Simulation in Anaesthesia and Intensive Care

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Simulation is a technique to replace or amplify real experiences with guided ones that evoke or replicate substantial aspects of the real world [1]. Another definition of medical simulation said: "a person, device, or set of conditions which attempts to present evaluation problems authentically. The student or trainee is required to respond to the problems as he or she would under natural circumstances. Frequently the trainee receives performance feedback as if he or she were in the real situation" [2]. It can be considered as an attempt to reproduce real or imaginary environments and systems to study the behaviours of the subjects and the consequences of their actions in real time. Despite this definition includes a wide variety of experiential activities, in the medical context the term "simulator" normally refers to a device that presents a simulated patient, or a part of a patient and interacts appropriately with the actions of the participant in the simulation setting.

Development of new technologies, more interest for a different way of teaching, awareness of the importance of continuous medical education moved physicians to consider simulation as a crucial step in the learning process. Anaesthesia seems to be an ideal field where simulation can offer advantages without risks. Till now, students and residents have learned how to intubate, to perform an epidural injection, to resuscitate a patient only 'on the field', including the risk of damages to the patient. Ethic issues, legal quests and the need for more practice to improve surgeons' and anaesthesiologists' skills brought to the development of centres of advanced simulation all around the world, some of these especially dedicated to

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anaesthesiology and critical care. The more we have to improve patient's care, the more simulation centres increase their different and specialistic proposals.

Simulation: WHY?

"Tell me and I forget, teach me and I may remember, involve me and I learn" stated Benjamin Franklin. This is the summary of what is represented in the Learning Pyramid (National Training Laboratories, Bethel, Maine): the retention rates grow from passive teaching methods, like lecture, reading, using of audio-visual support, to the participatory teaching methods like group discussion, practice and the immediate use of the new knowledge. The simulation is located at the basis of the Pyramid and is considered one of the best available way to fix a concept in the learning process.

It is only when something goes wrong that the ability and competence of a physician is bought into question, increasing the culture of blame. The traditional way to teach and learn medicine is still based on junior doctors that have to 'see one and then do one' hoping 'not to harm one' before [3]. New concepts in *medical education* consider more structured and planned curricula and the need to gain and to maintain competence in all aspects of clinical practice. Simulation not only referred to new practitioners. It offers a way to evaluate individual performance, to improve personal skills, and also to test the ability of a team to solve a problem. The concept of Crew resource management was developed by the aviation industry in 1970 and transferred to medicine changed into *Crisis resource management*. It refers to the ability, during an emergency, to translate knowledge of what needs to be done into effective real world activity [4]. It includes also non technical skills as communication, leadership, situational awareness and teamwork. In 1999, the US Institute of Medicine published a report [5] documenting the extent of the problem of human errors in medicine and challenged the existing view that errors resulted from individual recklessness. Instead they suggested it was faulty systems, processes and conditions that led people to make mistakes or fail to prevent them. Protocols, algorithms, but also *educational programmes* resulted to be the new way to face off the problem of human errors. So simulation probably offers an answer to many teaching and training questions about medicine and primarily anaesthesia learning process. Some institutions as US FDA, American College of Surgeons, American College of Surgeons (ACS), American Board of Anaesthesiologists (ABA) have already required a simulation-based training for some of their qualifications [6]. The American College of Chest Physicians (ACCP) published an Evidence-Based Educational Guidelines about simulation as educational tool [7].

The unsolved question is: does simulation training improve operational performance at the bedside and patient outcome? Many studies have demonstrated the effectiveness of simulation in teaching basic medical knowledge [8], procedural skills [9], teamwork features [10], communication methods, at different level of medical instruction, from students to residents. Despite this, some systematic reviews showed that it is not easy to demonstrate if medical simulation as teaching tool really improves outcome of the patients or if educational outcomes influence

the clinical effectiveness of the interventions [11]. A limit is often represented by the assessment tool chosen to measure the result, that in different studies has not be validated [12]. Moreover, the quality of the published articles in this field is generally weak [13] and is hard to obtain data of good quality to fix clear conclusions [14, 15].

The unquestionable benefit of medical simulation is to provide a safe virtual environment where mistakes are permitted and also considered as an opportunity to teach the trainee the implication of his error and to correct and organise his future behaviour [16]. Some errors are inevitable, but living errors in a simulation setting can allow participants to improve their emotional control and to have a better management of the situation if it happens again with live patients [17]. Avoiding 'learning on the job', in simulation settings patients can suffer injuries and even death due to management or practical errors. Participants can discuss their faults in a briefing session and be more prudent to face off the same problem in the real life. The ability to react carefully in an expected situation is one of the most critical factor in creating a positive outcome in medical emergency. Furthermore simulation allows to deal with unusual and complex situations or clinical conditions seldom or never observed in a lifetime. These peculiar features led some authors to define simulation-based medical education as an ethical imperative [18].

Simulation HOW?

The concept that simulator is the basis of a simulation centre is almost dangerous. Simulator is only a tool and, whenever it could be complex and advanced, it needs a team, time, competence and, first of all, a good project. So, once you know what you want to do (curriculum), where you want to do, then buy your simulator.

Educational technologies in medical simulation are divided into three categories: Web-based education, virtual reality and human patient simulation [19]. The Web-based simulation, or e-learning, includes also some experience of simulation of a different way of life. Second Life is a world created on the net where some avatars act as real individuals; it has been used as educational tool in medical field [20], implementing the ability to manage a medical problem in a virtual society.

Virtual reality reproduces a realistic not-real world where is possible to interact with the ambient and subjects mimicking usual and unusual clinical settings. Medical simulation can also be performed in a computer-based way: a simulated scenario is created by a software and the participant tries to solve some quests as in a videogame. It is called microsimulation [21]. The main advantage of this approach to simulation is the possibility to create an unlimited number of scenarios but the participants are often less involved in the action.

The human patient simulation refers to the use of high fidelity simulators that reproduce human patients or part of them. There are a huge amount of simulators in the market that can simulate almost everything. The term 'simulator' generally refers to technology that recreates full environment where to carry out some tasks, but simulation can be performed also using a doll on the floor or a picture of a patient. It depends on the topics that you want to teach. Different simulators were

created and marketed from the first 1960 [22, 23]. The first modern simulator was Resusci-Anne (Laerdal®), a half body of a girl intended for chest compression and ventilation. The last and most advanced one is the Human Patient Simulator (HPS) (METI®), specifically designed for training in anaesthesia, respiratory and critical care. It has the ability to provide continuous gas exchange analysis and haemodynamic monitoring using real physiological clinical monitors. HPS is able to measure the partial pressure of oxygen, carbon dioxide and nitrogen in its lungs, and, based on that, it calculates a real-time blood gas analysis using a mathematical formula. To perform such complex features, it needs a dedicated room with a control deck, a medical gas supplier, a hydro-pneumatic system and a lot of space. HPS can simulate almost every kind of patient because of its ability to set physiological parameters as arterial elastance, baroceptors sensitivity, lungs or chest wall compliance, pulmonary oxygen shunt, volume responsiveness and more over. It can recognise more than 150 different drugs by an identifying bar code and modulate pharmacological effects based on age, weight, physical or haemodynamic conditions. Each parameter can be measured and HPS reacts to physical or mechanical stimuli (photomotor eye reflex) in a physiological way. It can be defibrillated using a real defibrillator machine.

The key word in human patient simulation is 'realism' [24, 25]: the more the participant involves himself in clinical scenario, the more he learns from it. Concerning on this topic, the recreated ambient is also crucial: an operatory room, an emergency department, an intensive care unit must be as realistic as possible, promoting the interaction of trainers with objects.

To perform a simulation project, a simulator is not enough. The main part of the knowledge process during a simulation course is the debriefing session. After the simulated scenario, participants discuss their performance in a plenary session: each clinical choice can be analysed referring on clinical guidelines; mistakes can be underlined and corrected. This step needs a video-recording system and a screen to project the previous recorded performance, according to the latest assumptions about the debriefing session [26]. Trainee can look at his choices and behaviours from a different point of view and can analyse it in a critical way. The combination of brief frontal lessons, micro- and macro-simulations and a debriefing session can probably result in the best way to enhance the strength of a topic during a medical course.

Simulation: WHAT?

Everything can be simulated. Using micro- and macro-simulation, it is possible to create courses about anaesthesia (aortic clamping, anaphylaxis, malignant hyperthermia…), critical care (septic shock, extracorporeal membrane oxygenation management, infections control, …), emergency (basic, advanced and trauma life support, …), communication and more. It is possible to explain the pharmacokinetic and pharmacodynamic proprieties of a drug using microsimulation and to verify its clinical effects in a macro-simulation scenario. The neonatal resuscitation algorithm can be performed in the safest way using neonatal simulator [27]. A rapid access to trachea in a can't ventilate-can't intubate scenario can be obtained

without any risk for the patient. The communication of a tragic event, as a brain-death, can be approached by any medical student facing a simulated crying relative.

Simulation is also a research field where is possible to test new way of teaching [28], new medical devices, behaviours or human beings dealing with stressful or unusual situations. A new device intended for emergency transtracheal ventilation can be tested on a high fidelity human patient simulator measuring continuous blood gas analysis and average tidal volume ventilation [29].

Simulation WHO?

The staff of a simulation centre is the core of the project. In a medical simulation, knowledge, experience and hours of training are needed to get the best performance on stage. Otherwise, the hidden work in the backstage by administrative and audio–video technicians is crucial to manage a simulation medical course. The activity of a simulation centre can be addressed to academic education supplementing frontal lessons with simulated sessions for student or residents; or it can involve physicians and nurses/technicians to improve their knowledge or to refresh some main topics. The ability of tutors to perform as actors, to guide the participant in a foreign ambient, to understand the limits of clinical skill and to discuss the way to overcome these limits, are important feature for the success of a simulation course.

4.1 Fundraising

A simulation project is an expensive project. Money is needed not only to buy a simulator, to build or to arrange the ideal space where to perform the action. They are needed to keep on with the activity considering the staff and the service costs. A good manager must plan a financial project to let a simulation centre to survive. A solution to the problem could be to address a part of the activity to private company: for example, some drugs, medical devices or monitoring systems could be better understood in their application by physicians if explained in a simulated setting. Other solutions could concern European grants for educational or research projects in medical simulation. It's hard to begin, but it is harder to keep it on.

4.2 Simularti

Simularti is the simulation project of Institute of Anaesthesiology and Intensive Care of Padova (Italy). It was born in 2007 and has performed more than 120 medical courses, trained 1,234 physicians on more than 25 topics on anaesthesia and intensive care medicine. Participants came from Veneto region (28.9 %), other Italian regions (52.3 %), and 45 different countries (18.8 %) as China, India, Brasil, Germany, Russia and more over. Furthermore, medical students and

Fig. 4.1 Scenario of the course: coagulation disorders during major surgery

residents of Padova University can change theoric concepts into practical activity, supplementing frontal lessons with simulation scenarios (Fig. 4.1).

The centre is equipped with METI HPS, Laerdal SimMan and SimBaby, different difficult airway training simulators, epidural and spinal trainers, echo-fast simulator and a new transthoracic and transesophageal echocardiac simulator (Heartworks, UK). The last one is a new simulator intended to teach and improve the use of echocardiography by visualisation of ultrasound cardiac image next to a 3D heart model. The difficult in reconstruction 3D cardiac anatomy from 2D slices can be overcome by this simulator [30]. The simulation centre applies a multidisciplinary

approach to the medical simulation, encouraging the collaboration between different specialists as paediatrics, cardiologists, radiologists, pneumologists.

4.3 Conclusion

Simulation technology is a powerful tool for the education of physicians and other healthcare professionals at all levels.

Evidence-based education and training are the new basis of medical educational programs. Simulation will never replace the interactions learned through experience with real patients but it is a powerful and effective educational tool to maximize physician and other health professional training [2]. The cost-effectiveness of a simulation-based medical educational program must be considered in terms of improvement of clinical competence, patient safety and error reduction in the era of limited resources [31].

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