The place of simulation in the surgical resident curriculum. The pedagogic program of the Nice Medical School simulation center

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KEYWORDS
Training; Laparoscopic simulation; Academic teaching

Summary
Introduction: Surgical training relies on medical school lectures, practical training in patient care and in the operating room including instruction in anatomy and experimental surgery. Training with different techniques of simulators can complete this. Simulator-based training, widely used in North America, can be applied to several aspects of surgical training without any risk for patients: technical skills in both open and laparoscopic surgery, the notion of teamwork and the multidisciplinary management of acute medicosurgical situations.

Method: We present the curriculum developed in the Simulation Center of the Medical School of Nice Sophia-Antipolis. All residents in training at the Medical School participate in this curriculum.

Results: Each medical student is required to pursue theoretical training (familiarization with the operating room check-list), training in patient management using a high fidelity mannequin for various medical and surgical scenarios and training in technical gestures in open and laparoscopic surgery over a 2-year period, followed by an examination to validate all technical aptitudes. This curriculum has been approved and accredited by the prestigious American College of Surgeons, making this the first of its kind in France.

Conclusion: As such, it should be considered as a model and, in accordance to the wishes of the French Surgical Academy, the first step toward the creation of true schools of surgery.

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The French Surgical Academy recommends a surgical curriculum based on a triad including medical school lectures, practical training in patient care and in the operating room including instruction in anatomy and experimental surgery and, thirdly, virtual reality training with simulators [1].

Training at the bedside and in the operating room represents the keystone of preparation for residents in surgery, especially when the ever-increasing complexity of patient care is taken into consideration. However, this traditional form of training is becoming less effective for several reasons including the decreasing didactic impact of hospital rotations because of their heterogeneity [2], the lack of senior physician supervision [3] and, above all, the lack of evaluation of teaching results [3]. The compulsory rest period after being on-call has also considerably decreased the exposure of residents to patient care in hospitals [4]. The didactic efficacy of learning in the operation room has seriously been called into question [5].

Even if the notion of simulation for training is not new [6], the learning techniques through simulation have amplified in recent years because of the development of video-laparoscopy and other new technologies.

The concept of teaching through simulation depends on a defined curriculum, the elaboration of complex technical support and the development of evaluation of learning systems.

Surgery lends itself particularly well to this type of teaching and learning for several reasons. It is possible to learn and retain technical skills using a simulator [7], whether they involve laparoscopic [8–10], endoscopic, or traditional open surgical procedures. Simulation can be applied to the teaching of decision-making aptitudes in various clinical settings, the notion of teamwork, the medicolegal dimensions of surgical practice and particularly to board certification and continuing education. In North America, the medicolegal [11] and economical impact [12] of simulation-based training prior to certification in certain specialties or for “high risk” techniques is now well recognized. Patients may feel reassured to know that their surgeon has trained on a simulator before performing an invasive procedure on their body [13].

Several learned societies have initiated accreditation policies for simulation centers [14]. Health care agencies, such as the English National Health Service of the French Health Technology Assessment Agency (Haute Autorité de santé) are engaged in integrating simulation curricula into their recommendations for initial medical training and continuing medical education. A European consensus group has likewise proposed a competency-based virtual reality training program for laparoscopic surgery [15].

In North America, the place of simulation in surgical training is clearly defined, particularly in the United States: the Fundamentals of Laparoscopic Surgery program, developed by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) [16], must be successfully passed to obtain certification in gastrointestinal surgery [17] and a program of accreditation for medical simulation centers (Accredited Education Institutes) operates under the authority of the American College of Surgery.

The main goal of this study is to present the simulation program that has been introduced in the training of surgical residents at the Medical School of Nice Sophia-Antipolis.

After defining the conceptual basis of simulator training and the methodology used in Nice, we present the curriculum we have developed. The various facets of this program and anticipated future evolutions are then detailed.

Patients and methods

Conceptual basis for simulation in training

Simulation can be defined as an educative process that replaces interaction with real patients by interaction with artificial models, actors or virtual patients [18]. The aim is to recreate scenarios or learning techniques in a virtual reality environment with the double goal of immediate feedback of experience and evaluation of skills and knowledge that have been acquired and retained.

Medical simulation relies on the conceptual bases born out of educational sciences. Kolb’s model provides various learning strategies [19], the concept of deliberate practice [20], the concept of adult learning (andragogy) [14] and learning in different reality settings [21], only to mention the most important.

The mainstream principles guiding these models are as follows: active learning (clearly defined as such by the students), motivation, clear definition of pertinent learning objectives, an appropriate and progressive level of difficulty, targeted and repeated goals, knowledge acquisition built on previous information and/or errors, a teaching program that takes into account the diversity of the students and their previous training and knowledge, articulation with fundamental sciences, precise metrics, immediate feedback, realistic environments, a multidisciplinary approach and feedback re-evaluation [14,20,21].

Simulation techniques also allow improving communication within multidisciplinary teams (in the operating room for instance) [18]. Their application in medicine is derived directly from the analysis of accidents occurring in other domains such as the aeronautical and nuclear energy industries. There are several similarities between medicine and the aeronautical industry as regards the problems, their origins and their solutions [22].

Methodology developed for the creation of simulation programs

A group of university teachers (JPF, JL, DC, JB) collaborated in the creation and development of a simulation center in the Medical School of Nice. This group visited two well-recognized simulation centers (Carl Shapiro Simulation Centre — Beth Israel Hospital — Harvard Medical School, Boston, USA) and an active collaboration between the Nice Medical School and Harvard Medical School was established.

Next, the physical layout and teaching program was set up within the Nice Medical School, financed by the medical school and by the regional government (Conseil général des Alpes-Maritimes) through two successive installments.

The teaching program was elaborated by a pilot committee within the simulation center, including the involved teachers (JB, DC, JL) and other members of the department of medical education within the Nice- Sophia-Antipolis Medical School (JB, DC, JPF).

Structural aspect

The Simulation Center of the Nice Medical School offers three identical suites, each composed of a “medical unit” (a completely reconstituted emergency room, fully equipped with medical material reproducing an authentic clinical environment), a teaching unit (tables, chairs, interactive screen, various audiovisual equipment) for critique.
Simulation material

The choice between the different simulation supports was based on an analysis of the literature, the potentials of each simulator and their availability in France, aiming to obtain comparable and reproducible data.

The audio-visual aids include:
- several audio-visual demonstrations for simple technical procedures (trunk for chest tube placement and introduction of central venous lines, head with laryngopharynx for endotracheal intubation…);
- three "high-fidelity" digitalized mannequins (Simman®) (society Laerdal®), presenting programmable clinical and vital signs, with the possibility of interaction from the participants in the room (Fig. 1).

The surgical simulation aids include:
- five extremely simple apparatuses for open surgery, essentially for learning suturing and knot tying skills (Fig. 2);
- three simulators for simple laparoscopic procedures using real instruments. We preferred the F.L.S® model, which is the most widely used (Fig. 3);
- three virtual reality laparoscopic simulators, two without haptics feedback (Simsurgery®) with one of those which allows training with robotic surgery and one with haptic feedback (LapMentor® Simbionix®) (Fig. 4).

Table 1 shows the material available in the Simulation Center of the Nice Medical School.

Pedagogical team

The persons responsible for the development of the medical and surgical curricula in simulation continually update their knowledge and training, benefiting from international collaboration within these two domains.
Seven surgeons working in the University Hospital Center of Nice are involved in the training of surgical residents. They are specialized in pediatric surgery (JB), urology (DC), thoracic surgery (NV), gastrointestinal surgery (EB, AI, AM) and gynecology/obstetrics (JD). Each of them has a regular activity in laparoscopic surgery (having performed more than 100 laparoscopic procedures [15]). In addition, three are instructors in the Simulation Center (JB, DC, JPF) who teach the use of the simulators and their pedagogic implications.

Target population

The surgical residents participating in the teaching program are:
- first and second year residents, irrespective of their future specialization;
- third and fourth year residents in the fields of general surgery, thoracic surgery, pediatric surgery, gynecology and urology.

Validation of the Simulation Center and the program

The Simulation Center of the Medical School of Nice was certified and recognized by the American College of Surgeons (“American Educational Institute”) and is one of the 61 certified simulation centers throughout the world. The certification process evaluates the architectural, organizational, technical and educational aspects of the program.

The validation of different procedures and items in the complementary simulation teaching program is based on literature analysis and a selection of previously validated procedures (those of the F.L.S® performed on the LapMentor® simulator), or, whenever appropriate, validation standards established by the experts (JB, DC, JD).

Results

Presentation of the simulation teaching program

The teaching program revolves around three axes:
- instruction in surgical techniques including the most usual techniques in conventional and laparoscopic procedures;
- learning to function as a team (for example in the operating room);
- developing clinical acumen in the multidisciplinary management of acute medicosurgical emergencies.

Surgical techniques

Learning the most usual techniques

This is done according to themes: anatomical and technique-related reminders, training on dedicated simulators (fresh swine leg for sutures, heads (laryngopharynx) for intubation…) with direct monitoring by instructor, immediate feedback and repetition of the procedure until complete mastery is achieved.

The technical procedures comprise the introduction of peripheral and central venous lines (including sonographic localization); approaches to intubation of the upper respiratory tract; chest tube drainage; bladder catheterization; simple suture techniques.

Surgical exercises

Several technical skills are taught during the first 2 years of resident training. Some of them constitute exercises that must be successfully mastered by residents before progressing to the next level of resident responsibility.

The exercises retained for the continuous curriculum (first 2 years of the resident training) include

For traditional open surgery:
- suture techniques including simple and vertical mattress sutures, running sutures, knot tying and suture ligature, end-to-end and end-to-side gastrointestinal anastomoses (on foam blocks) and vascular sutures on synthetic models (LifeLike Bio Tissue®).

For laparoscopic surgery:
- the different F.L.S® exercises [16], 0 and 30° camera navigation exercises (SimSurgery® simulator), exercises to develop bimanual and three dimensional manipulation skills (“Place Arrow” and “Retract and dissect tissue” exercise on the Tissue Manipulation module (SimSurgery® simulator), “Basic Task 6” exercise (LapMentor® simulator), coagulation (“Basic Task 8” exercise (LapMentor® simulator), uncomplicated laparoscopic cholecystectomy (Fig. 5: “Patient 1” “Cholecystectomy” module [LapMentor® simulator]).
The exercises required for the validation examination for third and fourth year residents include

Performance of vascular and gastrointestinal (end-to-end and end-to-side) anastomoses in open surgery, validation of all the F.L.S module exercises, validation of 30 camera navigation exercises and performance of laparoscopic cholecystectomy (or management of ectopic pregnancy for residents in gynecology), since each of these procedures requires most of the usual laparoscopic hand movements (exposure – dissection – ligation – coagulation). Table 2 displays the entire curriculum, the validation and failure criteria for each exercise, their origin (literature or local information) and the exercises included in the validation examination.

Teamwork training

Each new resident is asked to view a video on the World Health Organization preoperative checklist, produced in the Simulation Center [23]; this illustrates all potential errors (wrong patient, non-fasting patient, faulty suction device…) that may occur without the use of a check-list, as compared to an error-free preoperative procedure without mishaps, when the checklist is used. This video was filmed in the simulation center using a script conceived by multidisciplinary cooperation between surgeons, anesthesiologists and quality-control managers and was dramatized with professional actors.

Developing clinical acumen in the multidisciplinary management of acute medico-surgical emergencies

This part of training involves residents in simulated medical cases comparable to those proposed to students in the second cycle of their medical studies:

- three residents play the roles of "surgeon", "anesthetist" and emergency physician and manage a "patient" presenting with a medico-surgical emergency in the totally realistic simulated "emergency room". They must examine the "patient", order complementary studies (the results of which are communicated in real time) and make appropriate therapeutic decisions (IV fluid management, antibiotic therapy, transfusion…) during a 15-minute period. The "patient" is a high-fidelity mannequin (SimMan®), controlled by computer from the technical observation desk by an instructor who has regulated vital signs and the physical examination characteristics (auscultation…) at the outset and then adjusts them in accordance with the therapeutic decisions taken by the residents. The instructor can also simulate patient speech, enabling dialogue between the "patient" and the three residents. Depending on the scenarios, communication with the family, the attending physician, or a specialist (a radiologist, for example…) can be simulated. All these roles are assumed by the instructor in charge of the "patient";
- this simulation sequence is followed by approximately 30 minutes of debriefing and commented analysis. This analytic session is divided into two parts. During the first 15 minutes, the instructor who manipulated the mannequin reviews the most important steps of patient management: essential points of information gathered from the history and physical examination, differential diagnosis, investigations ordered and their interpretation, therapeutic decisions and management. Use of a check-list standardizes this initial part. During the remaining 15 minutes, the teacher reviews the diseases involved, highlighting the evidence-based aspects;
- three case scenarios are created: a patient presenting with retroperitoneal hematoma due to coumadin overdose, a patient with severe thoraco-abdominal trauma and a patient with postoperative sepsis following colonic surgery.

Practical organization of the simulator program

The program includes an initial seminar, mandatory continuing training during the first 2 years of residency and an examination for third and fourth year residents, preceded by supplementary training sessions as necessary.

Initial seminar

This 2-day seminar is organized at the start of each clinical year, just before the new residents assume their clinical functions; all new surgical, anesthesia/intensive care and emergency medicine residents registered for the University Diploma in Emergency Medicine (diplôme universitaire de médecine d’urgence) must participate, that is to say, approximately 25 to 30 residents for each seminar.

During this seminar the students:

- role play the scenarios (developing clinical acumen in multidisciplinary management of acute medico-surgical emergencies);
- learn the common technical skills (intubation, thoracic drainage, simple suture…);
- view the video on team work.

Mandatory continuous education

Teams of three to four residents undergo 12 hours of training per year (six 2-hour sessions), always with the same instructor.
<table>
<thead>
<tr>
<th>Support</th>
<th>Exercise</th>
<th>Failure criteria</th>
<th>Duration</th>
<th>Final examination</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.L.S®</td>
<td>Peg transfer</td>
<td>Dropping the peg</td>
<td>Time &lt; 300 s</td>
<td>*</td>
<td>[15]</td>
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<tr>
<td></td>
<td>Precision cutting (swab)</td>
<td>Division &gt; 5 mm from the mark</td>
<td>Time &lt; 300 s</td>
<td>*</td>
<td>[15]</td>
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<td></td>
<td>Endo-loop</td>
<td>Untight knot</td>
<td>Time &lt; 180 s</td>
<td>*</td>
<td>[15]</td>
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<tr>
<td></td>
<td>Extracorporeal knot</td>
<td>Knot more than 3 mm from the mark</td>
<td>Time &lt; 420 s</td>
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<td>[15]</td>
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<td></td>
<td></td>
<td>Untight knot</td>
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<td></td>
<td></td>
<td>&lt; 3 half-hitches</td>
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<tr>
<td></td>
<td></td>
<td>Penrose drain pulled off or torn</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Intracorporeal knot</td>
<td>Knot outside of marks</td>
<td>Time &lt; 600 s</td>
<td>*</td>
<td>[15]</td>
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<tr>
<td></td>
<td></td>
<td>Untight knot</td>
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<td></td>
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<td>&lt; 3 half-hitches</td>
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<td></td>
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<td>Penrose drain pulled off or torn</td>
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<tr>
<td>Simsurgery®</td>
<td>Camera navigation 0°</td>
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<td>Internal data</td>
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<td></td>
<td>Camera navigation 30°</td>
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<td></td>
<td>Retract and dissect tissue</td>
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<td></td>
<td>(&quot;Tissue manipulation&quot; Module)</td>
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<tr>
<td></td>
<td>Place arrow</td>
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<td></td>
<td>(&quot;Tissue manipulation&quot; module)</td>
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<tr>
<td>LapMentor®</td>
<td>Camera navigation 0°</td>
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<tr>
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<td>Camera navigation 30°</td>
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<td>Retract and dissect tissue</td>
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<td>(&quot;Tissue manipulation&quot; module)</td>
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<td></td>
<td>Two-handed maneuvers (Basic Lap</td>
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<td>[25]</td>
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<td></td>
<td>Task 6)</td>
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<td>Coagulation (basic Lap Task 8)</td>
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<td>[25]</td>
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<td></td>
<td>Full procedure cholecystectomy</td>
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<td>[25]</td>
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<td>(Patient 1)</td>
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Table 2 (continued)

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Support</th>
<th>Failure criteria</th>
<th>References</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple 2/0 suture</td>
<td>Mattress</td>
<td>Untight knot</td>
<td>[8] Internal data</td>
<td>Time &lt; 30 s</td>
</tr>
<tr>
<td>End-to-end intestinal anastomosis</td>
<td>10 cm long 2/0 running suture</td>
<td>Poor approximation</td>
<td>Time &lt; 20 s</td>
<td></td>
</tr>
<tr>
<td>End-to-side intestinal anastomosis</td>
<td>4/0 running suture</td>
<td>Poor approximation</td>
<td>Time &lt; 20 s</td>
<td></td>
</tr>
<tr>
<td>Vascular anastomosis with interrupted 5/0 sutures</td>
<td>Ligation (3 throws) instrument tie to 2</td>
<td>Untight knot</td>
<td>Time &lt; 120 s</td>
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</tr>
</tbody>
</table>

The instructor adapts the typical curriculum (type of exercises, rehearsal rhythm following the criteria in Table 2) to the skill level of each resident according to the initial aptitude level and the progress made during the sessions.

Examination of technical aptitude

The residents must pass an examination of their technical aptitude at the end of their training. The examination takes place in the presence of an instructor and each exercise must be validated at least twice to eliminate confounding factors.

Feedback and preliminary results

Technical learning

At the present time, 32 residents in surgery are involved in our continuous education program. The level of progress is currently being evaluated and will be determined by the ability of third-year residents to pass the examination. However, subjective feedback by residents as well as by hospital staff has shown that real benefits can be obtained in terms of technical aptitude.

To date, three residents have successfully passed the technical aptitude examination.

Training in team work

The preoperative checklist video has been presented in several University Surgical Services. The number of items in the checklist and the quality of checklist implementation improved after viewing the video, independently of the type of surgery performed [24].

Teaching a multi-disciplinary approach to acute medicosurgical emergency situations

A questionnaire was sent out to all the participants requesting their assessment of the formative value of simulator-assisted learning. Evaluation was based on a Likert scale (grades ranged from −2 to +2: −2 = strongly disagree; 0 = neither disagree nor agree; 1 = agree [formative]; 2 = strongly agree [highly formative]). In addition, participants were asked to evaluate whether this instruction would have an impact in improving their professional practice (0: not at all; 10 enormously).

The simulator-based instruction was judged as being formative to highly formative (scores ranged from 1.48 to 1.89 depending on the scenario).

The expectation of improvement on profession practice scored 8.85/10.

Discussion

The development of teaching techniques through simulation is still in its formative stage in France, compared to other countries, particularly those in North America.

This is illustrated by the F.L.S® program, with more than 2689 participants and 88% of certifications obtained over the last 5 years [17].

The integration of simulation into the surgical resident training program at the Medical School of Nice started 2 years ago. This was the fruit of reflection on the necessity
of this type of training as well as the expected impact on resident formation.

The teaching program was developed through a review of the recent literature and an analysis of the available American and European curricula; it was set up within the framework of a collaborative project with Harvard Medical International. The program was re-evaluated and modified after 1 year.

Several principles were retained:
- the program is mandatory [25], of long duration [26] and inserted early into the curriculum [27]; results are evaluated by a certifying form 1 year after the end of surgical training, in order to validate the sustainable quality of the educational process [7];
- selection criteria for the precise and reproducible validation of the various exercises and simulations consisted of either scores [27,28], or other metrics [16,29], depending on the different procedures. These criteria were drawn from the literature whenever available [16,27–29], or established based on the average performances of the seven instructors (expert performance) [29];
- progressive learning, adapted to each individual’s skill level [10,30,31] and under expert supervision [32], is introduced into the resident curriculum at an early stage [33];
- multicriteria evaluation [10,34,35] includes several exercises to assess technical aptitude in open and laparoscopic surgery;
- concepts that go beyond mere technical acts are integrated into the training program—for instance, teamwork, whether in clinical situations or as concerns the application of the operating room check-list.

Several elements remain to be developed in the future, integrating other training models into the curriculum: these range from simple measures such as learning how to position a patient on the operating table, draping the sterile operative field, to the most complex tasks such as creating a virtual operating room with reproduction of complete procedures, anesthesia…).

Conclusion

Our training program is a complement to “classical” training in surgery. It conciliates technical and cognitive imperatives with real life behavior situations. The program has shown that surgical simulation is feasible within an academic medical simulation center. The program is a work in progress and therefore perfectible. The program was readily accredited by the American College of Surgeons and is the first of its type in France. As such, it should be considered as a model and in accordance to the wishes of the French Surgical Academy, a step toward the creation of true schools of surgery.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


