Introduction

Achieving surgical competence is a complex process that involves the attainment of knowledge, judgment, professionalism, and surgical skill [1]. For this reason education and training have been a main matter of concern since the beginning of surgery as a specialty. In 1907 at the presidential address of the American Surgical Association, Dr. Dudley Allen described the ideal product of surgical training as someone who “…should limit his personal service strictly to those fields in which he is a master…” and the conclusion of this presidential address was a recommendation that surgeons be trained thoroughly and broadly [2]. What Dr. Allen was describing in his speech were the need to have a concentrated and continuous training experience and the need to attain and demonstrate competency through examinations carried out by a respected institution. As the field of surgery evolves, new technology and devices emerge. This makes it more difficult to stay up-to-date and creates the need for continuous education and training.

The first big revolution in surgical education and training occurred with the emergence of laparoscopic surgery in the late twentieth century. In the 1980s Erich Mühe, a German, performed the first laparoscopic cholecystectomy [3], and Kurt Semm, also a German, completed the first fully laparoscopic appendectomy [4], despite being poorly accepted by the surgical community initially [5]. With the development of this new technology, surgeons had to learn a new method of operating due to the loss of both the third dimension and sense of touch. This paved the way for laparoscopic simulators and laparoscopic training boxes which allowed the surgeon to become acclimated to this new method of operating without compromising patient safety. Accreditation of surgeons using this new surgical technique became necessary in order to guarantee the best results and safety of patients. Thus, in 2009 the American Board of Surgery began requiring that all general surgery graduates provide documentation of successful completion of Fundamentals of Laparoscopic Surgery (FLS) – a validated and standardized education module designed to teach physiology, fundamental knowledge, and technical skills required for basic laparoscopic surgery, including simulation-based skills laparoscopy [6].

In the beginning of the 1990s came the emergence of the second revolution in surgery, robotic surgery. In 1992 the ROBODOC® (Integrated Surgical Systems, Sacramento, California) was introduced; this was the first computer-enhanced surgical instrument, allowing orthopedic surgeons to more precisely drill the shaft of the femur.
Then, in 1994, the first surgical robotic instrument intended for abdominal surgery appeared; AESOP®, or Automated Endoscopic System for Optimal Positioning (Computer Motion, Santa Barbara, California), was designed to hold and manipulate the laparoscope during minimally invasive surgery. In 1997, in Brussels, the first integrated robotic surgical system for clinical application appeared, the da Vinci® Surgical System (Intuitive Surgical, Inc., Sunnyvale, California). The first clinical robot-assisted surgical procedure was performed in March 1997 by Drs. Cadiere and Himpens, using the da Vinci® Surgical System for a cholecystectomy. Following clinical trials, the da Vinci® Surgical System was FDA approved for surgery in the USA on July 12, 2000 [7].

Due to its characteristics, the da Vinci® robot has become the most popular and useful because it allows surgeons to overcome many of the difficulties of laparoscopy surgery: loss of depth perception, loss of natural hand-eye coordination, loss of intuitive movement, and loss of dexterity. Depth perception is restored with a stereo visualization by using a two-channel endoscope which sends both left and right eye images back to the surgeon. The alignment of the surgeon’s hand motions to the surgical tool tip is both spatial and visual. To achieve spatial alignment, the system software aligns the motion of the tools with the camera’s frame of reference. To achieve visual alignment, the system projects the image of the surgical site atop the surgeon’s hands. Coupled together, spatial and visual alignment make the surgeon feel as though his hands are inside the patient’s body [8].

All of this has led to a new way of feeling, seeing, and working in the surgical field. We are now operating through the eyes and hands of a robot which reintroduces the problem of how to teach, learn, train, and credential this new technique.

**Training**

Training is the key to mastering any surgical technique and should be emphasized even more so when it comes to robotic surgery. One must learn new skills regarding hand-eye coordination and also become accustomed to the loss of touch sensation. To overcome these difficulties, we must take advantage of several tools, which are simulators, mentored cases, robots with dual consoles, and robotic courses (which obviously must be designed using the aforementioned tools). This makes it possible to bridge the gap between early surgical skills and effective surgical performance when using a robot in a clinical setting without subjecting patients to unnecessary risks.

### Simulators

A simulator is an educational tool which allows interactive performance of the trainee in an environment that re-creates or replicates a real-world clinical scenario, but is not identical to “real life.” They must be present in the initial training in robotic surgery because they ensure that some practice has taken place before trainees treat real patients; they improve the surgeon’s performance within a safe training environment by providing a controlled re-creation of critical steps of any surgery. There are many simulators available for health-care training [10], with surgical simulators generally being divided into two categories: virtual reality simulators, in which the task is performed in an artificially virtual environment generated by a computer platform, and mechanical simulators, in which the robot is connected to a box trainer.

Currently there are four main different robotic surgery simulation platforms available on the market: da Vinci Skills Simulator® (dVSS, Intuitive Surgical), Mimic dV-Trainer® (MdVT, Mimic Technologies), Robotic Surgery Simulator (RoSS®, Simulated Surgical Systems), and SimSurgery Educational Platform® (SEP, SimSurgery). A fifth simulator worth mentioning, the ProMIS® (CAE Healthcare), is a laparoscopy simulator which can be adapted to the robot to convert it into a robotic surgery simulator [11]. All simulators except the SEP have shown an educational impact [12]. Of the aforementioned simulators, the only one using the da Vinci console is the da Vinci Skills Simulator®, which is manufactured by Intuitive Surgical, the same
company that manufactures the da Vinci® robot. This gives it a potential advantage over the rest, because the surgeon trains in the same console that he or she will be using in live cases.

The da Vinci Skills Simulator® (dVSS) (Fig. 2.1a, b) consists of a small case which generates the virtual environment and is in turn annexed to an existing da Vinci surgeon console, transforming it into a practice platform. Some main features are built-in metrics which enable the surgeon to assess skills and to measure the improvement in a given exercise, real-time feedback and progress tracking, administrative tools which allow structuring of a training curriculum, and system software with an open architecture which allows integration of future development and incorporation of additional practice modules.

The dVSS comes with a set of exercises (Fig. 2.2) ranging from basic to advanced and is designed to be relevant to surgeons from any specialty. Some of these are EndoWrist® manipulation exercises which help gain familiarity with the movement of the robot’s instruments, camera and clutching exercises to improve camera control and effectiveness of clutch use, fourth arm exercises designed to promote instrument skill and to help users to think strategically about instrument placement during tasks, needle control and driving exercises designed to help users develop skill when manipulating needles (including a focus on how to effectively hand off and position needles while practicing with a range of geometries), and, finally, energy and dissection exercises which help gain familiarity with the foot switch
panel during dissection tasks requiring applica-
tion of monopolar and bipolar energy (the foot
switch panel enables users to swap between dif-
ferent types of energy instruments) [13].

To detect whether a simulator is useful, we
need to assess its validity, or whether an exam or
test succeeds in testing the competence that it is
designed to test [14]. The dVSS has shown face
validity (how much the simulation resembles the
situation in the real world), content validity
(whether or not the intended content domain is
being measured by the assessment exercise, in
other words, if it is useful as a training tool), and
construct validity (the extent to which a test mea-
sures the trait that it purports to measure; a test
with high construct validity has the ability to dis-
tinguish between a novice and expert user). The
dVSS has also shown an important educational
impact, meaning the ability to improve the per-
formance of the subjects. This was more
pronounced in novice surgeons than in experi-
enced robotic surgeons [15, 16] which makes this
simulator more useful in the initial training
stages. The weakest point of this simulator is the
lack of cost-effectiveness due to its high market
cost and the need of an existing da Vinci robot
console, which makes feasibility difficult.

The Mimic dV-Trainer® (MdVT) (Fig. 2.3) is a
stand-alone simulator built on a compact hard-
ware platform which closely reproduces the look
and feel of the da Vinci system and also replicates
its behavior. Its software (Mimic’s MScore™)
allows objective performance evaluation due to its
incorporated data collected from experienced sur-
geons to establish proficiency-based scoring base-
lines. The scoring is based on time to completion,
economy of motion, instrument collisions, num-
ber of drops, missed targets, instruments out of
view, blood loss, broken vessels, excessive instru-
ment force, and misapplied energy. The simulator
also comes with administrative tools for educators
to create customized training protocols and allows
uploading and sharing of these curricula via a
collaborative online portal, in turn providing

Fig. 2.3 Mimic dV-Trainer® surgery simulator (Copyright © 2014 Mimic Technologies)
access to validated simulation curricula from other institutions.

The MdVT comes with two groups of training modules (Fig. 2.4): the da Vinci® overview and basic skills training and advanced surgical skills training. The first group allows the surgeon to become familiar with the da Vinci console, review the basic da Vinci functionality, train on EndoWrist® manipulation, learn how to use the camera and the clutch effectively, and understand some common da Vinci error messages and determine how to react to them. The second training module consists of needle control and needle driving exercises, suturing and knot tying (including tube anastomosis and tube closure), energy and dissection exercises to learn how to apply monopolar and bipolar energy, and finally exercises to practice dissection and manage bleeding. Lastly, there is an interesting game module which allows competing while developing robotic surgical skills at the same time [17].

Several studies have shown that MdVT has face, construct, and content validity as a training tool [18–20] and that it significantly improves technical skills in robotic surgery. Moreover, MdVT seems to be equivalent to dVSS in regard to improving robotic aptitude in skill domains related to object manipulation, camera movement, and clutching [21].

The weakest point of this simulator, as with the dVSS, is its high market cost which makes it less cost-effective. On the other hand, the MdVT does not require an existing da Vinci robot console.

The Robotic Surgery Simulator (RoSS®) (Fig. 2.5) is also a stand-alone simulator which can be easily transported; it uses virtual reality to generate the case scenario. RoSS® comes with a multi-level curriculum designed with various levels of difficulty that takes the surgeon through the basic skills required to perform a robotic surgery. This simulator can be distinguished from the previous ones in that it offers the opportunity to train while being guided through the operative steps of a real procedure (e.g., radical prostatectomy, hysterec- tomy, cystectomy, extended lymph node dissection, etc.). See Fig. 2.6a, b. This feature uses the principles of checklist-based learning, meaning the user can only proceed through the procedure after successfully learning and executing each step. The RoSS® also shares some characteristics of the previously mentioned simulators: system settings, EndoWrist® manipulation, camera and clutching exercises, fourth arm integration, needle control and needle driving, energy and dissection exercises, and performance feedback [22].

RoSS® has shown face validity and content validity [23, 24], but several studies could not demonstrate construct validity [23–25] which means it may be less useful in discriminating between various levels of expertise. The cost of this simulator is also a limitation that may reduce its feasibility.

The SimSurgery Educational Platform® (SEP) (Fig. 2.7) is another option available on the market, produced by the company SimSurgery. It lacks some features offered by the previous simulators; it offers EndoWrist® manipulation, camera and clutching exercises, fourth arm integration, needle control and needle driving, energy and dissection exercises, and performance feedback (stores data on performance measures). The simulator offers exercises to train on basic and advanced skills organized into three groups: tissue manipulation, basic suturing, and advanced suturing. It may be considered when training hand-eye coordination and suturing [26]. SEP has shown face, construct, and content validity, and its market price is relatively lower than the previously mentioned simulators [27].

Lastly is the ProMIS® (CAE Healthcare), a laparoscopic surgery simulator which can be
connected to the robot in order to perform robotic surgery training. ProMIS® is a hybrid simulator which enables virtual reality simulation and mechanical simulation to be used together. The simulator has a laparoscopic interface which consists of a torso-shaped mannequin with a neoprene cover, all connected to a portable computer. Different trays are available, containing different training modules: suturing pads, knot-tying tasks, etc. These can be placed in the mannequin.

Fig. 2.5 Robotic Surgery Simulator (RoSS®) (Copyright © 2014 Simulated Surgical Systems)
Three separate camera-tracking systems are placed inside the mannequin, arranged to record the three-dimensional position of the tip of the instruments. This way, instrument movement is recorded and stored in distinct sections based on the time the tips of the instrument are detected until they are removed from the mannequin. The ProMIS simulator analyzes three parameters:
time, path, and smoothness [11]. This robotic surgery simulator has shown face, content, and construct validity. It is the least expensive of all the mentioned simulators; however, it requires an existing da Vinci robot for use [28].

Given the lack of comparative studies between these different simulators, we cannot affirm that any of them is more effective than another for training in robotic surgery [12]. It is worth mentioning that simulation models have been shown to be valid and reliable for the initial phase of training and assessment in surgical procedures; however, this is not the case for advanced and specialist level skill learning [29]. Simulators should play a role alongside traditional training, especially in the initial phase of training. The main drawback of simulator training is still the cost, although this may decrease in the near future.

**Mentored Cases**

Mentoring can be defined as a form of training whereby an experienced surgeon scrubs in on or supervises the procedure with the intention of guiding the surgeon learner and assisting in the acquisition of new skills during the steep part of the learning curve. In terms of robotic surgery, mentoring can be the second stage of training after the learner has demonstrated competence in basic skills. The entrance of the trainee into this clinical training stage should be gradual. The first approach should be live case observation which will allow the trainee familiarization with the procedures and technique. Prerecorded operative footage also can provide the trainee with an opportunity to observe the execution of the various steps involved in completing a specific robotic procedure from start to finish [30]. A library of prerecorded operative video footage can be provided to trainees for reference so that they can review the specific steps of the procedure. Live case observation will allow interaction with the expert surgeon in real time while also allowing review of certain steps of the surgical procedure.

The second approach before immersing into the hands-on clinical training should be the participation on a live case as the bedside assistant to the main console surgeon. This should incorporate the knowledge acquired during the procedure-specific familiarization. The ability to assist effectively in live robotic procedures demonstrates that the trainee has gained the knowledge of the steps of the procedure, general proficiency in working in the robotic environment, knowledge of the functionality and limitations of the robot itself, as well as the strategies and techniques used by the console surgeon to complete the specific procedure. The importance of beginning the operative experience as a surgical assistant has been reinforced by several authors [31–33] and serves to strengthen the trainee’s basic robotic knowledge and skills before commencing clinical training on the console. The number of cases recommended as the bedside assistant depends on which procedure the trainee is learning; there is still no general consensus in terms of this number.

Time on the surgeon console should represent the final approach of any clinical training. The procedure with which the trainee begins his clinical training at the console should be the type of procedure which constitutes the highest volume of cases at one’s institution. This provides the trainee with plenty of opportunities to effectively work through the clinical components of the required techniques.

The specific procedure should be clearly defined by the steps required to complete the operation from the initial positioning of the patient to the final removal of ports and recovery of the patient. These steps should be ordered somewhat by the complexity of the surgical tasks involved and then be ordered from least difficult to most difficult, providing the trainee with a gradual progression in their curriculum. This allows the trainee to go through a stepwise progression of defined tasks and steps of the procedure based on the degree of difficulty, all under direct supervision of an expert robotic surgeon who is at the bedside or at the console with the trainee. This approach to robotic training has been emphasized by several studies [34–38] and allows the trainee to acquire skills through repetition of tasks based on specific skill.

When the trainee has demonstrated complete control of a predefined step, through formal
evaluation or based on an expert surgeon’s judgment, he/she will be able to move on to the next sequentially difficult step of the procedure. Eventually the trainee will be able to integrate skills learned and practiced during each defined step into a comprehensive ability to complete the entire procedure. The learning process can be further enhanced through video recording and review of operative performance with a mentor or expert surgeon as it provides valuable formative feedback for the trainee [39].

Unlike traditional open surgical training where the mentor can be in close proximity to the trainee and facilitate hands-on teaching, in robotic surgery the mentor and trainee are separated in space, and the attending surgeon may not have full control of the operation as in open surgery. The fact that only one surgeon at the time can be at the console is an educational problem that has been previously documented [31, 36, 38], and the next training tool may be the one that brings light to this issue.

**Dual Console**

Intuitive Surgical has developed a da Vinci® model (Si) that has an available dual console which will potentially allow for expert surgeon direction and supervision for procedural robotic training and collaboration. The mentoring console has two collaborative modes [40]: (1) The swap mode allows the mentor and trainee to operate simultaneously and actively swap control of the robotic arms. (2) The nudge mode allows them to have control simultaneously, sharing the two robotic arms. Studies [40] have shown that the swap mode was most useful during parts of the surgical procedures that required multiple hands (e.g., isolation and division of vessels). The nudge mode, however, was more useful for guiding the resident’s hands during the more crucial and precise steps of an operation (e.g., suturing).

The introduction of the dual console could shorten the learning curve and help trainees feel more comfortable when initially performing the procedure [41].

This new robotic system could lead to safer educational training and also opens the gate to a whole new way of training, termed “telementoring,” defined as the use of audiovisual technology at any distance to provide mentoring or teaching.

**Robotic Courses**

Many guidelines have been published on how a robotic surgery course must be composed, but here we attempt to give general guidelines on the design of a robotic surgery course using the aforementioned tools. Whatever the course design, we believe it must be under the direction of an expert surgeon instructor (someone with substantial practical experience with the technology in clinical applications with reported results and reviews) and also, in the initial steps, an engineer from the company which designs the robots who can teach the basic knowledge about how the robot works.

Introduction and familiarization with the robot system itself must be the first step in any training course. The surgeon should learn about the robotic system components, draping the robot’s arms, patient positioning, docking techniques, port placement strategy, inserting and exchanging instruments, and, importantly, basic system safety, emergency undocking procedure as well as dealing with troubleshooting errors and faults which may happen during the initial experience. This information should be provided first through lectures (which may be provided online) and then, after an examination of the surgeon’s learned knowledge, transferred to the practical field through hands-on tutorials where the trainee can interact with the robot in a low-stress environment and apply what he has learned. This part of the course should allow a complete understanding of device function and technology, altered functional status, and device parameters and limitations.

Intuitive Surgical, the vendor of the robot, has created an online tutorial on the fundamentals of the da Vinci robot. It includes a technical overview of the robot, functional aspects of the system, as well as some troubleshooting tips. This online tutorial is available for the various robot models and includes a multiple-choice question-based examination that can be used by training
programs to evaluate trainee knowledge of the basic functional aspects of the robot [30].

After having successfully completed the first part of the course, the surgeon may move to the second step, learning the basic skills of any robotic surgical procedure: camera focus, movement, camera adjustment, clutching exercises, needle driving and wristed motions, precision cutting, dissection, suturing, and knot tying. These allow the surgeon to become familiar with the three-dimensional environment and will allow him or her to perform more complex procedural tasks. This step should have a theoretical component with lectures but also, more importantly, training on virtual simulation and dry labs with the robot. This will allow the surgeon to learn the basic components of any robotic surgical technique. A further step should be the application of these acquired skills in a live tissue lab (with animal or cadaver models) where the surgeon will be able to perform tissue dissection, hemostasis, and suturing.

Table 2.1 shows, in order of increasing complexity, exercises which will allow the surgeon to obtain the basic skills and become familiar with the 3D environment:

Module 1
- Instrument control: This task will allow the trainee to learn how to move the robot arms and familiarize themselves with the wrist movements of the arms.
- Camera control: This task teaches the trainee camera focus, movement, and camera adjustments.
- Fourth arm control: This task allows the trainee to learn how to use the fourth arm.
- Coordinate tool control: This task aims to integrate what the trainee had learned previously and will let him/her use the camera and the clutch together in a coordinated manner.

Module 2
- Ball placement: This task aims to develop accurate and precise control of instruments by picking up balls and placing them in a designated spot.
- Spatial control: This may be achieved, for example, by passing a ring along a curved wire.

Module 3
- Needle handling: This task should allow the trainee to handle a needle properly and to hand off a needle to a bedside assistant.
- Basic electrocautery: This task teaches the trainee how to use the electrocautery hook.
- Tissue cutting: With this exercise the trainee will learn how to use the scissors to cut tissue. It can be achieved, for example, by drawing a circle on a paper and soliciting the trainee to cut the circle in the most precise way.

Module 4
- Tissue retraction: This task combines the previously acquired skills and requires coordinated control of the fourth arm to retract tissue.
- Blunt tissue dissection: This task also combines the trainee’s previously acquired skills and requires coordinated control of the instruments and the camera to separate two layers of tissue.
- Vessel dissection: This task requires coordinated control of the instruments and the...

Table 2.1 Exercises that will allow the surgeon to obtain the basic skills and become familiar with the 3D environment, in order of increasing complexity

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<tr>
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<td>Coordinate tool control</td>
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<td>Knowledge</td>
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camera to dissect the vessel. One possibility is through use of animal models.

- Knot tying: The trainee will have to coordinate the control of the instruments to effectively tie common surgical knots.

After completing the previously mentioned steps, the surgeon may move toward specific training in his or her area of competence. Through training and repeating the basic skill tasks on a virtual simulator, in a dry lab and on animal models, the surgeon will eventually master the key components of the surgical procedure and perform them fluently. Simultaneously, the surgeon may be present in the operating room to observe and assist in live cases using the robot. The observation of a complete procedure is an essential part of preclinical training. This should include procedure preparation, system setup, review of case selection, and intraoperative technical aspects.

After demonstrating mastery of the key components of the surgery on lab and virtual simulators, the surgeon will be allowed to perform them in a live surgery. They may begin with the easiest key steps and work up to more difficult steps, in an increasing level of difficulty and always under the supervision of an expert surgeon in the robotic field. At this point dual consoles can play a fundamental role. During conventional open and laparoscopic surgery, the mentoring surgeon is adjacent to the trainee and has the same view of the procedure, as well as being able to take over at any given moment. This is not the case in robotic-assisted procedures as only one surgeon can be at the operating console at one time. However, now, through an additional console, both the expert and novice surgeons may operate at the same time. The expert can control the third arm to help the novice, or they can simultaneously control both arms and switch between who is controlling them. In this way the expert can take control of the surgery at any time if the safety of the patient is at risk.

After completing the key components several times, the surgeon will be able to perform a complete procedure under direct supervision. The number of mentored cases required to master the technique depends on the type of procedure and its complexity and has not been well established yet. In every specialty this number is under discussion because its determination will facilitate coming to an agreement regarding the topic of accreditation.

### Credentialing

Currently there are no governing bodies mandated for credentialing guidelines in robotic surgery. The requirement for acquiring credentials varies among hospitals. There is no standardized method, and more importantly, most of these requirements are not competency-based but rather require a number of proctored cases.

Robotic surgery credentialing should be the result of a standardized, competency-based peer evaluation system. It is important that this process be self-regulated by robotic surgery experts in a clear, comprehensive, and reproducible manner. It may be logical to follow the example set by the laparoscopic surgery and the Fundamentals of Laparoscopic Surgery (FLS) curriculum. The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) has created the FLS curriculum, which serves as a set of guidelines for laparoscopic surgery training and credentialing. After having been validated as a means of training and credentialing trainees [42], the FLS curriculum is now endorsed by the American College of Surgeons. All general surgery certification candidates are required to have successfully completed the FLS training curriculum before being eligible for the American Board of Surgery certification.

At this point in time, there is no such curriculum in place for robotic surgery. Until such a curriculum is developed, we believe that several requirements should be considered as a bare minimum necessary to obtain robotic surgery credentialing, including:

- Proficiency in basic laparoscopy
- Technical certification for use of the da Vinci robot
- Proof of basic preclinical training in robotic surgery
- Clinical proficiency status obtained from an approved robotic surgery proctor
In order to reach this goal, the SAGES and the Minimally Invasive Robotic Association (MIRA) have taken a step forward by creating a consensus on robotic surgery which analyzes the credentialing topic in a general way [43]. The purpose of this type of consensus is to generate uniform standards which may be applied to all medical staff requesting privileges to perform procedures utilizing the robot and also to decrease the heterogeneity of concepts and to generate criteria universally applicable to all those wishing to obtain privileges. In our opinion surgical proficiency should be assessed for every surgeon, and privileges should not be granted or denied solely based on the number of procedures performed.

Having clarified these points, we will attempt to give an overview of the steps which should be required for credentialing in robotic surgery. The first step, although seemingly obvious, is important and necessary: the physician seeking these privileges should have a formal specialty training; this means that he or she should have a satisfactory completion of an accredited surgical residency with subsequent certification by the applicable specialty board (or an equivalent allowed by the institution).

For the second step, we find two possibilities: a physician with a previous formal training in therapeutic robotic surgery during their residency and/or fellowship programs or one without such training.

In the first scenario, the surgeon ought to have learned during his residency/fellowship minimal access procedures, general laparoscopic skills, use of therapeutic robotic devices, and techniques of accessing the body cavity/area of surgery. They should possess adequate clinical experience to move to next step.

Alternatively, physicians with residency and/or fellowship training who did not receive structured experience in therapeutic robotic procedures or without documented prior experience in these areas should complete a systematic training curriculum. Until a universal governing body is created, the curriculum should be defined individually by institution and should include a structured program using the tools mentioned earlier.

The third step may possibly consist of presentation of documented experience in the field, including an appropriate volume of cases with satisfactory outcomes. These cases would preferably be equivalent to the procedure in question in terms of complexity. A committee of experts on robotic surgery could be the one which determines the appropriateness of this experience. As mentioned before, the initial clinical experience with the specific procedure could be completed under review of an expert (mentor) and may include assisting.

An adequate number of cases to allow for proficient completion of the procedure should be considered by this expert review. This “adequate number” of mentored cases to be considered has been a matter of debate, and there is currently no consensus on this matter, even in the field of urology, where robotic surgery has shown an increasing presence. Taking the robotic-assisted radical prostatectomy (RARP) as an example, the current literature reveals a wide range in the recommended number of cases required to move beyond the initial learning curve. Some authors refer that surgeons without extensive laparoscopic experience can successfully adopt RARP in 8–12 cases [44], while others determined that a minimum of 250 RARP cases are required to achieve comfort and confidence comparable to open radical prostatectomy [45].

Therefore, we recommend that the criteria of competency for each procedure should be established in advance by the committee and should include evaluation of familiarity with instrumentation and equipment, competence in their use, appropriateness of patient selection, general safety, and successful completion of the procedure.

After having successfully completed the previously mentioned steps, a formal assessment of competency can be done. An applicant’s abilities may be documented through validated measures of competency which include medical knowledge, decision-making abilities, and/or technical skill assessments. Certificates of completion of training or validation using assessment tools for competency and proficiency in a specific procedure (or set of similar procedures) could be accepted.
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