# Simulation as a teaching alternative: Utopia or reality?

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## Background

It is increasingly apparent that the professional prerequisites for surgical specialists have changed dramatically during the last decade. As medicine is an inherently developing field, doctors have always struggled to stay on top of new developments in their specialties, but in surgery this is compounded by the introduction of a completely new method for doing operations: laparoscopy.

Teaching and training this completely new method should fit within the scope of the existing conventional surgical techniques (ST); even in the face of budget cuts and increased demands on output. In truth few clinics can realistically offer ST candidates, i.e. residents, enough exposure to mentors and experience in the operating room. This implies severe difficulties for the individual surgeon to gain sufficient experience during medical training to be certified as a specialist. Pressure from patients who are not willing to go through procedures where a relatively inexperienced doctor's involvement can prolong the duration of the operation, and increasing operating room costs for resident training are additional factors in the equation. An illustrative example: a basic operating room is billed hourly at 10000 SEK (1000 USD); additional instruments and equipment are billed separately.

The importance of laparoscopy in general surgery and gynaecology is unquestionable; it is the de facto golden standard for surgical treatments in many areas. The advantages of laparoscopy are obvious; even complicated operations can be carried out highly precisely with a minimum impact on the patient. This implies substantial advantages for the individual and for society at large, which is well documented in a variety of studies which paint a convincing picture of the enormous value of this technology. This is especially timely in a climate where hospital budgets are shrinking and health care systems are searching for ways to minimize queues for treatment and operations under pressure from large-scale efficiency programs. An additional benefit is the quick recovery of patients who have been treated using laparoscopy.

This new method for performing operations puts great demands on education and training since the individual surgeon has to function in a new environment with completely different prerequisites as compared to conventional surgery. The difficulty of fulfilling these standards is reflected in an increasing frequency of reported complicated cases in gall bladder surgery. In Great Britain, for example, this type of problem is painfully obvious as evidenced by regular media exposure.

An argument against this reasoning is that we already have a cadre of highly educated surgeons with substantial experience who were educated within the existing system. Is the education problem real? After having met a relatively large number of surgeons, ranging from established experts to beginners, from Sweden as well as from abroad, I am forced to admit that the answer is yes. With few exceptions these surgeons identify the lack of operating room access and teaching hours as the most severe problems, and not seldom in combination with increased patient resistance to resident participation in the operation. An additional factor is the highly subjective impression of changing attitudes of surgeons which mirrors similar developments in society at large. For example, resistance to activities taking place outside of business hours, when many of the most instructional cases often develop, is apparent in recent years. Societal factors and obligations have an increasingly high priority even for serious medical students.

In order to attract new colleagues to the profession, the educational program must be adapted to these modern demands. The fact that there are vacancies for medical residents in the US for the first time in history is one of many signs of change. In the long run this might lead to serious consequences such as a shortage of specialists.

## Requirements on new training methods

The problems discussed above have led to a need for new, effective ways to train the new generation of laparoscopic surgeons. These must be complementary to traditional programs without being expensive and time consuming. An ideal would be to hold all training outside of the operating room where the surgeon would learn all of the fundamental and even advanced surgical techniques. During the training phase the surgeons would thus be able to tailor their training and practice to their own needs independent of the availability of real cases. The results of the practice are used for feedback to the candidates, and the teachers can follow the development of learning. Formal examination and certification could also be possible which would make a basic certification possible before contact with real patients is allowed, thus increasing legitimacy. This in turn implies that the need for time consuming, and therefore expensive, basic training in the operation room would be dramatically reduced; the ST candidate would instead focus directly on the critical steps in the problem at hand.

Until now the most relevant alternatives to human subjects are box trainers and surgery on animals. Box trainers enable training in basic laparoscopic methods with the disadvantage that the results are not measurable, thus development and progress cannot be compared, and that re-equipping the box for each practical moment requires a substantial time investment. On top of this, the candidates find the practical training with these boxes to be unrealistic and boring. Operations on pigs is the golden standard for laparoscopy as well as open surgery despite the disadvantage of a limited number of nonetheless expensive animals, and the question of ethical treatment of animals (opinion on this issue varies dramatically from country to country).

## Simulation, a complementary method?

Computer based training has been on the agenda for nearly a decade. The potential is great, and the requirements of efficient training outside of the operating room mentioned above are fulfilled. It is especially appropriate for practising minimally invasive techniques, especially since the surgeon receives information from the operation area via a two-dimensional picture on a monitor. The operating field can be recreated in the computer as well as the instruments needed for the procedure. The surgeon uses replicas of authentic instruments and their movements are shown on the computer monitor. Movements are calculated several thousand times per second to ensure a realistic situation. This technology even ensures the feeling of contact, with tissue or instruments, is transmitted to the operators hand; this is called force feedback. The simulations can even be used for training in open surgery, although certain problems in visualization must be solved; mainly with respect to three dimensional vision which is possible using computer screens with semipermeable mirrors in combination with 3D glasses.

The most important advantages of using the simulation can be summarized:

- unlimited possibilities for practising in a realistic scenario with complete freedom to compose complete programs of different content;
- tailored education adapted to individual needs and goals;
- objective measurement of progress and competence; and
- quality assurance through certification, of either operating surgeons of processes through comparison with established expertise, or well defined standards for achievement.

The critical reader will ask himself why these laparoscopic simulation tools are not established as a regular part of surgical training and education in light of all of these unique properties? A central problem is the inability to fulfil the profession's demands on realism and functionality. The first (semi-experimental) applications developed were built on an immature technology which was completely useless in clinical work. At the same time these first steps made the first territorial gains, and technological developments have accelerated since then. Important development factors include dramatic increases in processor capacity and graphics processing cards which makes the creation of virtual environments which are so realistic that in some cases they cannot be distinguished from the true operating environment. New schemes have been developed which integrate digital video sequences into the virtual environment. A continuous flow of new developments driven by the video game industry is another important factor.

A common expectation is that the virtual environment should be an exact copy of reality and can be used to recreate a complete surgical procedure. To achieve these goals additional developments in both computer processing and in graphics are necessary as well as new solutions on a fundamental programming level to realistically visualize deformation of large objects such as intestines or stomach. In light of the recent rapid development pace it is reasonable to expect that these developments will be achieved within two years.

Reasoning along these lines it is however easy to forget the step wise learning from basic skills to more complex comprehensive tasks finally to finished procedures. The primary goal of this training is not imitation of reality, but is to focus on the critical steps which need to be learned. Experience has shown that a high degree of realism is needed in order to capture the interest of the user and make it meaningful, without necessarily needing to imitate the true situation in detail. The simulation package offers a complete alternative for practical training of basic skills in minimally invasive surgery such as cutting, clip applying, haemostasis and suturing. More complex skills and compound steps such as dissection of blood vessels and bile ducts can be practiced with the new products which have been released recently.

Whether the goal is to train basic skills or more complex skills it is highly important that the new tools are stimulating, interesting and challenging. In other words it should be fun to practice, a certain degree of competition between different participants can be stimulating, but in turn requires that the results and achievements be quantified.

The technology can even be used for more than simply training manual skills. Information stress, decision making and training in human factors are further examples of applications which are well adapted to computer aided learning environments.

That the new tools have not yet become accepted by the surgical profession in more than a limited capacity is often motivated by a deeply rooted conservatism and an unwillingness to change routines which have existed for many years. This may very well be the case, younger ST colleagues are much more enthusiastic than established specialists. This is, however, likely a meaningful simplification.

The doubters become fewer in numbers when the latest technical advancements are presented with a high degree of realism and design motivated by the needs of the profession. Still we must require that data from well planned studies actually confirm that the skills developed in a computer generated environment can be effectively transferred to the operating table: 'from VR to OR'. Further, design, realism and functionality must meet the stringent requirements while those who train their skills find the tool stimulating. Still another important factor is the need for a restructured educational program where this type of training tool is integrated.

One tool which has been developed to fulfil the goals outlined above is *LapSim*. The simulation software, including a demonstration version, is found on the web site [http://surgical-science.com/](http://surgical-science.com/).

The *LapSim* instrument setup is shown in Figure 1. The instructor is following the work of the student controlling the instrument replicas whose movements are seen on the computer monitor. The virtual operating field is also shown on the monitor.

**Figure 1.**

Some examples where the virtual tools are implemented in the procedure simulations are shown in Figures 2a and 2b. Examples covering more features of *LapSim* can be found on the web site.

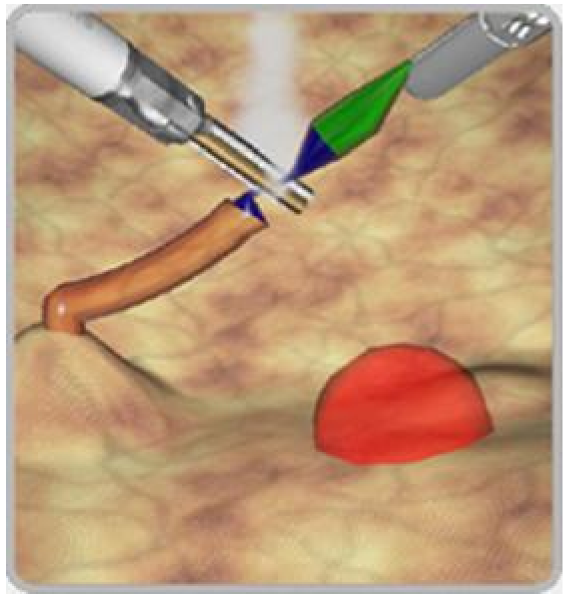

**Figure 2a. Graphic from the module for developing camera navigation skills. In this exercise the camera is the left instrument. The object is to find the red ball on the tissue surface, zoom up to it and match its size to the on-screen circle. If this fails, the ball disappears, after a few seconds. If not, the ball turns green. The camera is then held steady until the ball disappears. The next ball appears, and the exercise is repeated. If the camera touches tissue, this is indicated by the screen turning red.**

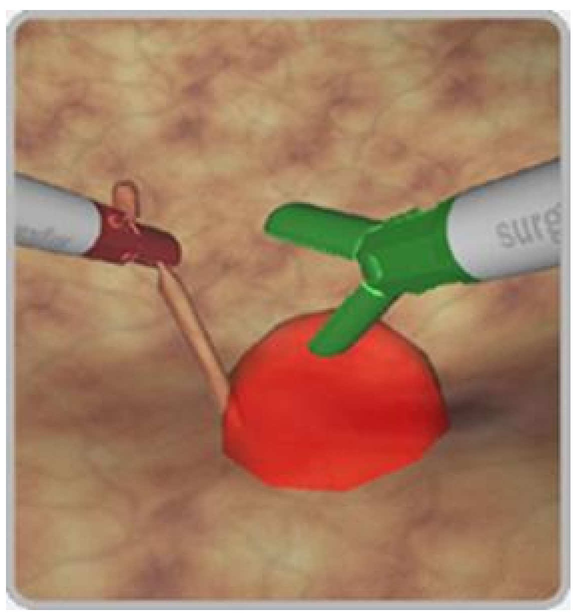

**Figure 2b. Graphic from the module for training grasp techniques. The two instruments are manoeuvred according to instructions from the program. Immediate feedback is given to the student.**

The requirements outlined above are being filled. A number of validation studies have been published which support the concept that computer based training is effective, and that the effect of this training is measurable in the operating room (see, for example, the validation report on the *LapSim* web site). Further, specialized training centres are being established at an increasing number of hospitals mainly in the US, where specialists have the possibility of well structured training with tools such as computer based tools and simulations. Strategies for how to effectively integrate these tools and methods into educational programs are being established. This type of organized training centre can be seen as an element of competition between different hospitals. An additional factor towards acceptance of the concept is the cost efficiency aspect: the more that can be learned in the training laboratory instead of in the operating room, the greater the economic interest in the technology. The list of references chosen below directs the interested reader to more information on the subject.

Search engines such as Google (http://www.google.com/) with search key 'laparoscopic simulation' will provide more information.

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