

**ІСТОРІЯ РОЗВИТКУ СИМУЛЯЦІЙНОГО  
НАВЧАННЯ СТУДЕНТІВ-МЕДИКІВ**

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**HISTORY OF SIMULATION-MEDICAL  
STUDENTS 'SIMULATION EDUCATION**

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**Чорненька Жанетта, Грицюк Марьяна, Бидучак Анжела, Доманчук Тетяна. История развития симуляционного обучения студентов-медиков.** История медицинской симуляции насчитывает много тысячелетий и неразрывно связана с развитием медицинских знаний, научно-технического прогресса и военными заказами. Так, успехи химической промышленности обусловили появление пластмассовых манекенов, прогресс компьютерных технологий определил создание виртуальных тренажеров и симуляторов пациента. **Цель исследования.** Описать исторические этапы становления симуляционного обучения студентов-медиков. **Методология исследования.** В статье использованы описательный, библиосемантический и историко-сравнительный методы. **Обсуждение результатов исследования.** В статье отражена история развития стимуляционного обучения в мире и, в частности, в Украине, современный подход и актуальность внедрения симуляционного обучения в медицинских ВУЗах. Показано формирование и структуру учебно-практического центра симуляционного обучения, его роль в усвоении знаний и умений в процессе подготовки врачей-специалистов. **Выводы.** Симуляционное обучение позволяет повысить усвояемость учебного материала, качество и эффективность учебного процесса, дает возможность не только увидеть и услышать, но и отработать на манекене, способствует формированию мотивации студентов к обучению.

**Ключевые слова:** симуляционное обучение, симуляторы, манекен, студент-медик.

**Introduction.** Currently, there are a number of ms facing medical education, the main ones being the nge in students' preferences for teaching style and the need to reduce the gap between theory and clinical practice. In addition, increasing attention is being paid to patient safety, ethical issues, increased responsibility of health als, the high level of professional qualifications required, and the rapid evolution of procedures and methods. All this requires the adaptation of curricula using all available cational tools.

At the same time, traditional forms of health education do not offer any particular process to ensure that training is completely safe and effective before a healthcare provider begins to actively work with patients. In addition, current forms of physician competence control are largely tent or inadequate.

Simulation training in medicine can help to overcome these problems, starting with higher education and ng education.

**Aim of investigation.** Describe the historical stages in the formation of simulation training of medical students, to analyze the traditional forms of control of the level of petence of future doctors in comparison with the on of simulation technologies of training, computer and virtual modeling of various clinical situations.

**Setting the main material.** The modern history of

training using dummies in medicine began only in the 60's. Nowadays little is known about medieval medical simulators, and the first documentary evidences and products that have survived to this day were the French generic phantoms of the eighteenth century. Ange 2lique Marguerite Le Boursier du Coudray (1712-1789), who went down in history as Madame du Coudre, invented her own method of simulation training with the help of a phantom. The daughter of eminent physicians, she became the head of the "Parisian Asylum of Paris" – the oldest and only public hospital in Paris at the time. According to her sketches, a "machine" was made to demonstrate and work out help during child-birth, later known throughout Europe<sup>1</sup>. In 1758 it was approved by the French Academy of Surgeons as a textbook. Angelique and King have done a tremendous service to France – over 25 years of educational work, Madame du Coudre has managed to train about 5,000 sub-surgeons and more than 500 surgeons. In the future, other industrialized countries began to pay attention to the training of doctors and nurses with the help of phantoms and mannequins<sup>2</sup>.

With the development of polymer chemistry and the advent of electronics, preconditions have emerged for the creation of modern plastic dummies with electronic control. Peter Safar, Head of Anesthesiology at Baltimore City Hospital (USA), developed the principles of CVR (cardiovascular resuscitation) and divided the process into

<sup>1</sup> Ahlborg L., Hedman L., Nisell H., Fellander-Tsai L., Enochsson L. “Simulator training and non-technical factors improve laparoscopic performance among OBGYN trainees”, *Acta Obstet Gynecol Scand.*, 2013, N 92(10), P. 1194–1201 [in English].

<sup>2</sup> Balasundaram I., Aggarwal R., Darzi L. A. “Development of a training curriculum for microsurgery”, *British Journal Oral Maxillofac Surgery*, 2010, N 48(8), P. 598–606 [in English].

three stages for mnemonic: A (Airway); B (Breathing); C (Chest compressions). In 1957, Peter Safar published a book, ABC of Resuscitation, detailing the basics of CVR that turned over the concept of emergency care. His work has caught the attention of doctors around the world. Dr. Bjorn Lind was able to inspire his story about the latest in the medical discovery of his acquaintance, Norwegian businessman Asmund Laerdal, and he produced the first prototype of a mannequin to work out artificial respiration. The simulator was presented to the medical community in 1960. Because the face of the mannequin was made from a plaster cast of the face of an unknown French girl who sank in the river Xena in the XIX century, the mannequin was given the trade name Resasci Anne<sup>3</sup>.

The first full-length computer simulator for anesthesia was designed at the University of Southern California in the mid-1960s. Engineer, Doctor of Engineering Stephen Abrahamson and therapist Judson Denson, in collaboration with Aerojet General Corp., have developed SIM 1. Functional features of the SIM 1 simulator include blinking eyes, pupil's diameter, lower jaw that protrudes. The simulator's chest was moving while breathing, the heartbeat was synchronized with the pulse on the temporal and carotid arteries and was consistent with blood pressure. The simulator responded to medications from the large list and involved working out the techniques of restoring the airway.

A little later, in 1968, at the University of Miami (Florida, USA), a dummy was designed to test the skills of diagnosing the condition of the cardiovascular system. Its creator, Dr. Michael Gordon, named the Harvey trainer in honor of his teacher. The model reproduced different variants of breathing, pulse, blood pressure, noise and heart tones, which corresponded to 25 different cardiovascular pathologies. Later, as technology evolved, similar models were released, such as the Japanese Simulator K. The Harvey dummy itself is still being released, of course, in a more sophisticated way, using modern computer technology. At present, the number of pathologies is reproduced to 30<sup>4</sup>.

An important step in the development of medical simulators was the development in the early 1980's of mathematical models of physiological processes of the cardiovascular and respiratory systems and their interaction with medicinal substances. Mathematics described not only the static picture, but also the successive changes that occur in the human body as pathology develops the correction of the state by pharmacological preparations and the implementation of resuscitation measures. Modeling physiology was a prerequisite for the creation of robotic patients whose prototypes were independently developed by two groups of American researchers – from Stanford (California) and Gainesville (Florida). A Stanford University research team created an android in 1986 called CASE – Comprehensive Anesthesia Simulation Environment. To simulate the monitoring, a commercially available physiological parameter graph generator was used in the simulator. Measurement of blood pressure using a cuff was guided by an automatic program installed on one of the first personal computers. Further modifications revealed the possibility of occlusion of

the main bronchus, intravenous infusions, mask and endotracheal artificial ventilation of the lungs with their auscultation, but the model was not provided with such usual functions today as spontaneous breathing and palpation of the pulse. David Gabby in 1992 together with prof. Jeffrey Cooper (Harvard School of Medicine) conducted the so-called "Great Simulation Experiment" in Boston, which was attended by 70 clinicians undergoing CRM training in anesthesiology (Crisis Resource Management). During the experiment, convincing evidence was obtained of the effectiveness of simulation technologies, which resulted in the establishment of a Center for Medical Simulation in Harvard in 1993.

Simulation is a simulation of the actual process or operation of a system over a period of time. The use of simulation as a method to acquire practical skills and training is called simulation training<sup>5</sup>.

It may be a misconception that simulation training is the training of certain procedures and manipulations on simulators. This is a really important part of the learning process, but by no means the only one. For example, when receiving childbirth, overall success depends not only on individual knowledge, skills, but also on the coordinated and effective work of the entire team of working physicians.

Insufficient training may in the future lead to a medical error. According to the US Institute of Medicine, around 400,000 deaths worldwide are annually caused by avoidable medical errors. Therefore, the most important tasks of modern higher medical education are to create the conditions for the qualitative training of highly qualified specialists, to develop and consolidate practical skills without the risk of harming the patient and developing the ability to make quick decisions and perform most manipulations and interventions perfectly.

In a stressful state, the number of mistakes that healthcare professionals make is significantly increased – even in procedures that they previously worked out on simulators in a quiet situation. Therefore, imitating the real situation in a particular specialty, you need to teach students, cadets to act properly and in a state of intense nervous tension. As you can see, simulation training has to solve a much wider range of tasks than just working out on special simulators of motor skills to perform certain manipulations and procedures. Equally important is the development of so-called non-technical skills – the ability to make decisions, leadership and organizational skills, team communication and support skills, and more<sup>6</sup>. If this approach is followed, the mankind's adaptability (level of computerization, feature set, etc.) is not a determining factor in the success of simulation training.

Recently, interest in simulation medical training in Ukraine has been increasing. Equipment appears, new training centers open. In order to make full use of the potential of simulation training, it is important to follow an effective methodology, to establish co-operation between simulation centers and to properly train teachers capable of organizing the learning process in the light of current experience.

In Higher State Educational Establishment of Ukraine "Bukovynian State Medical University" the principle of simu-

<sup>3</sup> Cannon W. D., Nicandri G. T., Reinig K., Mevis H, Wittstein J. "Evaluation of skill level between trainees and community orthopaedic surgeons using a virtual reality arthroscopic knee simulator", *Journal Bone Joint Surg Am*, 2014, N 96(7), P. 57 [in English].

<sup>4</sup> Daly M. K., Gonzalez E., Siracuse-Lee D., Legutko P.A. "Efficacy of surgical simulator training versus traditional wet-lab training on operating room performance of ophthalmology residents during the capsulorhexis in cataract surgery", *The Journal of Cataract & Refractive Surgery*, 2013, N 39(11), P. 1734–1741 [in English].

<sup>5</sup> Duncan J. R., Henderson K., Street M. et. al. "Creating and evaluating a datadriven curriculum for central venous catheter placement", *The Journal of Graduate Medical Education*, 2010, September, N 2(3), P. 389–397 [in English].

<sup>6</sup> Guillaume A. "A typology of educationally focused medical simulation tools", *Medical Teacher*, 2007, N 29, P. 243–250 [in English].

lation in medicine is used in the training of students of clinical departments and doctors-interns in practical classes in the center of simulation training, where the reproduction of the clinical situation in accordance with the topic and purpose of the lesson<sup>7</sup>.

For the equipment of the Center for Simulation Medicine and Innovative Technologies, the University purchased modern equipment: adult simulator work, newborn baby simulator work, dummy imitation dummies, gynecological simulators, dummies for evacuation skills, for difficult intubation, for individual training resuscitation, injections, auscultation training simulators, infant care dummies, etc. Thus, the Code Blue III Adult and Code Blue III Neonate simulator robots make the most of a variety of clinical situations and refine the physician's

tactics, sequence of actions, and provide leadership and teamwork skills<sup>8</sup>.

The simulation is in accordance with the clinical scenario. You need to specify the parameters of the situation and enter into the program possible ways to solve it. If the command is not working correctly, there are complications, if correct - the monitors can see the stabilization of parameters. Also important is the preparation stage for the simulation: what equipment to use, what to tell the participants, or reveal to them what they will now have to work with, etc. The simulation itself can take a short time – 10 to 20 minutes. Following is a discussion of the clinical case and the “work on mistakes” of the team. This is also a very important component of learning.



An extremely important and responsible part of simulation training is debriefing, that is, after-script discussions that take place in the appropriate rooms<sup>9</sup>. Defibrillation uses a set of techniques and rules, a list of questions, and more. During debriefing, teachers, together with students or interns, review and analyze videos of team actions, not only the technique but also the various aspects related to non-technical skills – communication and teamwork, decision making, the role of the leader, the distribution of tasks, the efficiency of use of all team members, etc. Teachers and students collectively identify successes and positives, key challenges, and come to the conclusion that what needs to change is to make the team work better and more effectively. Debriefing is a topic that needs special attention, and effective debriefing techniques greatly increase the benefits of training.

The simulation form of training is the most optimal for providing emergency and urgent medical assistance when working out scenarios in the emergency room and cardiopulmonary resuscitation room. In this case, it is possible to model the object more fully and realistically in a certain situation, to obtain the necessary theoretical and practical knowledge, to develop specific skills, without harming human health.

In the hall of cardiopulmonary resuscitation, the skills of providing the upper respiratory tract patency are performed by various methods, technique of artificial lung ventilation, basic resuscitation measures (technique of performing indirect cardi-

ac massage and artificial ventilation of the lung) using automatic defibrillator, recognition of heart defibrillation.

There are simulators available in the treatment room that allows you to practice your intramuscular, intravenous, subcutaneous, intradermal injection skills. Hand-held simulators in the form of an adult arm and a child with a realistic venous network allow developing the technique of staging a venous port with the establishment of an intravenous infusion through the system for intravenous infusions, as well as conducting blood sampling for examination. Realities are provided by simulated blood simulators.

Functional dummies are installed in the maternity room, which allows absorbing the necessary practical manipulations on obstetrics (Leopold techniques, external uterine massage, manual separation and removal of litter, overlay of obstetric forceps and vacuum extractor). The simulator of a woman allows you to master such practical skills as: palpation of the mammary glands, determining the degree of opening of the cervix, the method of insertion of the preterm part of the fetus, listening to the sounds of the heart of the fetus, reproduction of various variants of placental placement, imposition of vaginal sutures, to evaluate the course of delivery and to predict<sup>10</sup>.

In the gynecological room there is a model for teaching methods of gynecological examination allows you to acquire practical skills in diagnostic gynecological procedures by examining anatomical structures, palpation of the ab-

<sup>7</sup> Heitz C., Eyck R. T., Smith M., Fitch M. “Simulation in medical student education: survey of clerkship directors in emergency medicine”, *Western Journal of Emergency Medicine*’s, 2011, N 12(4), P. 455–460 [in English].

<sup>8</sup> Jamal M. H., Rousseau M. C., Hanna W. C. et. al. “Effect of the ACGME duty hours restrictions on surgical residents and faculty: a systematic review”, *Academic medicine*, 2011, N 86(1), P. 34–42 [in English].

<sup>9</sup> Miller M. D. “Simulations in medical education: a review”, *Medical Teacher*, 1987, N 91, P. 35–41; Miskovic D., Wyles S. M., Ni M., Darzi A. W., Hanna G. B. “Systematic review on mentoring and simulation in laparoscopic colorectal surgery”, *Annals of Surgery*, 2010, N. 252(6), P. 943–951 [in English].

<sup>10</sup> Palese A., Trenti G., Sbrojavacca R. “Effectiveness of retraining after basic cardiopulmonary resuscitation courses: A literature review”, *Assist Inferm Ric*, 2003, N 22, P. 68–75 [in English].

dominal cavity, the introduction of dilators and mirrors. This simulator allows for various gynecological studies: examination of the vagina and vaginal part of the cervix in the mirrors;

bimanual study; evaluation of different positions of the uterus; probing of the uterus; introduction and removal of the intrauterine contraceptive.



The mannequin, which simulates a one-year-old baby with movable handles, legs and head and is in the pediatric room, allows for basic and more complicated pediatric procedures such as bathing and dressing, eye procedures, oral and dental hygiene (movable jaw with teeth and tongue), tube feeding and gastric

lavage, intramuscular injection (thigh), tracheotomy, catheter insertion for girls and boys, enema. Computer-assisted simulators are available in this room to develop cardiovascular examination skills with electrocardiographic monitoring and a respiratory system that simulates a variety of pediatric situations.



The office of simulation training in internal medicine is equipped with a dummy in the form of a real patient's torso for auscultation in various respiratory and cardiac pathologies. The instructor selects one of the heart and lung states by remote control. The cabinet also includes a dummy that simulates cardiac monitoring with cardiac monitoring that allows the instructor to remotely control and change cardiac rhythms. The cabinet is equipped with an electrocardiograph with the ability, in real time, to practice the skills of cardiogram removal on a student volunteer<sup>11</sup>.

The available surgical and traumatological instruments allow the external fixation apparatus to be overlaid.

Simultaneous sterilization equipment with the possibility of preparation of instruments and surgical linen for sterilization, packing of sterilization pens, study of the principle

of operation of sterilizing devices is additionally equipped for the lessons in surgery.

The virtual simulation training room is equipped with an adequate number of personal computers to control the pasting of the material in the form of tests, as well as the ability to conduct simulation training using computer simulation programs.

**Conclusions.** The use of simulation technologies in medicine raises students' interest in the learning process and is an important part in improving the professionalism of future physicians. Simulation training allows increasing the assimilation of educational material, the quality and efficiency of the educational process, gives the opportunity not only to see and hear, but also to work on a dummy, helps to shape students' motivation for learning.

<sup>11</sup> Saleh G. M., Theodoraki K., Gillan S. et al. "The development of a virtual reality training programme for ophthalmology: repeatability and reproducibility (part of the International Forum for Ophthalmic Simulation Studies)", *Eye (Lond)*, 2013, N 27(11), P. 1269–1274 [in English].



**Чорненька Ж.А., Грицюк М.І., Бідучак А.С., Доманчук Т.І.** Історія розвитку стимуляційного навчання студентів-медиків. Історія медичної симуляції налічує багато тисячоліть і нерозривно пов'язана з розвитком медичних знань, науково-технічного прогресу та військовими замовленнями. Так, успіхи хімічної промисловості зумовили появу пластмасових манекенів, прогрес комп'ютерних технологій визначив створення віртуальних тренажерів і симуляторів пацієнта. Сучасний світ високотехнологічної медицини висуває підвищені вимоги до якості надання медичних послуг. Якість медичної допомоги та якість життя пацієнтів мають становити основу оцінки як професійної діяльності окремих фахівців і установ, так і рівня охорони здоров'я в цілому. Тому ключовим завданням сучасної середньої, вищої і післядипломної медичної освіти є створення умов для розвитку в учнів широкого спектру компетенцій і міцно закріплених практичних навичок без ризику заподіяння шкоди пацієнту. Саме таку мету і ставить перед собою симуляційна медицина, яка набула особливо активного розвитку останніми роками. **Мета дослідження.** Описати історичні етапи становлення симуляційного навчання студентів-медиків. **Методологія дослідження.** У статті використано описовий, бібліосемантичний та історико-порівняльний методи. **Обговорення результатів дослідження.** У статті висвітлено історію розвитку стимуляційного навчання в світі та, зокрема, в Україні, сучасний підхід та актуальність впровадження симуляційного навчання у медичних ВЗО. Показано формування і структуру навчально-практичного центру симуляційного навчання, його роль у засвоєнні знань та вмінь у процесі підготовки лікарів-спеціалістів. Нові підходи до медичної освіти, які дозволяють студентам-медикам вчитися та практикуватися і на чужих помилках, і на власних, не ризикуючи при цьому життям і здоров'ям пацієнтів. **Висновки.** Використання симуляційних технологій у медицині підвищує інтерес студентів до процесу навчання і є важливою частиною в підвищенні професійності майбутніх лікарів. Симуляційне навчання дозволяє підвищити засвоєність навчального матеріалу, якість та ефективність навчального процесу, дає можливість не тільки побачити і почути, а й відпрацювати на манекені, сприяє формуванню мотивації студентів до навчання.

**Ключові слова:** симуляційні навчання, симулятори, манекен, студент-медик.

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