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Virtual Reality and Simulators in Surgical Education

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Humans have used simulation to acquire a large variety of skills from the dawn of history. Looking closely at children's games, one can see that from ancient times games were not only pastime activity but a complex, intricate way by which children (and adults) learned various skills; physical, emotional, behavioral and social. Simulation can be defined as any process that enables a person to perform a task in an artificial environment, that enables different actions that will not result in harmful consequences, and will enable the performer to repeat, or rehears a task until a certain level of confidence, or proficiency, is reached. Simulation is used almost in any field in our life. From a flight simulator game, through the planning of a new home, to learning the structure of the solar system or the life of dinosaurs, humans use simulation on all levels of age, skill and purpose.

The use of **structured** simulation to teach specific skills or tasks developed first in new industries that were involved in high risk procedures, like the aircraft industry, nuclear industry and military training. Being allowed to make mistakes and learn from them in a protected environment, both for the performer or the subjects, is a powerful educational experience and as an opportunity for professional improvement. The medical "industry" was late to adopt simulation and integrate it into the educational process. Traditional medical education was (and in many ways, is) based on several paradigms that are of questionable value. First, it is almost exclusively aimed to teach students, and not geared to "adult" education for fully trained doctors. Second, It is based on the traditional learning process of learning "theoretical" material, and learning how to later apply it in the real world by the extensive use of the apprentice-master approach. These basic paradigms are no longer suitable to the way medicine is practiced today. Most practicing doctors need to learn new skills throughout their careers, and knowledge changes so rapidly that the practicing physician has to adopt and learn new techniques and skills, and enhance his knowledge constantly. The apprentice-master system is not suitable for such a rapidly changing environment, and is also inefficient for teaching skills in a defined period of time, to a crowd of learners.

In addition, the availability of computerized patient management systems and the need for increased cost effectiveness, force us, the physicians, to measure our performance and allow external evaluators to look at eh way we treat our patients and stand against criticism.

Surgery is potentially a wonderful field for the application of simulation as a tool. It requires both deep knowledge of the various systems on our body, understand pathophysiology of many diseases, but also physically act upon these situations, and involve in high-risk medical activities. Specifically, simulation can be used in learning and testing in all levels of knowledge in the surgical field:

1. Acquisition of basic manual skills: Performing

surgery requires basic manual skills, like dissecting, suturing, safe use of energy sources, stapling, etc. All these skills may be learned outside the operating room in a protected environment not involving patients. These skills can be learned simply be practicing on artificial materials or ex-vivo tissues in a rather simple simulation.

2. Acquisition of endoscopic surgery skills: These skills are rapidly becoming "basic", as more than 50% of surgical procedures are performed endoscopically. Minimally invasive skills demand a higher level of eye-hand coordination, and can be learned in box trainers or virtual reality simulators.

3. Learning and rehearsing complex procedures: The paradigm that one has to operate in order to learn a specific operation is only partially true. With virtual reality and physical simulators using artificial organs or ex-vivo animal tissue one can reach a basic proficiency level at performing an operation, like a laparoscopic cholecystectomy, before ever touching a patient. This type of training enables the student, be it a resident or a trained surgeon learning a new procedure, to make mistakes, study various techniques of using instruments in a environment resembling the real situation, and later analyze his or hers performance with the supervision of a skilled surgeon in a debriefing session. This type of training can be used not only to teach procedures but also bring the trainee to extreme conditions , like bleeding, injury to an organ or patient instability, and train performance under pressure.

4. Training patient-specific procedures: the use of powerful virtual-reality simulators enables simulation of patient-specific procedures. As an example, a commercially available virtual reality simulator (Simbionix Angio-mentor) enables feeding a patient's CT-Angiogram of the carotid arteries into the simulator, and then enables the performing of angiographic carotid stenting on the simulated anatomy of the specific patient. This enables the rehearsing of a potentially dangerous procedure, choosing the ideal catheters and approaches, and reducing radiation times before approaching the real patient, thus saving costs and reducing risk to both patient and team.

5. Team training: Simulation can be use not only to train and individual but also to train teams of all kinds, like surgeons , or an entire operating room team consisting of surgeons, nurses and an anesthesiologist. It can involve the use of virtual reality simulators both for the surgeon and anesthesiologist, and physical simulation to simulate a life-like operating room environment. Activity can be recorded and analyzed in a debriefing session with skilled observers.

6. Proficiency testing: To create a training program based on simulation one has to define benchmarks for proficiency in a given skill or task. Once these are defined, simulators can be used not only for training these skills but also for testing trainees for credentialing. This can be from simple suturing tasks to comples performance of a safe laparoscopic cholecystectomy or the safe dissection of the inferior mesenteric artery during colectomy. These benchmarks can also be used to build a complete training program, defining required skills for every stage of surgical training, and incorporating simulation training and testing as a parallel track to the traditional training of a young surgeon.

7. A tempting, but not yet well defined use of simulation, is testing candidates for surgical training: To become a good surgeon one doesn't need only the theoretical knowledge and deep understanding of diseases and patient care but also needs to have basic capabilities of acquiring manual skills, eye-hand coordination and performing complex physical tasks. To date there are no benchmarks for understanding what are the basic talents one possesses that increase the chance for him or her to become a good surgeon. However accumulation of data on surgical trainees may allow us to create a comprehensive test, or even score, that will predict the chances of a specific candidate to become a good surgeon.

The use of simulation for surgical training can be on several levels of simulators:

1. Simple, physical simulators. These can be home-made boxes or training tools for specific skills and tasks. They can be purchased or made, and are useful for teaching simple tasks and skills, including microsurgery skills.

2. Complex physical simulators. These involve artificial models or ex-vivo animal tissue to train on more complex tasks, such as endotracheal intubation, insertion of a venous catheter of chest drain etc. Some simulator platforms, like the Tubingen simulation tool, allow the use of ex-vivo animal organs for the simulation of complex laparoscopic or endoscopic procedures like TEM.

3. Virtual reality simulators. These tools are complex, expensive machines that allow a big variety of training modules, from basic skills to complex, even patient-specific, procedures. They create a real-life environment and allow making errors and seeing the real consequences like bleeding, organ injury and patient instability. To date, no available simulators have a realistic force-feedback, or haptic properties, that give the user an experience closer to real life, but it seems this will be overcome soon. Virtual reality simulators have more advantages. They enable precise measurement of performance on many levels, the creation of a personalized training program with proficiency testing, and the accumulation of a large database of trainees for research and evaluation.

4. Multi-modal simulation. In several places around the world multi-modal simulation centers were developed (a good example is MSR - http://www.msr.org.il/e/). These centers allow the training of medical personnel on all levels, acquiring skills from basic technical skills, communication skills and teamwork on all levels.

The politics of simulation training is not simple. The mindset of trainers in the medical and specifically in the surgical professions, has to change to allow a more structured, comprehensive training method. Training suddenly becomes a field that requires investment, and the gap should not be filled by medical device companies that have an invested interest in teaching specific skills and tools that are in line with their commercial ambitions. Benchmarks and programs should be defined and studied in academic, non profitable institutions for the sole purpose of improving the efficacy of training, improving cost-effectiveness of the care we provide, and enhance patient safety.

The making of a surgeon is no longer in the hands of his personal teacher. It is our responsibility to look openly into various alternatives to the making of a good surgeon and choose the best one for our times.