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CHAPTER

Simulators in Anesthesia

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ABSTRACT

Simulation in medicine is gaining widespread acceptance as a teaching tool and as an adjunct for competency testing and continuing training. Simulation allows personnel to practice and learn principles in a controlled environment that will better prepare them for the safe administration of health care to patients. This chapter focuses on the equipment available for simulation in anesthesiology teaching and training.

INTRODUCTION

Simulation refers to the recreation of something real by imitation. A simulator is a device or product that is used in simulation.

Medical simulators were introduced in the early 1960s, in the form of manikins designed to aid in teaching mouth-to-mouth resuscitation, and the first computer-controlled simulators were seen in the mid-1960s.[1]

The aviation industry provided the impetus for the development of simulators in anesthesia. Anesthesia practice involves multiple task which requires high degree of vigilance, procedural, monitoring, and decision skill in complex environment. Which is affected by simultaneous interaction between members of team. In anesthesia, a serious complication need to diagnose quickly and correct the problem; also one requires to practice skills in crisis management without harming to real patient.[2]

ADVANTAGES OF SIMULATORS[3-5]

- They simulate a high degree of reality
- No risk for a real patient
- Tasks/scenarios can be created to demand
- Skills can be practiced repeatedly
- Allows for practice on clinically rare scenarios
- Videotaping allows for review
- Simulation can be stopped or restarted for teaching
- Transfer of training from classroom to real situation is enhanced.

SIMULATOR FIDELITY

Fidelity is the extent to which the appearance and behavior of the simulator or simulation match the appearance and behavior of the simulated system.[6] The level of fidelity required depends on the type of task and stage of training and influences skills transfer. Simulators are typically described as low, intermediate, or high fidelity based on this attribute. Fidelity could be physical fidelity (the device replicates physical aspects of the human body), environmental fidelity (the simulation room looks like an operating room), equipment fidelity (the clinical equipment works like or is the real thing), or psychological fidelity (the simulation evokes behaviors similar to the real situation).

CLASSIFICATION OF SIMULATORS

Simulators have been categorized as follows:[7-9]

- Part task trainers
- Computer-based systems
- Virtual reality and haptic systems
- Simulated patients
- Simulated environments
- Integrated simulators
  - Instructor-driven
  - Model-driven.

Part Task Trainers

These are designed to replicate only part of the environment and resembles anatomical areas of the body, e.g., models used to train basic skills, such as intubation, or venipuncture. They are relatively inexpensive.

Computer-based Systems

Computer systems can be used to model aspects of human physiology or pharmacology, simulated tasks or environments and allow interaction with these through a computer interface.

The focus is on learning and on using the information to make treatment decisions and it also provides feedback to the student allows independent learning. These systems are inexpensive.

Virtual Reality and Haptic Systems

It is the ultimate computer-based technology and it presents virtual objects or environments to all human senses which are identical to their natural counterpart.

Haptic (touch) feedback produces a feeling of resistance while using instruments within the simulated environment, which creates the illusion of coming into physical contact with the model, e.g., flexible fiberoptic intubation trainer.

Simulated Patients

They are the highest "fidelity" simulators and its use is restricted to the teaching of communication and interpersonal skills.

Simulated Environment

It is recreating the working environment so multidisciplinary teams can work together, e.g., operating room which gives learners an opportunity to examine their roles within a team.

Integrated Simulators

It is combination of in part or whole-body mannequins on which to carry out interventions with computers. This "drive" manikin to produce physical signs and feed physiological signals to monitors.

Model-driven (high fidelity) simulators are lifelike manikins with computer programs driven by scientifically derived complex mathematical models of respiratory and cardiovascular physiology and extensive pharmacological modeling.

The Medical Education Technologies, Inc. human patient simulator, emergency care simulator, PediaSim are examples of commercially available high-fidelity simulators.

Model-driven simulators make the dynamic interaction and feedback less operator-dependent and hence more complex scenarios can be undertaken. Due to their complexity, model-driven simulators are very costly, both in terms of purchase and running costs.

"Instructor-driven (intermediate fidelity)" simulators combine part or full body manikins with less complex computer programs, e.g., Laerdal SimMan®. The computer software produces physiological signals that are displayed on a computer screen rather than standard clinical monitor and an instructor is required to adjust signs to reflect patient responses.

Cumin and Merry classified simulators based on three features: (i) How the user interacts with the simulator, (ii) its simulated physiology, and (iii) its use (Table 1).[9]

INTERACTION

Screen-based Simulators

A screen-based simulator runs on a computer with no additional hardware. Users interact with it through conventional devices (such as its keyboard or mouse), e.g., Gas Man®, used to simulate the uptake and distribution of anesthetic gases in the body. Screen-based simulators are good devices to acquire technical skills. The advantage of screen-based simulators over hardware-based simulators is their low cost. Screen-based simulators can more readily be used by a trainee alone, without the need for a tutor or actors, which also reduces cost. The disadvantage of screen-based simulators is that they cannot be used to practice psychomotor skills or teamwork.[10]

TABLE 1 Attributes of simulators according to the classification proposed by Cumin and Merry

Interaction	Physiology	Used for teaching
Hardware-based	No physiology	Knowledge
Screen-based	Script-controlled	Cognitive skills
Virtual reality-based	Model-controlled	Psychomotor skills

Hardware-based Simulators

It is also called mannequin-based simulator (commonly used synonyms are full-scale simulator, hands-on simulator, realistic simulator, high-fidelity simulator). The trainees interact in much the same way they would interact with a real patient. The control logic is manipulated through an instructor/operator's station that allows the instructor to create specific patients, select and implement abnormal events and faults, and monitor the progress of the simulation session. It is common to obtain detailed records of the simulation and the actions taken from video and audio recording of the personnel working in the replicated clinical environment. Mannequin-based simulators would probably provide better training for behavioral aspects of crisis management, such as communication, leadership, and interpersonal conflicts (Table 2). Hardware-based simulators usually require more space, as well as other equipment (such as anesthetic machines and defibrillators). The ongoing costs, such as repairs and maintenance, are therefore higher for hardware-based simulators.

Virtual Reality Simulators

Virtual reality refers to a set of techniques in which one interacts with a synthetic (virtual) environment that exists solely in the computer. Using virtual reality, parts or all of the patient and environment are presented to the user by three-dimensional representations with or without "touch" to create a more "immersive" experience. A screen-only simulator could be viewed as a very limited virtual reality simulator.

PHYSIOLOGY

Some simulators have no physiological attributes. Others have computer programmable physiological interactions, e.g., an increase in blood pressure following a fluid bolus. Script-controlled physiology depends on a set of commands (a script) specifying physiological responses. Model-controlled physiology depends on the use of mathematical models to determine the physiological responses to various interventions.

TABLE 2 Functionality of current mannequin-based (high fidelity) simulator systems[6,11,12]

Clinical area	Features and functions
Airway	• Appropriate pharyngeal, glottic, and bronchial anatomy • Placement of face mask, ETT, LMA, LT, combi tube • Laryngospasm, tongue and airway swelling, cervical immobility, jaw closure, breakable teeth • Cricothyrotomy, transtracheal jet ventilation
Head	• Eyelid movement, pupil dilation, and reaction to light or medications • Patient voice and sounds, such as coughing and vomiting (through built-in loudspeaker) • Palpable carotid pulses • Cyanosis by blue light • Tearing
Chest	• Physiologic and pathophysiologic heart and breath sounds • Spontaneous breathing with chest wall movement • Bronchospasm • Adjustable pulmonary compliance and airway resistance • Pneumothorax • Needle thoracotomy and chest tube placement • Defibrillation, transthoracic pacing • Chest compressions
Extremities	• Palpable pulses • Cuff blood pressure measurement • Modules for fractures and wound modules • Intravenous line placement • Thumb twitch in response to peripheral nerve stimulation • Arm movement • Representations of tonic-clonic spells
Monitoring (waveforms or numeric)	ECG (including abnormalities in morphology and rhythm), SpO_2, invasive blood pressure, CVP, PAP, PCWP, cardiac output, temperature, CO_2, anesthetic gases (may have actual uptake and distribution of agents)
Automation	Quality of chest compressions, ventilation rate and volume, defibrillation and pacing (including energy measurement), respiratory gas analyzer, drug recognition

ETT, endotracheal tube; LMA, laryngeal mask airway; ECG, electrocardiogram; CVP, central venous pressure; PAP, positive airway pressure; PCWP, pulmonary capillary wedge pressure.

USE FOR TEACHING

A simulator may be used to teach skills (psychomotor or cognitive) or to impart knowledge.[13,14]

The range of commercially available technologies used in medical simulation range from simple part-task training models to highly sophisticated computer-driven models. No single system is the best choice for all uses, so the decision about the type of simulator required must be based on the objectives and needs of the application.

CONCLUSION

Simulation is an educational technique that allows interactive activity by recreating all or part of a clinical experience without exposing patients to the associated risks. Many applications have been found for simulators in anesthesia including teaching and training, evaluation, and research. The range of medical simulator devices continues to grow with technological advances. These range from simple part-task training models to highly sophisticated computer-driven models. Appropriate simulators must be chosen to address identified key skills or techniques.

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