



# Simulation in surgical education: mentors' point of view

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**Abstract:** Simulation allows surgical trainees to practice in a safe and standardized setting. Reduction of working hours, financial need of efficiency, and ethical dilemmas over patient's safety have motivated the development of surgical simulation. Currently, a wide variety of surgical simulators are available with a broad range from simple and economic models to highly sophisticated and expensive ones. Some of them are used to train basic surgical skills, and others offer realism and opportunities to train entire surgical procedures. Acquisition of surgical skills and improvement of intraoperative performance are main advantages associated with simulation. High-fidelity simulated operating rooms also allow for training teamwork technical and non-technical skills such as response to intraoperative crisis scenarios or communication skills among team members. In addition, simulation is very useful for practicing surgeons who want to embrace new technologies in their practice. On the other hand, costs, limited manpower resources, and lack of standardized simulation curricula are significant challenges of surgical simulation. While in some countries surgical simulation is already well-established, in others simulation is not yet formally included in the training curricula. As simulation is a key component of surgical education, further efforts are needed to formally incorporate simulation in every surgical residency program.

**Keywords:** Surgical simulation; education; training; surgical residents

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## Introduction

Simulation allows surgical trainees to practice in a safe and standardized setting. Several changes in our health care system have motivated the development of surgical simulation: reduction of working hours (80-hour resident work week), financial need of efficiency (necessity of shorter operative times and shorter admission times), and ethical dilemmas over patient's safety (1-3).

Currently, a wide variety of surgical simulators are available (broad range from simple and economic models to highly sophisticated and expensive ones): box-lap trainers, virtual-reality platforms, 3D printed artificial models, animal-based tissue blocks, cadavers, and live animals among others (4-7). Some of them are used to train basic surgical skills, and others offer realism and opportunities to train entire surgical procedures (Figures 1 and 2).

In some countries like the United States, surgical

simulation is already well-established. In fact, the Accreditation Council for Graduate Medical Education (ACGME) has determined that surgical training programs in the US must ensure the availability of simulation which "must address acquisition and maintenance of skills with a competency-based method of evaluation" (8). In other countries, however, simulation is not yet formally included in the training curricula.

In this manuscript, I aimed to describe advantages, disadvantages and potential challenges of surgical simulation based on my experience as a surgical educator.

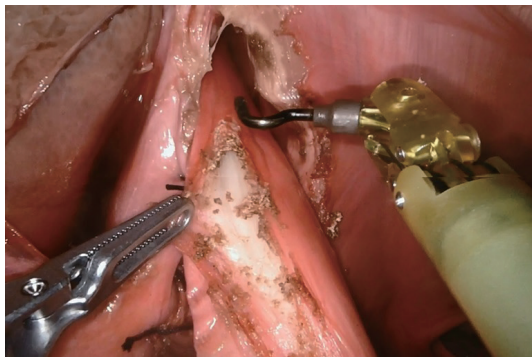
## Advantages of surgical simulation

I believe surgical simulation has several strengths that should be highlighted:

- ❖ Acquisition of surgical skills: It is already proven that surgical skills can be adequately acquired



**Figure 1** Box lap trainers allow for training basic laparoscopic skills.



**Figure 2** Entire surgical procedures can be simulated with the use of perfused animal tissue blocks (Robotic Heller Myotomy).

and mastered with the use of simulation. For example, a previous randomized trial showed that trainees undergoing simulation for laparoscopic cholecystectomy were 9 times less likely to fail to make progress and 5 times less likely to injure the gallbladder or burn nontarget tissues, as compared to those without simulation (9). A recent study also demonstrated that robotic surgery simulation increases confidence levels among senior residents for port placement, docking process, suturing, use of energy devices, and use of staplers (10).

- ❖ Improvement of intraoperative performance and reduced operative times: Simulation training before performing a “real case” in the operating room helps reducing operative time. From my experience, the difference is clearly noted in surgical steps such as laparoscopic suturing, in which residents with hours of simulation perform better and faster. In fact, a randomized trial proved that training on either a virtual reality simulator or on a box trainer

significantly decreases the learning curve necessary to learn laparoscopic suturing (11). In addition, a systematic review analyzing 10 randomized trials and one nonrandomized comparative study confirmed that most skills acquired by simulation-based training are transferable to the operative setting (12).

- ❖ Improvement of team-based surgical skills: High-fidelity simulated operating rooms currently allow for training teamwork technical and non-technical skills (response to intraoperative crisis scenarios, team performance, situation awareness, decision making, communication skills among team members, etc.) (13).
- ❖ Adoption of novel procedures / new devices: Surgery is a rapidly evolving field and novel devices and procedures are constantly available. Simulation is very useful for practicing surgeons who want to embrace new technologies in their practice.
- ❖ Training during a pandemic: Although COVID-19 pandemic has affected almost every aspect of the healthcare system, surgical specialties have been specially troubled by a decline in their activity. A recent study showed how the quarantine associated with the pandemic provoked a decreased in the number of procedures performed by surgical residents (14). Increased hours of surgical simulation can potentially help to mitigate the lack of clinical training during pandemic times (which unfortunately may occur again in the future).

### Disadvantages and challenges of surgical simulation

Surgical simulation is also associated with potential disadvantages or challenges:

- ❖ Real world surgical training is irreplaceable: Although simulation indeed helps obtaining proficiency of surgical skills, some aspects of real operations cannot be taught in a simulation laboratory (e.g., real tissue feeling, live human anatomy, stressed generated by intraoperative complications). In other words, simulation helps but it has certain educational limitations. Educators should be aware of these limitations, exploit all the learning tools that simulation training provides and finally teach and supervise trainees in real cases.
- ❖ Costs: The cost of creating a simulation laboratory

can be as high as \$1 million and maintaining personnel, materials, and equipment can represent expenses of up to \$55,000/year (15). Therefore, costs are an undoubtedly limitation for the adoption of surgical simulation in low- and middle-income countries.

- ❖ **Manpower resources:** Besides the financial burden of simulation, the limited availability of faculty to teach outside the operating room is another barrier. Well-trained trainers with dedicated time for simulation are critical for the success of training activities.
- ❖ **Lack of standardized training curricula:** Although there are some validated programs of education and assessment such as the fundamentals of laparoscopic surgery (FLS) (16), we still lack comprehensive simulation curricula addressing all the components of surgical competency (cognitive aspects, technical skills and non-technical skills).

### **Simulation in surgical education: yes or no? If yes, how?**

Interestingly, many current practicing surgeons did not have simulation activities during their training. In fact, I did not have the opportunity to train in a simulation laboratory as a trainee. However, we should not be proud about that. It would be inconceivable to allow a pilot to fly a plane with passengers without prior training in simulators. Similar to the aviation industry, there are now high-fidelity surgical simulators. Therefore, surgical simulation should be mandatory throughout the residency in order for trainees to safely perform on patients.

Simulation must be formally incorporated in the surgical residency curriculum in order to be an effective educational tool. Episodic and opportunistic simulation activities on a voluntary basis (“gym modality”) should be discouraged. Residents should rather have protected time for simulation activities with instructors guiding and teaching them.

As expenditures may limit the use of simulation in some institutions, development of low-cost and useful surgical simulators is still needed. Resources should also be properly administrated; while junior trainees can reliably learn basic skills with simple low fidelity models, sophisticated simulators with higher fidelity are more important for senior trainees learning complex procedures. Finally, return on investment analyses demonstrating that potential cost savings from shorter operative times, decreased

intraoperative complications, and better handling of surgical equipment might outweigh the high expenses associated with simulation are needed. These types of analyses might help convincing hospital administrators and policymakers that simulation is critical.

### **Conclusions**

Simulation is a key component of surgical education that should be formally integrated in every surgical residency curriculum. Well-trained trainers with dedicated time for simulation are critical for the success of this educational tool. In addition, further efforts are needed to develop standardized simulation programs with validated simulators.

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