation skills.

Although the project was not commercially successful and soon closed, after 3 years the Harvey robot simulator appeared, which is still being produced in a significantly modified form. It was capable of reproducing up to 25 cardiological diseases and allowed the trainee to perform some active actions, in particular, cardiopulmonary resuscitation. This project was commercially more successful. The release of analogues of such simulators was started in Japan already in the 70s [4].

The next stage in the development of simulators was the emergence of mathematical models of physiological and pathological conditions of the cardiovascular and respiratory systems, as well as the interaction of an analogue of the body and drugs. The development of these technologies led to the creation in 1988 of the CASE device (comprehensive anesthesia simulation environment) is the first simulator for anesthesiologists based on the mathematical models described above [5]. In the Gainesville apparatus Anesthesia Simulator , an independent developer project from Florida, was the first to apply accurate simulation of gas exchange [6] .

The development of surgical simulators followed a slightly different path. The pioneers here were the US military specialists who began to develop the Trauma rescue medical capsule program. Pod in the late 1980s They assumed the combination of evacuation, diagnostic and treatment programs with minimal human participation, which required the creation of computer models of the anatomical structures of the human body. The data obtained in the course of this work prompted the idea of the possibility of their use in the training of surgical specialists.

Another important stimulus for the development of surgical simulators was the development of laparoscopic surgery, which required the development of completely new motor stereotypes, in particular, preparation for the fulcrum effect (acquisition of a sense of depth and eye-hand coordination, etc.).

Although at first many surgeons used box simulators for training, since 1984, attempts began to create a simulator that allows not only to rebuild motor skills, but also to develop the skills of tactile and visual perception of the abdominal cavity using laparoscopic instruments. This project, developed by scientists from the Karlsruhe Research Center, was called KISMET, and in 2000 the commercial simulator VEST (Virtual Endoscopic Surgery Training) was put into commercial production.

It implemented a number of advanced solutions such as 3D visualization and feedback mechanisms. Unfortunately, the high price and ongoing discussions in the medical press about the feasibility of medical training in general reduced the sales of the simulator to a minimum, and the project was considered commercially unsuccessful. The first company to achieve commercial success with a video laparoscopic virtual simulator was Ethiskill (a division of Ethicon Ltd.) with the MIST simulator.

To date, the priority in the development of simulators is aimed at creating the so-called hybrid simulators, which allow practicing the joint actions of doctors and nurses of various specialties. A wide range of such products is presented as foreign manufacturers. In the latter case, there are a number of advantages associated with the pricing policy, the ability to manufacture simulators "to order" using specific equipment used by the customer in everyday practice, as well as simplifying warranty service.

Thus, at the moment there is a huge range of different devices for simulation training, which differ in the quality of simulation, price and training capabilities of medical specialists. For a more detailed acquaintance with this topic, the article discusses the specific advantages of such simulators, the issues of their classification and organization of the educational process.

Since the advent of the first medical simulators, the feasibility of their use has been widely discussed. Opponents of simulation training pointed to the low realism, high cost and dubious effectiveness of simulators.

The discussion on this topic is ongoing to the present, but in the 80-90s. a number of scientific and practical discoveries forced the old questions to be formulated in a new way. These noticeable changes include a sharp increase in the prevalence of endoscopic interventions, which required surgeons to master fundamentally new techniques and create reliable mathematical models of human physiology and pathophysiology. There was a need to develop powerful small-sized and inexpensive computers capable of coping with the tasks of adequately simulating the functions of the human body. Thanks to them, the medical simula-

tor market currently has a huge list of products that differ in realism and price.

Thus, at the moment, three main questions regarding the effectiveness of simulation training can be formulated as follows:

— what is the real effectiveness of medical simulators at different levels of education?

— what is the place of simulators in the structure of medical education?

— How should training be organized on medical simulators?

Of course, the solution of all three issues is beyond the scope of this article and requires serious comparative studies for each model of the simulator, but at the moment, based on the literature data, we can postulate the following. Simulation training improves the quality of manipulations in ordinary and, above all, stressful situations in anesthesiology, allows achieving and, using high-class simulators, maintaining the quality of nursing manipulations, increases the quality of patient care for beginners, increases the frequency of successful minor surgical interventions, reduces the number of complications when performing surgical and obstetric-gynecological interventions after a course of simulation training. It has also been proven to improve role and team functioning when training surgical and anesthesia teams on medical simulators. The successful experience of using simulation devices in the research of technical innovations in medicine, comparing various methods of surgical interventions or the safety of technical medical devices is described.

At the same time, the results of studies on simulation training in ultrasound research methods remain ambiguous.

A unified system for organizing training on medical simulators has not yet been developed. However, at the present level, there is a tendency to collect simulators available to a medical or scientific and educational institution into single educational units. The advantages of such a scheme are obvious: specialized personnel for organizing training and maintenance of equipment, reducing operating costs due to the availability of a single set of consumables, the possibility of organizing team training, providing a territory for installing large-sized simulators (for example, simulators for ambulance teams).

The place and share of simulation education in the structure of education depends mainly on the nature of the medical specialty in which it is carried out. At the moment, there are a huge number of training schemes, the verification of the effectiveness of which is difficult due to the lack of generally accepted standards for simulation equipment, and, as a result, difficulties in comparing the results of its application. But the expediency of simulation training in medicine is recognized in most countries of the world. There are various organizations involved in the formation of standards in the field of simulation education, although the certification of equipment and training centers is in most cases voluntary, and their main task is to promote the development of simulation education.

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